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COMITÉ FRANÇAIS
D'HISTOIRE DE LA GÉOLOGIE

INTERNATIONAL COMMISSION
ON THE HISTORY OF GEOLOGICAL SCIENCES



PROCEEDINGS OF THE 47TH INHIGEO SYMPOSIUM

LES EYZIES - FRANCE
15-24 SEPTEMBER
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Volume XXXVI^{BIS}

PROCEEDINGS OF THE 47TH INHIGEO SYMPOSIUM

EDITED BY

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LES EYZIES, FRANCE – 15-24 SEPTEMBER 2022

SYMPOSIUM ORGANIZED BY

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Preface

These proceedings gather 21 papers written on various topics presented in September 2022 at the 47th symposium of the International Committee on the History of Geological sciences (INHIGEO), which was held at Les Eyzies de Tayac in south-western France. A glance at these papers, and at the 16 abstracts also submitted by other authors, reveals the wide variety of themes discussed, which is in fact a hallmark of INHIGEO symposiums. The whole set thus provides a vivid illustration of the vitality of History of geology. Thanks are due to all authors for having produced such a concrete outcome of lively presentations and friendly discussions during the symposium and the excursions, and also for their responsiveness and quick reactions during the reviewing process of the Proceedings.

As a matter of fact, the 2022 INHIGEO symposium was initially planned in Russia. In 2020, however, it appeared that an alternative location had to be sought after. The idea then came to Claudine Cohen that France could take the responsibility to organize it, with rehistory and Geology as a special theme. The idea was at once endorsed by COFRHIGEO, the French branch of INHIGEO, which set up a four-member organizing committee for this purpose. It was the pride of place taken by prehistory that led to select as the central site of the symposium the small town of Les Eyzies, which has been dubbed the *Capital of Prehistory* because of the wealth of inhabited shelters and ornamented caves found nearby along the Vézère valley. Owing to its tourist importance, Les Eyzies was in addition making available the nice auditorium of the *Centre international de la Préhistoire* as well as a variety of boarding options for the participants.

It happened that the preparation of the symposium was fraught with uncertainties related to the covid pandemic, the risk of yet another confinement in France, travel restrictions caused by the war in Ukraine, and the ensuing consequences on the planned budget. Luck was on our side, fortunately, as a single participant became positive to covid only near the end of the symposium. A funny view was then offered by the participants when all of them got tested at the same time on the parking lot where the bus was waiting to leave for the post-symposium excursion. Three additional participants tested positive either on the spot or

slightly later on, but two of them could nonetheless continue the excursion in the car of one of the organizers — a useful rescue vehicle!

In the end all initial worries have been alleviated. Despite a situation that was not completely back to normal, 43 participants and 10 accompanying members were present. From a material standpoint, things went smoothly thanks to COFRHIGÉO treasurer Françoise Dreyer who managed to keep within the planned budget — production of the present volume included — despite the great many different sources of expenses related in particular to the excursions. In a masterly way, these excursions were mainly designed by Claudine Cohen for Prehistoric caves and shelters and by Gaston Godard for the sites of geological interest. Here it is not needed to describe the sites visited in any detail. It will thus suffice to list them and let interested readers know that the relevant field trip guides can be downloaded at <https://hal.sorbonne-universite.fr/COFRHIGEO>.

In practice, it proved convenient to pick up the participants at the Poitiers TGV railway station on September 15 before making the first visit at the PALEVOPRIM human paleontology laboratory (and collections), which is known, among other things, for the discovery of the 7 million-year old Toumai hominid in Chad. A stop was then made at the former abbey of Nouaillé, near the site of the 1356 Poitiers battle between the French and English, and the night spent in the small town of Saint-Junien. The day after, the second site visited was the former Rochechouart crater, produced 215 million years ago, whose breccias were long considered to be volcanic in origin until François Kraut eventually showed in the late 1960s that these and other strange rocks found locally had been produced by an impacting asteroid. The bottom of the crater could be seen at the Champagne quarry whereas additional information was found at the Pierre Pellas Museum in Rochechouart.

The symposium itself opened on September 16 with a late-afternoon guided tour of the beautiful, recently refurbished National Prehistory Museum. The tour began with a speech of the museum director Nathalie Fourment and was followed by an evening cocktail on the Museum terrace dominating the Vézère river during which

welcome addresses were given by Les Eyties mayor Philippe Lagarde and current COFRHIGEO and former INHIGEO president Philippe Taquet.

From September 17, the scientific part of the symposium was made up of 39 oral and 5 poster presentations that alternated with a series of visits to the Lascaux International Center of Cave Art, the Lascaux 4 fac simile, Le Moustier shelter (of Mousterian fame), La Ferrassie shelter (where 8 reasonably complete Neanderthal skeletons have been found, out of the 12 found in the Dordogne region and 44 worldwide), Commarque Palaeolithic cave and castle, Cro-Magnon, Laugerie-Basse, Laugerie-Haute, Abri du Poisson and Cap-Blanc shelters and Font de Gaume cave. What made these visits specially informative is that many of them were made under the guidance of the anthropologists who are still excavating them. As for the accompanying members, they were taken care of during the sessions with visits of the well-known village of Domme, Marqueyssac gardens, and Beynac castle, followed by a boat trip on the Dordogne river, and of yet another picturesque village, La Roche Gageac. From a social standpoint, worthy of note were also a dinner in Sarlat, after a late afternoon guided tour of this beautiful city, and the symposium banquet held in Les Eyzies on the evening of September 21st.

The post-symposium excursion began the day after with yet another visit to an ornamented cave, that of Pech Merle, famous for its painted horse, which is located 90 km south-east of Les Eyzies in the Quercy region. Not far away are the *phosphatières* of Cloup d'Aural, one of the many former sites of extraction of phosphates that were actively mined in the 1860s for producing fertilizers and have since then proved valuable from a paleontological standpoint because of the variety of fossils trapped in the phosphates during their formation. After a night spent in Agen, the last day on September 24 was devoted to three Miocene historical stratotypes North of Bordeaux, namely, L'Ariey and Bernachon for Aquitanian, Pont-Pourquey for Burdigalian and Lassime for Serravallian; additional information was then obtained at the Saucats Nature reserve museum. Another site visited at Loubens shows thick Miocene oyster beds, which form a small cliff over the Garonne river at Sainte-Croix-du-Mont. As described by Gaston Godard in

his paper, this site has the additional interest of having triggered reflections on the nature and deposition of fossils that antedate by several decades Steno's *Prodromus*. Followed by a wine testing offered by the owner of the place, this visit was quite appropriate for the last day of the symposium, which ended for good at the Bordeaux TGV station.

Needless to say that such an extensive program could not be worked out by the organizing committee alone. Hence, the organizers warmly thank the numerous people who helped us plan either the symposium in Les Eyzies or the excursions, namely, G. Merceron et O. Chavasseau for the Poitiers PALEVOPRIM laboratory; M. Yserd, for the Rochechouart Nature reserve; Ph. Lagarde, Les Eyzies mayor; N. Fourment, director, and M.-C. Ruault-Marmande, B. Gravina and A. Turq, researchers at the Musée National de la Préhistoire; C. Vigne, director, C. Roudet, his assistant and all staff of the Pôle d'Interprétation de la Préhistoire; G. Pinçon, N. Coye and S. Konik at the Ministry of Culture; M. Martinez, administrator, and C. Tyssandier, his assistant, of the Sites de la vallée de la Vézère, A. Mathieu, A. Maureille, J.-P. Chadelle and E. Bougard for the guided visits of the prehistoric sites; B. Defois, curator of the Pech Merle cave; J.-M. Touron, owner of the Cro-Magnon shelter; P. Texier, Research director at C.N.R.S., S. Maury and A. Raux, prehistorians; I. Petrin, of the Maison Bordes, which hosted the headquarters of the symposium; R. Bondonneau for the guided tour of Sarlat; T. Pélissier et his team for the Cloup d'Aural *phosphatières*; A. de Seze for the Sainte-Croix-du Mont outcrop and the generous wine testing at his property; B. Cahuzac, of the Bordeaux Linnean Society, and M. Locascio and Y. Gilly, of the Saucats-La Brède geological reserve for the Miocene stratotypes, for which they in addition kindly provided us with relevant information for the fieldguides; and A. Léautier, travel agent at Périgord Voyages, for valuable help in planning bus transportation.

Last but not least, these warm thanks must be extended to Philippe Grandchamp for efficiently producing these Proceedings, as he is doing every year for the COFRHIGEO *Travaux* of which the present volume is a special issue.

Pascal RICHET
On behalf of the Organizing Committee

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Prehistoric archaeology and geology, a historical perspective

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Abstract. This paper examines the role played by Geology in the constitution of Prehistoric Archaeology as a scientific discipline. Geology was a tool for the establishment of its evidence, and a scientific model whose concepts, vocabulary and onomastics were directly imported from one discipline into the other. Despite the limits of its usage as sole evidence, Geology remains until today an irreplaceable companion to prehistoric archaeological research.

By the turn of the 19th century, Geology had accessed the status of a scientific discipline, and thus gained a unique prestige among the natural sciences (Rudwick, 2005, 2008). It became a powerful driving force for several disciplines such as palaeontology¹ and evolutionary biology², and even a key to the recognition of their scientific status. In prehistoric archaeology, geology constituted the very basis of a knowledge that it helped to found.

Early evidence for human antiquity was established in Northern France (Cohen & Hublin, 2017). From the 1830s, Casimir Picard (1838) then Boucher de Perthes working in the region of Abbeville, showed that the stratigraphy of the lower Somme river valley gave evidence to the contemporaneity of extinct animals and flint tools made by human hands; the succession of layers provided evidence for the relative antiquity of chipped vs polished flint artefacts, as belonging to two distinct epochs of human prehistory -- “Celtic” (Neolithic) vs “antediluvial” (Palaeolithic) epoch (Boucher de Perthes, 1847, 1857, 1864). Whereas French academic authorities were reluctant to admit Boucher’s claims for the antiquity of Man, great English geologists

such as Charles Lyell, Joseph Prestwidge, and Hugh Falconer travelled to the Somme valley in Abbeville to recognize and confirm their validity (Cohen, 1997; Cohen & Hublin, 2017). The word “*archéo-géologie*”, was coined by Jacques Boucher de Perthes to name his own research: for him it meant a new way of looking at archaeological objects and their antiquity, in which geology had a central place. Eventually, Charles Lyell (1863) summarized this new body of knowledge in an important book intitled *Geological Evidences of the Antiquity of Man* in which he listed a number of significant discoveries made in France, in England and elsewhere, and recognized in Quaternary terraces the geological traces of glaciers which punctuated the period during which prehistoric Humans thrived in Western Europe.

Geology was not only a tool; it truly became a model for prehistoric archaeology. Beyond the uses of geology as evidence, Prehistory’s methods and concepts were directly borrowed from geology: thus the constitution of a scientific language in Prehistoric archaeology used, as it had long been the case in Geology, the names of eponymous localities (such as Mousterian from Le

¹ Cuvier’s first volume of his *Ossements fossiles de quadrupèdes*, generally considered as the founding work of scientific palaeontology, opens with a « Géologie du Bassin de Paris ».

² Darwin’s early training at Edinburgh and Cambridge was in Geology, and he recognized the influence Lyell’s geological thinking had upon the constitution of his own evolutionary thought. See Sandra Herbert, *Darwin, Geologist*, Ithaca, Cornell University Press, 2005.

Moustier, or Magdalenian from La Madeleine, etc.) to establish a nomenclature of successive prehistoric levels; typical stone tools of these prehistoric cultures were used as stratigraphic markers, in the same way as “guiding fossils” were used in stratigraphic palaeontology (Mortillet, 1884). Similarly, the succession of prehistoric industries in a vertical sequence (Mortillet, *ibid.*) illustrates the impact of geological methods and concepts upon the epistemological foundations of prehistoric archaeology.

Geological evidence eventually proved insufficient or even inadequate to address certain issues raised by prehistoric archaeological research, it could also be the occasion for mistakes, or even frauds: the Moulin Quignon jaw (Boucher de Perthes, 1864), whose antiquity was established by its sole stratigraphic position (Cohen & Hublin, 2017; Cohen, 2018), appeared later as a recent human bone which had simply been planted by workers at the bottom of a stratigraphic section. With the multiplication of finds, anatomical studies, which had been until then impossible because of the lack of fossil remains for comparison, could now take place over geological considerations.

However, geology still was, and remains today, essential to the stratigraphic study of sites, their interpretation and relative dating. Geological knowledge constitutes an essential framework for the study of prehistoric cultures, and is part of interdisciplinary research into human Prehistory. It is enlightening in what regards the exploration of shelters and decorated caves (Pigeaud, 2023), as it makes it possible, in particular, to study human actions, behaviours and artistic productions in relationship with mineral and geological materials specific to a given site. Geology is indeed today an irreplaceable companion for the prehistorian to study the material contexts of early cultures and art, and to explore the relationships of humans with their environments.

Approaching the history of prehistory from the perspective of its changing connections and articulations with geology and exploring the various collaboration of these two disciplines for more than a century and a half thus proves important and fruitful for science historians, as well as for scientists engaged in these two domains.

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Palaeolithic uses of natural reliefs and geological formations in South Western French cave art: a few examples

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Abstract: Going to draw in the caves required a certain courage, but above all elaborate logistics, in order to be able to work there properly and then come out without a hitch. It is logical to postulate that such an organization in the underground movements also implies an elaborate program of decoration of the walls. In particular, the use of natural reliefs by Palaeolithic artists testifies to an in-depth study of volumes and rocky asperities, carried out in our opinion during a preparatory phase. The image of the solitary hunter-gatherer etching randomly from his visual impressions, guided by the shadow cast by his torch, is a scientific myth.

Keywords: Cave art – geology – natural reliefs

Introduction

In prehistoric times, in our imagination, cave is a scary place: it is dark there, and lots of dangerous beasts live there, like this lion waiting for the hunter, after having slaughtered his entire family, depicted in the painting "A drama in the Stone Age" by Paul Jamin (1886). Primates, as a whole, do not like to go underground. Admittedly, the Chimpanzees of Fongoli, in Senegal, go into the caves to cool off, at the hottest hours of the day, as do the Baboons of South Africa or the Semnopithecines in China¹, but if they leave the daylight zone to take shelter in the half-shade zone, they hardly venture into the dark zone². Hominine fossils found in deep caves were brought there by a predator who feasted on their flesh (this was the sad fate of a *Paranthropus* dragged into Swartkrans cave in South Africa)³, or fell there by accident, like the unfortunate Neanderthal in the cave of Lamalunga, near Altamura (Italy)⁴.

There are, however, two cases where Man dared to overcome his apprehensions and progress, of his own volition, in total darkness:

- in order to deposit or throw corpses there, from 430,000 years ago for *Homo heidelbergensis* in the *Sima de los Huesos* (Atapuerca, Spain)⁵, and perhaps between 236,000 and 335,000 years ago for *Homo naledi* in the cave of Rising Star (South Africa)⁶; it is then only in the Gravettian in the caves of Vilhonneur (Charente) and Cussac (Dordogne) between 3100 and 29400 years (calibrated radiocarbon ages)⁷ that *Homo sapiens* will find this "tradition", promised later to a bright future in the Neolithic with the "sepulchral caves".
- to practice activities there that we will quickly qualify as "symbolic": accumulation of speleothems to build circular spaces like Neanderthals in the Bruniquel cave (Haute-Garonne) around 176,000 years ago⁸; tracings engraved or

¹ Pruetz, 2007,

² Pastoors, Weniger, 2011.

³ Brain, 1969.

⁴ Lari *et al.*, 2015.

⁵ Sala *et al.*, 2022.

⁶ Berger *et al.*, 2015, 2023a; Dirks, Berger *et al.*, 2015; Dirks *et al.*, 2015.

⁷ Henry-Gambier *et al.*, 2007; Kacki *et al.*, 2020.

⁸ Jaubert *et al.*, 2016. I just mention for memory the traces that *Homo naledi* would have left on the walls of Dinaledi Chamber. Their study has just begun and, if they are indeed anthropic traces, nothing

painted on floors and parishes, by Neanderthal⁹ and *Homo sapiens*, non-figurative and figurative. This is what will concern us here.

Problematic

For *Homo sapiens* and Neanderthal, the cave is a place of adventure. With grease lamp or torch, humans ventured deep into the galleries to decorate the walls. We imagine prehistoric artists working comfortably by the light of fire, after a long journey in the galleries. But you have to take into account all the logistics necessary to venture into this constrained space from which you had to be able to get out.

We know, for example, that they took food, and probably also something to drink, on their underground expeditions. It is hard to imagine, indeed, the artists of Lascaux going out for the lunch break! In this cavity, the excavations and work have brought to light the remains of one hundred and eighteen reindeer corresponding to at least fourteen individuals, including six young ones, plus the remains belonging to two deer, a young wild boar and a horse¹⁰. In the cave of Villars (Dordogne), it is the haunches of a young swine that the artists have shared¹¹. In the “Chapelle de la Lionne” in the Trois-Frères cave (Ariège), the Magdalenians cooked bison meat¹², and in the “Couloir du Faisan”, two deers¹³; in the

cave of Isturitz (Pyrénées-Atlantiques), the Gravettians feasted on mammoth flesh¹⁴. Bone remains show that the Gravettians and Solutreans also ate in the cave of Ardalès¹⁵. It could also happen that a bivouac was set up for a few days in a corner of the rooms or galleries, such as at Portel (Ariège), 50 or 120 m underground¹⁶ or at Trois-Frères¹⁷. At Fontanet (Ariège), the Magdalenians, who came between the end of spring and the beginning of August, would even have brought armfuls of grass, “probably to constitute a litter”¹⁸. Artists have even built up reserves of ochre or manganese, as in Cougnac (Lot), Sinhikole (Basque Country), Tito Bustillo (Spain), Les Trois-Frères and Lascaux¹⁹. These reserves constitute proof of a certain organization of the artists, who thus had at their disposal large quantities of colouring matter, without it always being necessary to come out of the cave to collect it. But they can also constitute residues of matter transported there for a specific use and then abandoned, like the small pile of charcoal used for the drawing of a horse, in the “Galerie du Megacéros” of Chauvet²⁰.

Of course, the most important question remains that of lighting. Recent experiments have shown that the lighting that prehistoric men had was much less clear than that which we have today with our electric lamps. It was more orange,

indicates that they were traced by this curious Hominine; other humanities were able to browse the galleries (Berger *et al.*, 2023b).

⁹ I am only mentioning here the current controversy over the graphic activity of Neanderthals in the caves: if it is now proven that he was able to engrave or paint abstract motifs (Gorham's cave, Gibraltar, Roche Cotard I in Indre-et-Loire), Trinidad de Ardalès (Spain), in other sites dating and attributions are still questionable. For the moment, no convincing observation allows us to conclude that our cousin was also able to reproduce human or animal figures. See Rodriguez-Vidal *et al.*, 2014, Marquet *et al.*, 2023; Pitarch Martí *et al.*, 2021; White *et al.*, 2020.

¹⁰ Bouchud, 1979.

¹¹ Delluc, Delluc, 2016, p. 108.

¹² Bégouën *et al.*, 2014, p. 106.

¹³ Bégouën *et al.*, 2014, p. 141.

¹⁴ Villaluenga Martínez A. *et al.*, 2022, p. 94-95.

¹⁵ Ramos-Muñoz *et al.*, 2022.

¹⁶ Baillis, 1997, p. 229.

¹⁷ Bégouën, Fritz *et al.*, 2009, p. 235-236.

¹⁸ Clottes, Rouzard, Wahl, 1984, p. 434.

¹⁹ Lorblanchet 2018, p. 259; Garate, Bourrillon, 2017, p. 227; Balbín Behrmann *et al.*, 2002, p. 574; 2003, p. 95; Bégouën *et al.*, 2014, p. 173; Glory, 2008, p. 68. The manganese reserve of Lascaux, with a quantity of 10 dm³ of black powder, would, according to André Glory (*ibid.*), have made it possible to “remake another Lascaux!”.

²⁰ Clottes, Geneste, 2007, p. 372.

visibility was reduced²¹. Three types of lighting were used: the torch, the lamp and the hearth.

The torch, by its greater extent (it can illuminate over thirty meters²²), although it partially dazzles its wearer, facilitates underground progress. However, it is impractical for prolonged station work; its lifespan is limited and it must be revived regularly. The lamp, of less range (about five meters), is dangerous for exploration in unexplored galleries, because the lamp creates a cast shadow which prevents the ground from being seen correctly. On the other hand, it is suitable for stationary work, provided that someone holds it so that the artist is not embarrassed by the shadow cast by his own arm; easily rechargeable, it has a greater autonomy²³. Large hearths make it possible to envisage a large space of walls²⁴, but it is necessary to carry underground a large quantity of wood, which imposes there also a certain organization. Lamps and torches are thus complementary. It is therefore highly probable that the artists who went underground had both: the torch to move around²⁵, the lamp to work. Moreover, as we have just mentioned, there must be at least two people: the luminaire holder and the artist. This puts into perspective all the romantic ideas about the isolated explorer who braved danger. One thing is certain: the artists were not suicidal!

Another achievement of recent research: the development of underground spaces²⁶, as well as the preparation of surfaces for drawing, whether by prior heating²⁷, scraping, smoothing or flattening of microreliefs, removal of surface clays in

order to obtain a clean support²⁸ and luminous and/or make preforms to facilitate the composition of the decorated panel²⁹. It can happen, as in the Gazel cave (Aude), that a layer of clay or pigment is spread on the wall to create a contrast effect with the engraved line³⁰. It can also happen that the artists modify the relief of the wall, as Michel Lorblanchet noted in the Cougnac cave: a drapery was broken to allow the outline of the nose of the great red *Megaloceros* to be completed³¹, another in Villars to more easily draw a pseudo “ibex head”³².

All this long preamble to affirm that we are now practically sure that the representations of the decorated caves were not positioned at random from subjective visits, based on impressions born of the hazards of lighting and the dispersion of shadows. Apart from a few cavities which seem quickly decorated, with a few quickly elaborated drawings as if to date and indicate that someone has been there, most of the decorated caves seem to have benefited from a preparatory phase, during which the artist and his team carefully examined volumes and surfaces³³. It is from this learned examination that we are going to try to get a glimpse, by detailing the ways in which the artists have integrated the rocky relief into their compositions. Of course, we will not forget that these are works of art and that an important factor comes into play: what art historians call the *kairos*, that is to say (to be quick) the opportunism of the artist, who moved by his inspiration will go beyond the initial intention and create an original work. This is unattainable in a scientific approach. We can only work upstream

²¹ Hoffmeister, 2017; Jouteau, 2021.

²² Pastoors, Weniger, 2011.

²³ Jouteau, 2021, p. 154-158.

²⁴ Traces remain in Cougnac (Lorblanchet, 2018, p. 453) and Chauvet (Salmon et al., 2021).

²⁵ « Wooden torches are the best lighting system for transiting wide spaces and exploring caves because they project light in all directions (illuminating the floor and the highest spaces correctly) » (Medina-Alcaide, Garate et al., 2021, p. 19).

²⁶ Pigeaud, 2018.

²⁷ Ferrier et al., 2014.

²⁸ Aujoulat et al., 2001, p. 154.

²⁹ Fritz, Tosello 2004, p. 77 et figure 10.

³⁰ Sacchi, 2023, p. 80.

³¹ Lorblanchet, 2020, p. 48.

³² Delluc, Delluc, 2016, p. 128 et 146.

³³ I will not approach here the delicate question of the rituals nor of the existence or not of an iconographic program imposed by the group or the “sponsors”.

and downstream of the artist's work, discussing his intentions and the final result. What happens between his head and his hand is none of our business.

1. Direct the gaze

In lighting, as we remember, the shadows are denser and the volumes more accentuated. This is why it is not uncommon to see artists use reliefs to create their figures, as here in Niaux (Ariège), where a hole was transformed into a stag's head, with just two antlers drawn on each side³⁴. The relief was first used to frame the figures, as here

at Lascaux. The animals run between the ceiling and the rock bench, that serves as an imaginary ground line (Fig. 1). The relief is also used for staging, like these two stalagmitic columns painted in red in Cougnac. The gravettian coloured them to make us understand that this ibex can only be contemplated without being deformed at this precise place, in a "surprisingly theatrical staging"³⁵. The relief can also attract drawings, as here in the cave of "le Sorcier", where the engravings are concentrated around a large crevasse, like the famous "sorcerer", an ithyphallic anthropomorph (Fig. 2).

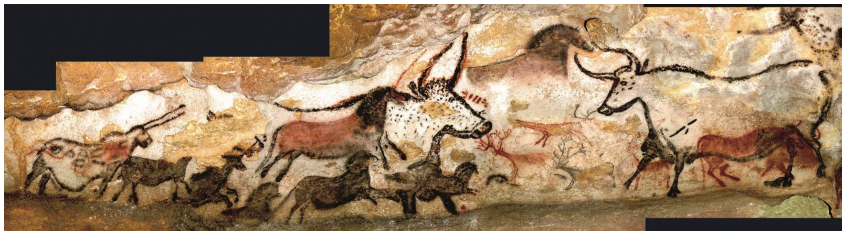


Fig. 1. Lascaux (Dordogne). The animals are positioned and framed according to the reliefs of the wall. The gaze is thus fixed and oriented. Photo Norbert Aujoulat. ©MCC/CNP.

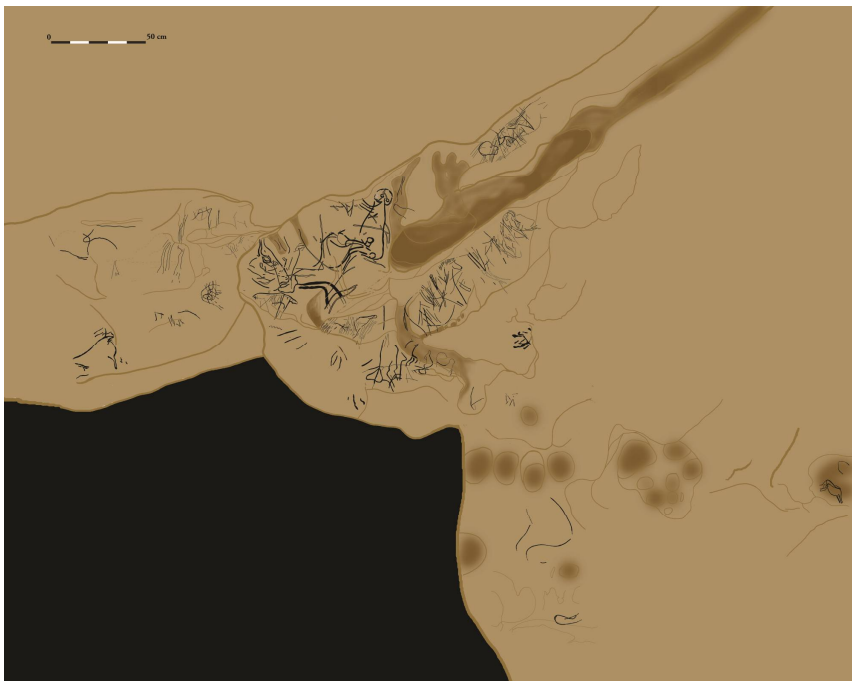


Fig. 2. Sorcerer's Cave (Dordogne). The engravings, including that of the famous ithyphallic nicknamed "the Sorcerer", seem to be concentrated around a large concavity. Drawing research team. DAO Romain Pigeaud.

³⁴ Clottes, 2010, p. 152 et figure 142.

³⁵ Lorblanchet, 2018, p. 304.

2. Emphasize or express reliefs

Cracks and crevices, from which water has sometimes flowed, appear under the lamp like « mouths of shadows », following Victor Hugo's poem³⁶. Animals seem drawn to them, like here in Las Covalanas (Fig. 3), or come out of it, like this engraved rhinoceros of Margot Cave (Fig. 4). It also works for signs, like those lines of dots that follow cracks or rock ridges (Fig. 5).

Most often, the drawing is positioned on the volumes, in order to give them more life, this « jumping » cow springs from the wall, thanks to the exploitation of the different volumes, which makes its legs appear closer than the rest of his body (Fig. 6).



Fig. 3. Las Covalanas (Spain). These hinds seem to come out or enter a crevasse. Photo Jean Clottes.



Fig. 4. Margot Cave (Mayenne). The head of this rhinoceros was engraved at the edge of a crack in the wall, as if the animal was emerging from it. Photo Hervé Paitier (at top); drawing Philippe Thomas (at bottom).



Fig. 5. Moulin de Laguenay (Corrèze). Lines of red dots following a rocky ridge. Photo Jean-Dominique Lajoux.



Fig. 6. Lascaux (Dordogne). "Jumping cow" whose volume is accentuated by the rocky relief. Photo Norbert Aujoulat. ©MCC/CNP.

³⁶ « Ce que dit la bouche d'ombre » (*Les Contemplations*, livre VI).

3. Sketch of typology

But what makes the reputation of European cave art, that is thorough use of the reliefs through two modes of exploitation of the particularities of the wall. It has become commonplace to underline the optical illusions or the associations of shapes induced by the weak lighting of the lamps on the accidents and reliefs of the walls, what Michel Lorblanchet calls “the effect of emergence³⁷”. For Derek Hodgson and Paul Pettitt, this ability was particularly developed among Palaeolithic hunters, because it allowed them to more easily identify prey and predators hidden in the landscape³⁸. The novelty is to see to what extent artists have applied these visual principles, to the point of practically systematizing them, which obviously changes the perception of the role of the wall, as Georges Sauvet and Gilles Tosello point out:

“When the use of morphological particularities is obvious in the first degree, it may have only anecdotal value, be only a game, but when it is so tenuous and subtle as a close examination, with illuminations varied, is necessary to identify it, we must admit that

the rock wall is not just a simple “support”, but that it plays a role, and undoubtedly a primary role, in the realization of the work”³⁹.

I have proposed a classification of these uses of reliefs⁴⁰, which overlaps in part with that of Georges Sauvet and Gilles Tosello and is inspired by that proposed by Marylise Lejeune⁴¹. My classification, however, is the opposite of theirs, which starts from the wall, while mine starts from the graphic unit itself and, I postulate, from the artist’s primary intention.

First, we have an “implicit use” or “luminary”, there is the « plastic rhyme⁴² », an expression coined by the painter Pierre Soulages. There is no direct insertion of the relief in the plot. This one is content to double or imitate it⁴³. The graphic unit is glued against the relief, which serves as a graphic template; there are also imaginary ground lines, formed by the cracks or the edges of the walls directly above the representations. The shape of the wall constrained the artist here, by strongly suggesting which theme to choose for his drawing, like a graphic “pattern”. The layout follows or imitates a relief on the wall, like the head of this horse from Pech-Merle which itself imitates an animal



Fig. 7. Pech-Merle (Lot). Panel of “punctuated horses”. The head of the one on the right is inscribed in a rocky beak which already evokes the protome of an equine. Drawing Éric Le Brun. After Le Brun (2022).

³⁷ Lorblanchet, 2020, p. 85.

³⁸ Hodgson, Pettitt, 2018.

³⁹ Sauvet, Tosello, 1998, p. 57.

⁴⁰ Pigeaud, 2004.

⁴¹ Sauvet, Tosello, 1998; Lejeune, 1985.

⁴² Lorblanchet, 2018, p. 433; 2020, p. 93.

⁴³ Types 1 and 3 of Georges Sauvet and Gilles Tosello (Sauvet, Tosello, 1998, p. 60 et 73).

But, the most spectacular and what I call « revealing use » appears when the prehistoric artist integrates the relief directly into his outline⁴⁴. The examples are countless. It can be a form which imposes itself immediately, like the hollows of the walls transformed into vulvae or the rocky edges, which have become lines of the back. Let us cite the most extreme case: a rocky form evoking a female figure, on which the Gravettians only had to place two red dots to represent the areolas, in the Great Cave of Arcy-sur-Cure (Yonne)⁴⁵. There are also instances where the artist of Lascaux has made a larger composition, as here the assemblage of clay appeared to represent a turbulent stream through which a herd

of deer appears to be advancing (Fig. 8).

Sometimes the relief is so obvious that the artist adjusts it underlined by a few additions such as this rock block transformed into a sturgeon (Le Pergouset, Lot) (Fig. 9). But in some cases, they may be “discrete⁴⁶” forms, such as, at Mayenne-Sciences, the microfossil that outlines the beginning of the neck of horse n°16 (Fig. 10). This particular and accentuated form of use of reliefs means that the wall has necessarily been inspected in detail. It is excluded that the artist discovered them while drawing; the insertions in the plot are too perfect.



Fig. 8. Lascaux. Frieze of "swimming deer", where an clay on the wall suggests the possible movement of water. Photo Norbert Aujoulat. ©MCC/CNP.

⁴⁴ Type 2 of Georges Sauvet and Gilles Tosello (1998, p. 61).

⁴⁵ Baffier, Girard, 1998.

⁴⁶ Sauvet, Tosello, 1998, p. 72.



Fi

g. 9. Le Pergouset (Lot). Rock bank transformed into a fish (sturgeon?) by adding an eye and gills. Drawing Michel Lorblanchet. After Lorblanchet (2018).



Fig. 10. Mayenne-Sciences (Mayenne). The origin of the neck of this horse is formed by a microfossil (black circle on the photo at top; detail at bottom). Photos Jean-Dominique Lajoux and Romain Pigeaud.

Conclusion

The prehistoric artist has perfectly integrated the reliefs and volumes of the walls. By doing this he has somehow « domesticated » the underground space, transforming it at his convenience⁴⁷.

This “rock science”, this knowledge rather, certainly based on the experience of several underground explorations, should not, however, deceive us: let us not fall into the opposite excess, which would transform all Palaeolithic artists into managers. Remember that this is a practice (the decoration of the walls of caves) that lasted about 36,000 years, covering a geographical area from England to Siberia and from France to the extreme tip of the Iberian Peninsula. Despite certain attempts, which defend a global intention to go draw underground in order to evoke a common myth of emergence (telling the exit of Humanity from a hole in the ground)⁴⁸, there remain deep regional and cultural differences, which for us in the distant past seem homogenous, but which it is up to the prehistorian to differentiate and put in order. These tendencies that I have mentioned are not always

expressed in a refined way and are part of a cognitive baggage from which not all artists have benefited. It is in these differences that lies the possibility of an anthropology and of the updating of behaviours⁴⁹, like our colleagues are doing since many years concerning lithic technology and the work on hard animal materials. In particular, what remains to be discussed is the intuitive perception that the Palaeolithic people had of underground geology, for example the vault channels, markers of the path in the galleries, as well as the traces of the passage of water, creating suggestive volumes. How much were they looking for them? Was this one of the criteria for selecting one cavity over another? Lots of research ahead!

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⁴⁷ Pigeaud, 2018.

⁴⁸ Le Quellec, 2022.

⁴⁹ Testart, 2021.

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The “making of” La Denise fossil man (French *Massif Central*) The history of a persistent scientific forgery

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Abstract. Discovered on the southern flank of the ancient volcano called *La Denise* located near the town of Le Puy-en-Velay in the south-eastern French *Massif Central* (Aymard, 1844), “*La Denise* fossil man” is a little-known object today but was of a major interest at the time of the emergence of the prehistoric discipline. As soon as these human remains came to the light, they triggered a controversy over their authenticity and their age. This controversy has continued for over a century, until the recent age of these bones was established in 1969 (Heintz & Oakley, 1969), reinforcing doubts on a fake.

In terms of current thinking on scientific knowledge, this case study is interesting to examine the persistency of an archaeological forgery (Kaeser, 2001). More specifically, it raises the question of how and why the authenticity and the age of this discovery are justified over time. An analysis of scientific publications and archives related to these human remains will provide a clearer picture of how this controversy unfolded and worked. Our development will be chronological, outlining the basis of a biography of this object (Bonnot *et al.*, 2018). The other goal of this paper is to show how the tension between residential knowledge and cosmopolitan knowledge (Kohler, 2006) can explain the persistency of this forgery.

First, we will focus on the way in which “*La Denise* fossil man” was defended when the high antiquity of man was not yet recognised by the scientific community. We will then take a closer look at the uncertainties surrounding this discovery which has been anthropologically interpreted by various ways. Finally, we will expose how this object ended up on the margins of the history of the prehistoric discipline. Looking at these human remains through the prism of the question of fakes and authenticity in prehistory (Cohen, 1999) will enable us to question the value of this find. *La Denise* forgery is one of the first case of a fake fossil man, preceding those of Moulin-Quignon and Piltdown.

Keywords: “*La Denise* Fossil Man” – Velay – Forgery – Controversy – Biography of object – Residential and Cosmopolitan Knowledge.

“Was it the proud full sail of his great verse,
Bound for the prize of (all too precious) you,
That did my ripe thoughts in my brain inhearse,
Making their tombe the wombe wherein they grew?”

William Shakespeare, *Sonnet 86*, 1609

Introduction: The fallacy of truth



Fig. 1. L'âge de la pierre taillée, La Denise en éruption, 1874, Gustave Richond, © Musée Crozatier, Luc Olivier. Data base POP: <https://www.pop.culture.gouv.fr/notice/joconde/01160005331>

Today, a visit to the Crozatier Museum will not allow you to see “*La Denise* fossil man”. Since 2010, this object has been stored in the reserves, out of sight. The bones are carefully wrapped in plastic bags and stored in a grey box on a metallic shelf in the basements of the building. On the other hand, on the ground floor of the museum, in the prehistory room inaugurating the Historical Gallery, we can find a painting of Gustave Richond entitled *L'âge de la pierre taillée, La Denise en éruption*. This canvas, painted in 1874, offers to us a prehistoric reconstruction based on scholarly observations. This work of art was produced on the advices of Auguste Aymard, the main 19th century scholar of the Velay area. It provides us information on the fact that he thought had been established and confirmed by other scholars of the time: Man would have attended to the last volcanic eruptions in the Velay area and would have been contemporary with the extinct fauna. Here, we can see a lake topped on the right by a cliff of basalt organs and in the background, we can actually see *La Denise* volcano erupting. A mammoth and a reindeer can be seen on the left, but in the foreground, we can distinguish a man, almost hidden by a tree stump and carrying a tool on his shoulder: there's no doubt about it, this is “*La Denise* man”. If art here has seized upon a major scientific

concern of the second half of the 19th century, namely the question of the great antiquity of Man, it is today the only trace that seems to have been left by “*La Denise* fossil man” in the current museography of the Crozatier Museum. But what is this object that is the starting point of our study? It consists of human bones found in 1844 in their rocky gangue, on the southern flank of *La Denise*, an ancient volcano located around two kilometres south-west of the town of Le Puy-en-Velay in the Haute-Loire French department. The three main discoveries were made in the vineyard of a cabaret owner named in all likelihood Dominique Adsklénard. The first one, called “*frontal-limonite*”, was supposedly sold or traded to Barthélemy Eyraud, a former teacher and a “natural history merchant”, who sold it to a lawyer named Pierre-Isidore Pichot-Dumazel. The second discovery was called “*bloc du musée*” (Museum block) because it was acquired by Auguste Aymard and Bertrand de Doue, members of the *Société d'agriculture, sciences, arts et commerce du Puy*, to enrich the collections of their museum. Finally, the third discovery, made up of two other blocks containing various bones, was, like the first one, bought by the lawyer Pichot-Dumazel. A few other bones were also discovered *in situ* by Louis Pascal, Auguste Aymard and Paul Gervais.

But today, the absence of the human remains of *La Denise* in the permanent collections of the Crozatier Museum, and the absence of any commentary explaining the context in which Gustave Richond's painting was produced, would almost make us forget what is essential, and what we will take as our starting point: "*La Denise* fossil man" is a forgery. Visitors will be completely unaware of the forgery "hiding" in this painting, which seeks to capture the truth of the past. But after all, it would seem that "*Fingunt simul creduntque*" (Ginzburg, 2020). Indeed, although doubts were raised on its authenticity from the beginning, "*La Denise* fossil man" was recognised as a genuine scientific object and the forgery lasted for 125 years, ending with the demonstration of the recent age of these bones (Heintz & Oakley, 1969). But even after this dating, some people continued to defend this object, which we consider to be one of those "Senseless signs of History" (Gould, 1982).

Why and how did this forgery worked for so long, whereas the Moulin-Quignon forgery was

detected very quickly (Hurel et al., 2016) and the Piltdown hoax only after forty years (Weiner, Oakley & Le Gros Clark, 1953)? We will propose a chronological approach and invoke the concepts of residential and cosmopolitan knowledge. In the first part, we will take a look at the period from the discovery of the bones in 1844 to the death of Auguste Aymard in 1889, outlining the way in which this object finally gained consensus in the scientific community. Then, in the second part, starting in 1889 and ending in 1969 with the relative dating of the bones, we will see how new interpretations have maintained the credibility of this discovery. Finally, in the third part, which will explore the period from 1969 to 2024, we will explain how this object has gradually been relegated to the dustbin of history, even if some individuals have remained attached to it locally. Through this chronological development, we will discuss the evolution of this object as well as the dichotomy between residential and cosmopolitan knowledge, before concluding by addressing the deeper meaning of this forgery.

Method



Fig. 2: Attempting to make a "Fossil Man" from rocks from "*La Denise*" site, plaster and bones, 2022, © Edgar Lhoste

The purpose of this short methodological section is simply to remind to the reader the two main aspects of historical work, namely the development of a corpus of sources and its analysis.

During my researches, I collected as many publications as possible that mentioned the

human remains of *La Denise*. In order to carry out this work, I drew on several existing bibliographies (e.g., Bout, 1946), which I supplemented with research on the Internet (Gallica, Google Books, Persée, etc.) and in libraries (*Campus Condorcet*, *Bibliothèque nationale de France*, *Bibliothèque de la Société Géologique de France*, *Institut de*

Paléontologie Humaine). In parallel, I led research in the archives in Haute-Loire (*Archives départementales, Bibliothèque Municipale du Puy-en-Velay, Musée Crozatier*) and in Paris (*Bibliothèque centrale du Muséum national d'Histoire naturelle, Bibliothèque du bâtiment de paléontologie, Bibliothèque de l'Institut de France*). I also had access to digitised archives (*Musée des Confluences, Tolosana*, private archives, University of Edinburgh Library Heritage Collections).

My analysis was initially inspired by the biography of object. According to me, the finest example of such an approach is *Bones and Ochre: The curious after life of the Red Lady of Paviland* (Sommer, 2007). I then wanted to test the relevance of the concepts of residential and

cosmopolitan knowledge developed by the historians of science Robert Kohler and Jeremy Vetter (Vetter, 2011). To sum up very briefly, residential knowledge “is acquired by intimate experience of the sort that comes from living in a place, and may be true only for the present or only in that place”. It is particular and immediate. By contrast, cosmopolitan knowledge “is acquired anywhere there are books and libraries, and is presumed to be true everywhere”. It is presumed to be true everywhere, and is intended to be global and theoretical (Kohler, 2006). These authors have insisted above all on the fact that “residential” are indispensable to the “cosmopolitans”, seeking to take into account the work of both and not just scientists’ authority, a position that we will discuss in the light of our case study.

1844-1889: Defending a new scientific object: the fossil man



Fig. 3. Photograph showing the museum block, Charles Lyell Notebook 40, Folio 69, 1859 (?), Henri Malègue (?). University of Edinburgh Library Heritage Collections: <https://libraryblogs.is.ed.ac.uk/lyell/2023/03/>

In 1844, at the time of the discovery of *La Denise*, the high antiquity of Man was not recognised by the scientific community, despite the discoveries of human bones associated with extinct fauna

made by the pharmacist Paul Tournal in the Gard (1830) and by the doctor Philippe Charles Schmerling in Belgium (1833). The discovery made by the “scholars of *Le Puy*” first circulated in

the academic world through papers presented by Auguste Aymard to the *Société géologique de France*. He had great difficulties in silencing rumours of fraud, but nevertheless succeeded to obtain recognition of the authenticity of the discovery by some famous scientists, including Isidore Geoffroy Saint Hilaire, Charles-Léopold Laurillard, Jules Pictet, Paul Gervais, Henri Lecoq, Jean-Baptiste Croizet and Auguste Pomel.

In 1855, the Scientific Congress of France provided an opportunity for local scholars as Aymard, Pichot-Dumazel, Robert to discuss the authenticity and the age of these human remains directly in the field, although these issues were not fixed at the end of this scientific gathering. On the other hand, the arrival of the writer George Sand in June 1859, of Edmond Hébert, professor of geology at Sorbonne university, and finally of the British geologist Charles Lyell in August of the same year boosted the reputation of the "scholars of *Le Puy*" and their "fossil man", which after being forgotten for a few years was back in the debates. Although Charles Lyell officially ruled out the possibility of a fraud, he did not consider "*La Denise* fossil man" to be a proof of the coexistence of Man with extinct fauna, and even less of the fact that Man had witnessed the last eruptions of the volcanoes of the Massif Central, arguing alongside Edmond Hébert in favour of a reworked geological formation (Lyell, 1859), a fact which the "scholars of *Le Puy*" did not accept.

One of the most famous photographs of prehistoric archaeology is the one showing a worker pointing the location of an *in-situ* stone axe in a stratigraphic sequence of a quarry at Abbeville in northern France. The photograph was taken by Charles Pinsard, a civil engineer, at the request of the British geologists Joseph Prestwich and John Evans. When Charles Lyell left for Scotland in September 1859 to attend the 29th meeting of the British Association for the Advancement of Science, he took Charles Pinsard's photograph with him, as well as a photograph of the Museum block from *La Denise*. The latter was probably taken by the engineer Henri Malègue, who had already taken photographs of "*La Denise* fossil man" (Robert, 1863). This photograph, probably produced by the "residents" and passed on to the "cosmopolitans", made it possible to objectify the discovery, as in the case of Abbeville, emphasising on the

importance of the geological context represented by the rock matrix. The "scholars of *Le Puy*" were not only the holders of residential knowledge, as witnessed their library, museum and scholarly relationships that brought them closer to the cosmopolitan world. But above all, they were first of all excellent guides for "foreign" visitors to their "country", who, far from being solely occupied by books and collections, have acquired residential knowledge by exploring the field with them.

The extraordinary meeting of the *Société géologique de France* in 1869 was an opportunity for the scientific community to recognise the authenticity of the "*frontal-limonite*" and the Museum block. Although the human remains from *La Denise* were initially considered to belong to the "Caucasian race", an article published by the doctor Henri-Emile Sauvage (1872) completely changed their anthropological interpretation, considering them to belong to "the dolichocephalic palaeontological race of which the Neanderthal, Eguisheim and Canstadt skulls are representatives". His proposal, inspired by Ernest-Théodore Hamy, will be spread in scientific literature, particularly through the *Crania ethnica* (Hamy and Quatrefages, 1882). During an excursion organised by the French Association for the Advancement of Science in 1876, the discovery of *La Denise* was taken for granted, so much so that it hardly seemed to interest the excursionists, who preferred to concentrate on the landscapes around *Le Puy*. It was therefore gradually that the "scholars of *Le Puy*" were able to acquire the authenticity and the antiquity of a discovery that was initially surrounded by rumours of fraud. As some letters testify, "foreign" scholars were welcomed with beer, *pâté* and ham, as well as a "*Champagne Velayaisien*" according to Georges Poulett-Scrope. Although the Velay region was of particular interest to geologists, it was ardently defended by the "scholars of *Le Puy*", for whom "*La Denise* fossil man" was a mean to promote their region and their local studies. Visits of recognised scientists were important for the local elite, who gained in notoriety. Thus, at the end of his life, Auguste Aymard became one of the "precursors" of prehistory. Its work was praised by Gabriel de Mortillet (1883) and Camille Flammarion (Du Cleuziou, 1887). We should notice that this status of "precursors" is only achieved respectively, when the discovery has been recognised.

1889-1969: Overcoming the uncertainties of physical anthropology

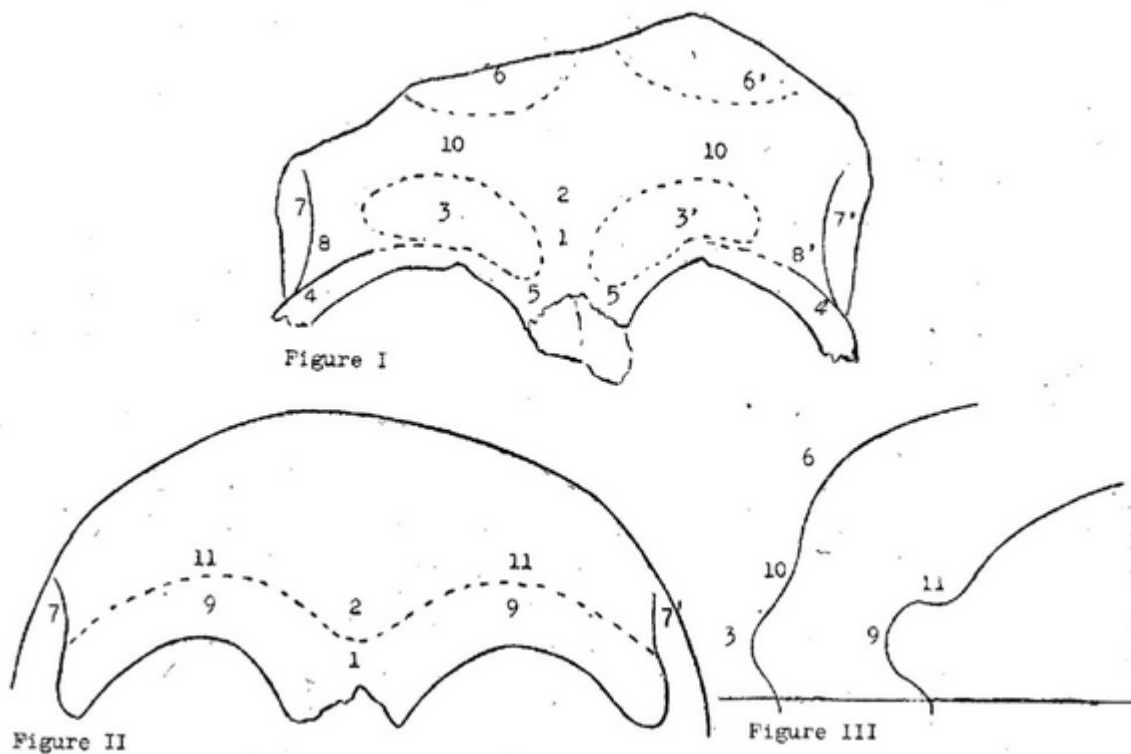


Fig. 4. « Frontal Aymard » compared to *La Chapelle-aux-Saints* frontal bone, *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, tome 183, p. 311, 1926, Lucien Mayet.
Gallica: <https://gallica.bnf.fr/ark:/12148/bpt6k3136h/f311.item>

Before becoming one of the leading specialists in human palaeontology, Marcellin Boule was first a geologist, defending his doctoral thesis on the geology of Velay in 1892. In this work, he vented the “courage of the naturalists of *Le Puy*” and recognised the authenticity and the antiquity of “*La Denise* fossil man”. Although he did not initially take part in an anthropological view, in a dissertation that won an award from the *Académie des sciences* (Boule, 1906), he adopted the doctor Sauvage's conclusions, although he did suggest that it would be necessary to lead a new study on these bones. In 1908, the doctor Bouchereau showed that the human remains from *La Denise* could not be related to the “Neanderthal or Engis type” as Henri-Emile Sauvage had claimed. But its observation did not stop a number of scientists, including Marcellin Boule, the geologist Emile Haug and Henri Breuil which will continue to refer to this

erroneous interpretation. In 1913, the veterinary Jean Pader studied *La Denise* bones and concluded that they belong to the species *Homo Sapiens*. In the meantime, Marcellin Boule had described the man of *La Chapelle-aux-Saints*, largely influencing the perception of Neanderthal man (Hurel, 2005) and in 1921, in his famous book *Les Hommes fossiles*, he did not rule out the idea of a more recent burial concerning *La Denise* discovery, finally giving up on the antiquity of these human remains.

For his part, the geologist and palaeontologist Charles Depéret from Lyon undertook new excavations on the site in 1925, carried out by the farmer and “fossil hunter” Pierre Philis accompanied by his brother-in-law Auguste Andrieux (Faure et al., 2022). Charles Depéret's letters to Pierre Philis show us how this man was useful to,

the scientist in negotiating the access to the site and underline the importance of workforce management. The results of these excavations were not perceived in the same way by the two men: Pierre Philis was disappointed because, in spite of his efforts, they had discovered nothing, whereas Charles Depéret was delighted to have clarified the geology of the site. On the other hand, Pierre Philis's letters to Claude Gaillard, Director of the Lyon Museum of Natural History, show that this peasant went to the Crozatier Museum, kept himself informed through the press and made his own judgements about his discoveries or even those of other researchers. These letters show a typically residential actor with cosmopolitan practices and who can be critical towards paleontological issues. From a residential point of view, the members of the *Société académique du Puy et de la Haute-Loire* celebrated their "fossil man", which they were proud to possess, and were happy to see their "little homeland" at the heart of new research.

Following Charles Depéret's excavations, the anthropologist Lucien Mayet re-examined the human remains of *La Denise*. While he also refused to see in these bones the remains of a "neanderthaloid", he considered them as bones of a *Homo Sapiens* comparable to "the most primitive of modern humans: the Australians" (Mayet & Chossesros, 1926). It was in particular the presence of a voluminous brow ridge on the Aymard frontal (belonging to the Museum block) that enabled him to make this suggestion. For him, it was an "archaic" characteristic in keeping with evolutionary ideas and the late age of the deposit. But for others, such as the Abbot Théophile Moreux, the zoologist Louis Vialleton and the engineers and graduates of the *Ecole Polytechnique* Louis Lafont and Georges Salet, "*La Denise* fossil man" became an argument to support their hypotheses against a

Darwinian conception of the evolution. The human remains from *La Denise* were then considered to be the oldest representatives of *Homo Sapiens* in France. Like the discovery of Piltdown Man, the remains of *La Denise* became major evidence for the defenders of the existence of *Homo Sapiens* at a very early period, considered to predate the Neanderthals, who were seen as a "degenerate branch". This prefigured the presapiens theory, which was defended in particular by the anthropologist Henri-Victor Vallois. Despite his positions, when Vallois was in charge of the third edition of Marcellin Boule's book in 1946, he still mentioned the idea of a burial site, but explicitly added that of fraud, also mentioning the misinterpretations made by Charles Depéret, who was at odds with Marcellin Boule. Although the anthropologist was very precautious about the discovery of *La Denise*, he did participate in the supervision of a DEA thesis made by a student named Renée Gabis, who studied the morphology of the radius, ulna and iliac bone of *La Denise*. She concluded that these were the bones of a "modern man" and "of the present-day white race" with no "australoid" characteristic as Pierre Teilhard de Chardin had already stated in a letter in 1948.

To mark the centenary of the discovery, the geologist Pierre Bout published a long article in which he reviewed the history of *La Denise* human remains, defending their authenticity, their antiquity and proposing a new geological interpretation of the deposit by invoking the role played by the periglacial phenomenon of solifluction (Bout, 1946). This work of synthesis illustrates perfectly how "residents" are attached to what they consider to be an important discovery. With this "anniversary paper", the author wished to commemorate and rehabilitate it.

1969-2023: Relegating “*La Denise* fossil man” to the History margins



FIGURE 1
Crâne et vertèbre de l'homme de la Denise découvert en 1844 par Auguste Aymard. Musée Crozatier, le Puy-en-Velay.

Fig. 5. Photograph illustrating a book chapter written by Nathalie Richard entitled « Les sociétés savantes & la question de l'antiquité de l'homme », In *Dans l'épaisseur du temps, Archéologues et géologues inventent la préhistoire*, p. 270, 2011, © Frédéric Lacombe - Musée Crozatier - Le Puy-en-Velay.

Open Edition Books: <https://books.openedition.org/mnhn/2665>

In 1969, Nicole Heintz, a researcher at the laboratory of anthropology in Paris, was in charge of writing the French section of the fossil men catalogue for the British Museum. It was in this context that she collaborated with Kenneth Oakley to carry out a relative dating of the human bones from *La Denise* using a fluorine and nitrogen dosage. Fluorine amount in the bones increases over time, while the nitrogen amount decreases. They showed that none of the *La Denise* bones were very old (Heintz & Oakley, 1969). However, this dating could not have been carried out without the help of the curator of the Crozatier Museum and his colleagues, who helped him to take the samples that were analysed and to take photographs that were useful to the researcher. On the same occasion, the "frontal-limonite" left *Le Puy* to be presented at a meeting of the *Société d'Anthropologie de Paris*. Following this announcement, Henri-Victor Vallois spoke of "the end of a myth" and even if he had formulated the presapiens

theory, he considered that "*La Denise* fossil man" should be "definitively struck off the list of Palaeolithic men of France" (Vallois, 1969).

Subsequently, several anthropologists just mentioned this discovery as marginal (Vandermeersch, 1986), a discovery which had an uncertain geological context (Hublin, 1989) and foreshadowed the presapiens theory. But others, such as Yves Coppens, still considered it to be authentic but recent, defending the rigour of Henri-Victor Vallois despite his errors (Coppens, 2009). As far as historians are concerned, this discovery has not been dealt with in any depth (and we hope that we have opened the way to approaches that allow us to understand the life of an object over the long term). It is barely mentioned by Donald Grayson (1984) and then by Goulven Laurent (1989), and in their biography of Jacques Boucher de Perthes, Claudine Cohen and Jean-Jacques Hublin completely overlook this episode in favour of the

Picard scholar, making a mistake by stating that the volcanic activity of *La Denise* "continued until very recent prehistoric times" (Cohen and Hublin, 1989). Among recent work on the history of Prehistory, those of Nathalie Richard focus solely on Auguste Aymard's difficulties to get his "Velay man" recognised by other scientists and on the fact that he did not consider it to be very old. She also made a mistake when she referred to the "flora of the site" (Richard, 1992) that Auguste Aymard used to estimate the age of the human bones, which in fact did not come from *La Denise* but from *Ceyssac* site, located three kilometres away. These small "passing" mentions and inaccuracies show us that this discovery was mentioned according to the interests of the authors, who often did not pursue their research further.

In the *Velay* area, a period of silence followed the dating verdict and the 70s and 80s saw a renewal in the practice of geology, with researchers from the University of *Clermont-Ferrand* and amateur geologists from associations such as the *Centre permanent d'Initiatives pour l'Environnement du Velay* and the *Groupe Géologique de la Haute-Loire* (CPIE, GGHL, 1987) working together. This research led to a description of the different eruptive phases of *La Denise* volcano, which consisted of the juxtaposition of Surtseyan, phreatomagmatic and Strombolian phases. From then on, the site where "*La Denise* fossil man" was discovered gradually fell into oblivion, first located above a petrol station and now above a nightclub car park.

It was also a period of great renewal in prehistorical studies in the *Haute-Loire* (Musée Crozatier, 1981). New sites were emerging, gradually erasing the memory of *La Denise*, which was no longer considered to be a genuine site. Amateurs of both prehistory and geology played an active part in the growth of new research in *Haute-Loire*, as access to cultural leisure activities became more democratic.

But if this discovery has been relegated to the background, several persons have continued to defend this "fossil man". Thus, Pierre Bout speculates that the gases emitted during the last volcanic eruption might have altered the chemistry of the human bones, thereby distorting the analysis that concluded that they were recent (Bout, 1973). The old narratives about this "affair", which had become a major episode in local history (Viscomte, 1973), were repeated in the local press when exhibitions were organised to showcase new prehistoric or geological research, seeking to bring to the centre an object rejected by the new scientific works. Some individuals will continue to defend the importance of this discovery, remaining very attached to this "fossil man" and its history, even if these positions are quite residual. Finally, in 2010, when the international event *Mammoths and Co.* was organised, the bones of *La Denise* were put into the Crozatier Museum's storages and subsequently not integrated into the new museography because of a lack of space and thus falling into oblivion.

Discussion

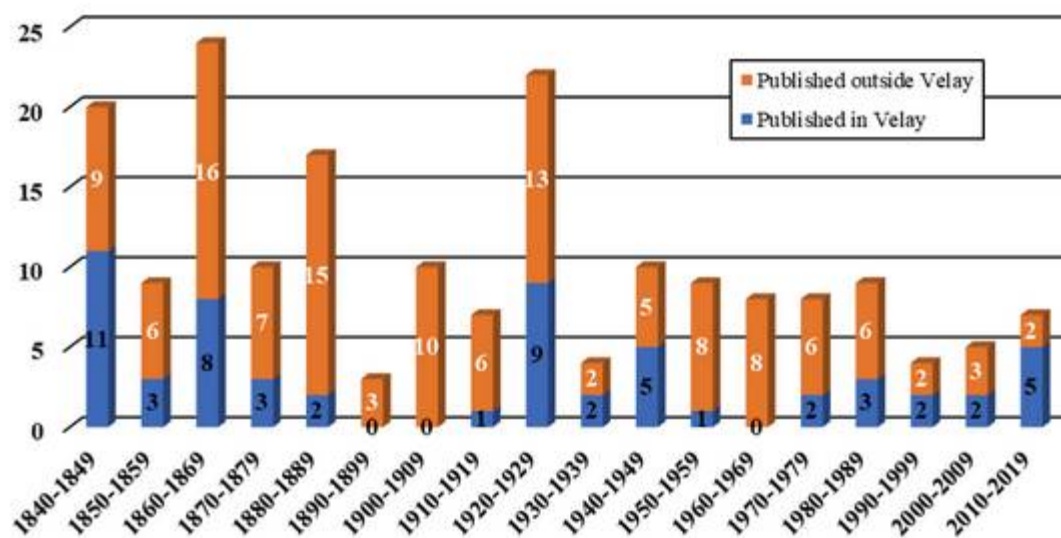


Fig. 6: Number of publications mentioning human remains from La Denise by decade (Lhoste, 2023)

This graph, plotting the number of publications mentioning *La Denise* human remains by decade, shows a general downward trend in the scientific interest in this object over time. However, the three main periods mentioned above are clearly distinguishable. Initially, the object was discussed in relation to the question of the antiquity of man, before playing a role in the rise of human palaeontology, fuelling the idea of the very ancient existence of *Homo Sapiens*, before becoming an anecdotal detail of the history of prehistory. It should be noted that in *Velay*, “*La Denise* fossil man” was not

a topic for publications after the death of Auguste Aymard, at a time when the *Société d’agriculture* was losing its dynamics. After this short period of silence, these human bones were coming back in force, especially thanks to the works of Charles Depéret, Lucien Mayet and Pierre Bout. Then, in the 1960s and until the relative dating of the remains in 1969, there was once again a period of silence surrounding these human remains, after which a certain local attachment to the discovery persisted.

	Residentials	Cosmopolitans
1844-1869	Auguste Aymard, Félix Robert	Charles Lyell, Gabriel de Mortillet
1889-1969	Pierre Philis, Pierre Bout	Charles Depéret, Marcellin Boule
1969-2023	Roger Gounot, Jacques Viscomte	Nicole Heintz, Kenneth Oakley

Fig. 5. Some of the main actors of *La Denise* controversy according to the concepts of residential and cosmopolitan knowledge

With regard to the concepts of residential and cosmopolitan knowledge, unlike Kohler and Vetter, we wish to emphasise that this dichotomy is not so marked. For example, “residents” who know the area very well may also have cosmopolitan activities, such as collection practice. They also keep abreast of the latest advances in research and are critical about other discoveries, as we saw with the example of Pierre Philis. As we pointed out in our short methodological section, according to Kohler and Vetter, “cosmopolitans” need the knowledge

of “residents”. While this finding was indeed confirmed in the course of our research, we also emphasised that the “residents” needed visits from “cosmopolitans”, whom they used to defend their position in the scholarly world. Finally, while the role of “residents” is essential, we do not want to place them at a same equality level as the “cosmopolitans”. They did not have the same authority. Above all, scientific activity is highly hierarchical, as this case study also reminds us.

Conclusion: True from false



Fig. 7. View of the town of Le Puy, drawing by Viard, printed by Senefelder, 1800, *Les Cahiers de la Haute-Loire*, 1996. Gallica: <https://gallica.bnf.fr/ark:/12148/bpt6k32056080/f267.item>

In conclusion, we can ask what such a forgery tells us about the truth. As Claudine Cohen (1999) points out, fakes can have a “founding effect” (e.g., Moulin-Quignon) but it can also give rise to false theories (e.g., Piltdown man). It is also possible to think that forgeries can generate knowledge: the carving of tools from flint makes it possible to reconstruct prehistoric gestures in a heuristic way. But our case study shows something quite different.

On this engraving, which echoes to Gustave Richond's painting, we can see *La Denise* in the background but one detail can catch our attention: a cloud of white smoke emanating from a lime or a plaster kiln, materials produced during the 19th century in *Le Puy* basin. These materials were used to fertilise agricultural land, particularly vines. “*La Denise* fossil man” was “discovered” in a vineyard, and some of the associated rocky moulds were probably made of a mixture of plaster and volcanic tuff. According to us, this forgery reveals a social order and also gives us a glimpse of the

relationship between residential and cosmopolitan knowledge. On the one hand, there were the “scholars of *Le Puy*” in search of recognition, for whom this “fossil man” was a tool of scholarly socialisation, like the fossils extracted from limestone and gypsum quarries for example. On the other hand, there was a winemaker and also a kind of innkeeper and a “fossil merchant” who probably needed money.

We will never know who was behind this fraud, but today “*La Denise* fossil man” still slumbers peacefully in the reserves of the Crozatier Museum. Nevertheless, we have retraced its eventful life as an object of science, first at the time of the emergence of prehistoric archaeology, then with the rise of human palaeontology, before it became an object of history. No one knows what the future holds for one of the first fake fossil man, and while “we must preserve fakes because they are objects of art and science” (Olivier, 2011), we must also consider them as the product of a social order.

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Prehistory and archaeology in 19th century France on the pages of *L'Écho du Monde Savant*¹

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Abstract. The journal *L'Écho du Monde Savant* was published weekly in Paris from 1834 to 1846. Established and directed, for many years, by Nérée Boubée (1806–1862), *L'Écho* aimed to « present a summary of the most important news that happened within the savant world » to both the specialized and non-specialized public and constituted a relevant facet of Boubée's professional activities, namely as a science popularizer. *L'Écho* was subdivided inside into seven sections, namely: *Discussions de la semaine*; *Cours scientifiques*; *Nouvelles*; *Bulletin archéologique*; *Prix proposés*; and *Annonces*. From January 1836 onwards, the journal split into two different weekly issues, which embraced different science fields: on Thursdays, it informed about astronomy, meteorology, physics, chemistry, mechanics, industrial economy, archaeology, and history; on Sundays, it published matters relative to zoology, physiology, botany, paleontology, mineralogy, geology, and geography. The above-mentioned section *Bulletin archéologique* was expected to be a privileged space for disseminating archaeological news and contents mixed with those on prehistory. In addition, it published information received from learned associations, like the *Société Royale des Antiquaires de France*. From number 37 onwards (August 1, 1834), *L'Écho* became the official journal of archaeological societies. As an example of themes, one may mention the fossil bones found in caves in France, which received strong attention for a long-lasting period, on many occasions compared with the situation in other countries – Paul Tournal (1805-1872), Boucher de Perthes (1788–1868), as well as William Buckland (1784–1856) undoubtedly cited. The present paper focuses on the contents related to human prehistory and archaeology published in *L'Écho*, aiming to identify their main topics and place them within the broader context of those scientific fields.

Keywords: *L'Écho du Monde Savant* – Prehistory – Archaeology – Nérée Boubée – Paul Tournal – Marcel de Serres – Société géologique de France

Comment! on ne vous a pas conté, à Perpignan, comment M. de Peyrehorade avait trouvé une idole en terre? [...] M. de Peyrehorade nous a dit que c'était une idole du temps des païens... du temps de Charlemagne, quoi! [...] Vous ne vous doutez pas de tout ce que nous allons vous montrer. Monuments phéniciens, celtiques, romains, arabes, byzantins, vous verrez tout, depuis le cèdre jusqu'à l'hysope. [...] Ah! il vous a parlé de l'idole, car c'est ainsi qu'ils appellent ma belle Vénus Tur... [...] Demain, au grand jour, vous la verrez, et vous me direz si j'ai raison de la croire un chef-d'œuvre. Parbleu! vous ne pouviez arriver plus à propos! Il y a des inscriptions que moi, pauvre ignorant, j'explique à ma manière... mais un savant de Paris!... Vous vous moquerez peut-être de mon interprétation... car j'ai fait un mémoire... moi qui vous parle... vieil antiquaire de province, je me suis lancé... Je veux faire gémir la presse..

(Prosper Mérimée, *La Vénus d'Ille*, 1837)

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Introduction

As already well established in the literature, the geological sciences in the nineteenth century experienced significant development, many advances, and conceptual and institutional developments, not only in its so-called « Golden Age » but throughout the century. The reasons for that were diverse, but the increased exploitation of mineral resources caused by the First Industrial Revolution and modern imperialism played an important role. The Geological Surveys – already identified as a « trademark » of the 19th century (Secord, 1986) –, in parallel with the construction of roads and expansion of communication systems, the implementation of urban lanes, supply or sewage networks, were responsible for excavations, cartography and inventory of natural resources (Secord, 1986; Guntau, 1988; Oldroyd, 1996). The impact of this surface and subsurface « sweeping » was felt in many ways, from the refinement of stratigraphy and the location of new mineral deposits to the discovery of traces of ancient civilizations and the ancestors of the human race, not only in European countries but also in colonial territories, like India, or former colonies, like Brazil:

« In the nineteenth century, geologists, archaeologists, Orientalists, engineers, and urban planners began digging the earth like never before. [...] Yet geologists were not alone in this pursuit of terrestrial resources and antiquity, nor was geology a singular discipline. Sometimes digging to create underground sanitation systems revealed human remains, excavation of ancient cities unearthed prehistoric fossils, or cutting channels for canals uncovered buried cities. Besides the earth, geologists, ethnologists, archaeologists, and missionaries were also digging into ancient texts and genealogies and delving into the lives and bodies of indigenous populations, their myths, legends, and pasts. One pursuit was imbricated with another in this encounter with the earth and its inhabitants and between the past, present, and future. » (Chakrabarti, 2020, p. 1).

Those scientific findings also reverberated in the arts. In literature, an example of the French case is the short story *La Vénus d'Ille*, from which we extracted the epigraph, written by Prosper Mérimée (1803-1870) – himself Inspector of Historic Monuments. He traveled throughout France on a large mission already in 1834 and also became acquainted with Paul Tournal in Narbonne (Guilaine & Alibert, 2016). Published in 1837, the tale is classified as a “fantastic tale”, narrating the story of a Roman Venus that comes into life in the backyard of the provincial archaeologist’s house who found her. The text mobilizes various elements that were part of the contemporary context: amateur archaeologists scattered across French territory, as well as objects, relics, and monuments; disputes and distances (physical and metaphoric) between Paris and the countryside, between professionals and amateurs; the construction of a noteworthy past and the search for traces – Celtic, Roman, or whatever – that would serve as proof of it and object of pride. The short story is worth reading, and it is not up to us to dwell on its presentation. However, it was quoted here just because it translates into literary form much of what appears in the news and articles published in *L'Écho du Monde Savant*, resonating with the « spirit of the time ».

Hence, the present paper focuses on the content related to prehistory and archaeology published in the journal *L'Écho du Monde Savant*² (hereafter referred to as *L'Écho*), especially in its initial years. Rather than a systematic, comprehensive survey, it intends to highlight special topics that might be of interest to the discussions involving prehistory and earth sciences, which were the central topic of the 47th INHIGEO symposium (Les Eyzies, France, September 2022).

Situating *L'Écho du Monde Savant*

L'Écho was published weekly in Paris from 1834 to 1846, established and directed, for many years, by the naturalist and geologist Nérée

²The digital version of the collection available at the *Bibliothèque nationale de France* (BnF), with complementary information, can be read and downloaded at Gallica: <https://catalogue.bnf.fr/ark:/12148/cb327622829>. Therefore, for clarity reasons, throughout the text, we will indicate only the numbers, pages, and dates of the cited data and not every electronic address of each issue. They may be easily accessed via the link above. Only the years 1834, 1835, 1836, 1844, 1845, and 1846 are available at Gallica. The missing volumes at Gallica can be found at the Biodiversity Heritage Library (<https://www.biodiversitylibrary.org/search?stype=F&searchTerm=L%27Echo#/titles>).

Boubée (1806–1862). The journal aimed at a large-scale popularization of science and technology, intending to « *present a summary of the most important news that happened within the savant world* »⁴ (*L'Écho* no. 1-2, April 10, 1834) (Fig. 1) to the public, both lay and specialist, and constituted a relevant facet of Boubée's professional activities, namely as a science popularizer, as he called himself. Simon-Suzanne-Nérée Boubée was born in Toulouse on May 12, 1806, and died on August 2, 1862, in Luchon (Fig. 2), both towns in the Meridional French region, also known as the Midi. Although he is currently little known, he experienced a certain prestige in his days. Boubée was one of the founders of the Société Géologique de France (SGF) in 1830 and a regular, active presence in the sessions, besides belonging to several other scientific associations (Figueirôa, 2018, 2021 and 2022).



Fig. 1. Opening page of the first edition of *L'Écho du Monde Savant*



Fig. 2. Bust of Nérée Boubée in his tomb in the Graveyard at Luchon

(https://ressourcespatrimoine.laregion.fr/ark:/46855/inventaire_IA31012387.fr, accessed June 22, 2023).

As already discussed in a previous paper (Figueirôa, 2021), the French intellectual context at the time, in what it specifically concerned science and technology subjects, was then a driving force for science popularization. Within that context, « *science occupied a central place in French society and culture. [...] The overriding pattern was one of science's growing prominence, both in governmental policy and in public perceptions of its importance in the life of the nation* ». (Fox, 2012, pp.1-2) A product of its time, *L'Écho du Monde Savant* appeared on April 10, 1834, and lasted until 1846, printing more than 6.000 pages over 13 years. The first issue announced the intention of publication twice a week, which happened only from January 1836 onwards (in its 3rd year). Then, the journal split into two different sections: on Thursdays, it reported on astronomy, meteorology, physics, chemistry, mechanics, indust

⁴ Hereafter, all translations from the original French texts into English are the responsibility of the author of the paper.

rial economy, archaeology, and history; on Sundays, it circulated matters relative to botany, zoology, physiology, mineralogy, geology, paleontology, and geography. Inside, *L'Écho* was subdivided into seven sections, namely: Discussions of the week; Scientific Courses; News; Archeologic Bulletin; Proposed Premiums; and Advertisements. That general structure subsisted, almost unaffected, until the end of the journal's life. In 1839, *L'Écho* went to the hands of Adrien (the viscount of) Lavalette (1813(?)–1886). By 1844, the journal had proved itself to be a great success: the subtitle became the all-embracing *Encyclopaedic Review of the Works of Scientists of all Countries in all Sciences*; it displayed more than ten different thematic sections, and collaborators included quite a lot of influential scientists, such as Auguste Bravais, Henri Becquerel, Alphonse De Candolle, Auguste Daubrée, Bory de Saint-Vincent, Johan Christian Poggendorf, among others (Figueirôa, 2021). However, it is unclear why *L'Écho* was discontinued after the last issue of 1st of January 1846. Absolutely nothing different is said on the pages that could indicate the newspaper was reaching its final days. A possible hypothesis is that the legal process in 1844, which involved the Viscount of Lavalette against Bruno Fraysse, a former employee at *L'Écho* who scammed the newspaper's accounts by a few thousand francs, had been the reason for a possible insolvency that might have brought the business to an end.

The pages of *L'Écho* allow the readers to perceive its wish to connect the « deep France » – meaning everywhere that was not Paris – with the capital, the perpetual heart. News about scientific developments, meetings, museums, learned societies, publications, and naturalists from the provinces was constant. As put by Robert Fox, « *provincial savants were an indispensable element, [...] in the gathering vogue for the collecting and study of specimens* ». (Fox, 2021, pp.62-63) A sense of native pride, particularly under Boubée's rule, may also be detected here and there. These aspects are present in and relevant to the articles on archaeology and prehistory in *L'Écho*, sometimes intermingled with academic disputes, such as those that opposed Boubée and Paul Tournal (1805–1872), mentioned further in this paper.

News and articles on prehistory and archaeology

As referred to above, *L'Écho* published the section Bulletin Archéologique, which was thought to be a privileged space for disseminating archaeological news and contents mixed with those on prehistory. Why did the journal include these topics? The reason seemed clear because, for Boubée, the chief editor, geology and prehistory were both parts of natural history:

« *All our readers have understood the philosophy that makes us mix the scientific news of L'Écho with the archaeological news. All the natural sciences are summed up in geology, which is the history of the earth, the history of its rocks, and the history of the animals and plants that populated the globe in ancient times. In a word, the world's ancient history until the appearance of men. Archaeology, that science of the first times of humanity, often throws light on geology, and it often borrows, in its turn, from the geologist the fruit of his observations; so that these two sciences, which lead to the same point in the past, the appearance of man, will serve each other as a counterproof when we try to determine the age of the human race. In the important question of the fossils of the diluvian terrain or the human remains of contemporary man and mammals, archeology and geology present an intimate connection.* » (*L'Écho*, no. 36, 05/12/1834)

Indeed, as explained by Claudine Cohen (1999, p.31), « *in the middle of the 19th century, [...] the sciences of the prehistory of man – paleontology and prehistoric archaeology — were founded as disciplines aimed at reconstructing, from anatomical and cultural remains, the very ancient history of humanity.* ». Nevertheless, the scientific community, in France and outside, was not entirely enthusiastic about accepting the notion of fossil humans. Therefore, at a time when absolute geochronologic dating was not available, stratigraphy and geology were then the required scientific fields for the discussions, as well as history, which brought ancient traditions, testimonies, and even mythologies of different cultures in support of fossil, or antediluvian human beings, as they were called. Several journals and magazines, whether

academic or not, published articles on those topics, which interested both Christians, religious and non-religious people. *L'Écho*, for instance, reproduced the text « Note de M. le docteur Holmbaumur sur des traces d'animaux fossiles, proche à la ville d'Hessberg » from the *Annales de philosophie chrétienne* (*L'Écho*, no. 79, October 2, 1835). Boubée himself, a catholic who sponsored George Cuvier's and William Buckland's ideas, believed that it was possible to bring together the earth's history as supported by geology and as told by the Bible. The articles in which he argues about the concordance between geological facts and the Genesis narrative are noteworthy.⁵

However, Boubée was critical of the strict « mosaic geology », adopting an intermediate view where science was paramount. In his manual of geology (Boubée, 1842 (1833), p.165-166), he differentiates the Flood of the Bible from the other « geological deluges », affirming that « *since the appearance of men there have positively occurred [...] deluges of which the history of peoples preserves the tradition* ». Boubée was in accordance with other relevant French scientists, for instance, Marcel de Serres (1780–1862), who already in 1829, affirmed that the historical reality of the Flood is not only indicated by physical facts but also established by the most constant and universal traditions, the memory of which has been preserved in all peoples (Stoczkowski, 1993). However, de Serres will be on the opposite side as regards human prehistory.

That was then a relevant point of debate: were there distinctions between the geological deluges and the biblical Flood? If positive, how could one demarcate the lines? It is well-known that a non-negligible group of naturalists saw no conflict between a long-lasting history of the earth and the creation stories in Genesis. Rudwick alerts that « *the 'diluvial theory' deserves to be taken seriously as an attempted explanation of some extremely puzzling physical features [...]. The 'geological deluge' was eventually recognized as having been far earlier in Earth's history than any event recorded by literate human societies. Among geologists [...], this gradual dissociation [...] was generally amicable, not acrimonious* ». Such discussions were to have a profound impact on the constitution of human paleontology and prehistory

because « *the notion of the antediluvian period is found in the first half of the 19th century at the very center of the debate which will give rise to prehistory; the notions of prehistoric and antediluvian times were then often interchangeable* ». (Stoczkowski, 1993, p.14) *L'Écho* plunged into these debates early in its history. Let us now look closely at the variety of the contents.

News about the associations

The *Bulletin archéologique* section published information received from several learned associations, like the Société Royale des Antiquaires de France or the Société de l'Histoire de France, covering the membership and the discoveries of all kinds of material historical-archeological evidence. First, in a more « bureaucratic » style, the journal registered the foundation of historical and archeological associations, praising local experts and amateurs. One reads, for example, that « *an Archaeological Society was recently founded in Montpellier; Mr. Bégé, Prefect of Hérault, has put the greatest zeal into assisting this useful association* ». (*L'Écho* nos. 1-2, April 10, 1834, p. 2) Or that « *a Literary and Archaeological Society has just been founded in Narbonne. It specifically proposes to bring together and make known the large number of monuments that are widespread in the district of Narbonne. Mr. Tournal Fils [Son] is the secretary-general. The ministry has already favored this association via the concession of superb premises, some funds, and delivery of precious books* ». (*L'Écho* nos. 1-2, April 10, 1834, p. 2) Also, we read that « *under the name of Société des Antiquaires de l'Ouest, a society has just been formed in Poitiers, for the research, conservation, and description of monuments and historical documents in the provinces between the Loire and the Dordogne* ». (*L'Écho* no. 23, September 5, 1834, p. 90) From number 37 onwards (dated August 1, 1834), *L'Écho* proudly announced it became the official journal of various archaeological societies:

« *Moreover, it is to the opinion of archaeologists that we will be indebted for the hereafter regular communications of the Société Royale des Antiquaires de France, of the Société des Antiquaires de l'Ouest à Poitiers, of the Société*

⁵ For instance, see *L'Écho du Monde Savant*, 9 (May 29, 1834) and *L'Echo du Monde Savant*, 37 (December 12, 1834).

Archéologique du Midi de la France, etc. After a special deliberation, the Société Royale des Antiquaires de France instructed its secretary to write henceforth, following each session, an analysis of the work of the Society and to send it immediately to the director of L'Écho du Monde Savant. L'Écho du Monde Savant will thus, from now, be the Official Journal of the Archaeological Societies and, consequently, the special journal of antiquarians, as it is already that of naturalists, geologists, and all friends of the physical and natural sciences. » (L'Écho no. 37, December 12, 1834, pp. 147-48)

However, the catholic Boubée did not miss opportunities to disclose his agenda. Commenting upon an article published by Adolphe Napoléon Didron (1806-1867), a specialist on Christian archaeology and iconography, in the then recently founded *Revue du Progrès Social*, Boubée regretted that the Société Royale des Antiquaires de France relucted to give priority to the study of France's Christian past, which he considered « *so eminently useful, so truly national* » and that « *would give us back what we essentially lack, an art, an artistic nationality.* » (L'Écho no. 29, October 17, 1834, p. 116)

It is worth mentioning the news about the advent of the above-mentioned Société Littéraire et Archéologique at Narbonne, founded by Paul Tournal son (1805–1872), a key figure in the establishment of the field of prehistory, which he called « *anté-histoire* ». This society in Narbonne, and Tournal, were to become very relevant in the field. Paul Tournal, from the same generation as Boubée and his countryman from the Midi region, was a pharmacist and prehistorian born and dead in Narbonne. He is frequently mentioned in *L'Écho* and occasionally collaborated with it, authoring some texts. However, several times Tournal was strongly criticized by Boubée, whether on geological or archeological interpretations, an attitude that reveals the latter's ambition to be « the » authoritative voice to speak from and about the French Midi.

Tournal undertook excavations in the caves of Bize in 1827, being one of the first to propose the contemporaneity between prehistoric humans and certain extinct animal species. He published several texts on this subject, the best known being *Considérations théoriques sur les cavernes à ossemens*, which appeared in the *Annales de*

Chimie et de Physique in 1833. Before that, however, he presented to the SGF his *Observations sur les ossemens humains et les objets de fabrication humaine confondus avec des ossemens de mammifères appartenant à des espèces perdues*, in the session of May 16, 1831 (Bulletin SGF 1830-31, pp. 195-202). The ensuing discussion was enlivened by the voices of Roulland (former navy officer and member of the SGF, with a strong interest in paleontology), Henri Paul Reboul (1763-1839), Léonce Élie de Beaumont (1798-1874), and Boubée himself, all adding complementary information and positive comments. Furthermore, Tournal was the first to put forward that only the period of recorded human history should be referred to by the term « *historical* » to be distinguished from the strict geological period, named *anté-historique* by him, which encompassed both human and geological history lacking decipherable records (Guilaine & Alibert, 2016).

Other researchers, namely Jules de Christol (1802–1861) and Marcel de Serres, would make similar discoveries. Together with the Belgian Philippe Schmerling (1791–1836), all of them present in the pages of *L'Écho*, they would be part of a group who believed they had unearthed human bones from before the Flood. Finally, in the report on the progress of geology in the year 1830, presented to the SGF on February 21, 1831, its secretary Ami Boué (1794-1881) offered a rich picture of the ongoing research on prehistory and human paleontology around Europe, in which he referred to many other scholars interested in that topic – by the way, not an infrequent one in the meetings of this French association for several years, as it is possible to read in the Proceedings of SGF meetings:

« *Did the human race precede the formation of the alluvial terrains, or is it even contemporary with the tertiary and secondary periods? Such is the question on which geologists differ greatly and which was treated last year by several scholars. [...] Messrs. Marcel de Serres, Christol, Tournal, Farine, and others believe they have found human bones and works of art in the bone caves, and they conclude from this that man existed at least during the alluvial period. On the other hand, Donati and Mr. Germar claim that there are human bones in the bone breccias of Dalmatia. Mr. Keferstein keeps a piece of glass from this same rock. MM. of Schlotheim, Count Sternberg, Schottin, and*

Count Razoumovsky described human bones in alluvial marl or ossiferous clay detritus and concluded that man suffered the same catastrophes as the lost animals with which his remains are found associated in rock cavities. Finally, one of our secretaries [probably Ami Boué] announced that he had, on two separate occasions, found human bones on the banks of the Rhine [...]. Let us, therefore, wait some time for the solution to this interesting problem. It is the wisest course. » (Bulletin SGF 1830-31, pp. 105-107)

Such ideas also attracted strong criticism from various voices from many institutions, a famous one being Jules Desnoyers at precisely the Société Géologique de France, seconded by Boubée on many occasions and others (Guilaine & Alibert, 2016; Stoczkowski, 1993). In the session of January 30, 1832, he delivered a long talk based on a catastrophist and historical approach, envisioned « to prove that these bones, and the objects of human manufacture that have been found with them, were left there after the last great cataclysms, and are not contemporaneous with the destroyed species of mammals with which they are found united. I rely first on a passage from Florus, a historian of the beginning of the second century. » (Bulletin SGF 1831-32, pp. 126-133) It is worth remarking that Desnoyers, Boubée, de Serres, Tournal, and de Christol all belonged to the SGF since its very beginning (1830), a situation that could account for the fact that the debates were held in its meetings, seen as reliable spaces for scientific discussions.

Tournal also founded the Narbonne Museum, a fact reported by *L'Écho* with vivid colors, in the founder's own words: « The creation of the museum of Narbonne will contribute powerfully to propagate, in the South, the taste of the archaeological studies, and to fix the attention of the scholars on the rich monuments which have the department of Aude and the neighboring departments. When all the archaeological wealth that Languedoc contains is known, scholars who come to study history in its most brilliant and poetic aspect will see that the materials are spread in great numbers in our valleys and our mountains. It will be enough for me, to justify what I have just said, to cite only the monuments which are within a radius of a few leagues [...] », and a long list follows. (*L'Écho* no. 54, April 10, 1835, p. 248) The Narbonne Museum became indeed a highlight of the

rich historical heritage of the town and surroundings, where also « anté-historiques » fossils and objects were carefully displayed, as those Tournal collected from Bize (Guilaine & Alibert, 2016).

Debating the cave fossil bones

L'Écho also published originals – or reproduced articles from other journals, a common practice by then (Csiszar, 2018). In *L'Écho*, the fossil bones found in caves in France received strong attention for a long-lasting period, on many occasions compared with the situation in other countries. The Christian geologist and naturalist Marcel de Serres, a professor at the University of Montpellier with whom Tournal worked (not without quandaries and difficulties), contributed to writing several texts. As an example, it is worth reproducing part of his article, published in *L'Écho* no. 29 (October 17, 1834, p. 114):

« There is, however, a point which, in the eyes of certain geologists, still needs to be cleared up; it is the coincidence of the time of the filling of the caves with that of the appearance of man. In this respect, the new caves of Lozère are of some importance, for they show that the human bones are at least of the same date as the other organic remains associated with them, if not older. What is certain is that the remains of our species are found there, not only confused with them but, moreover, buried below the layer in which we see the bones of bears of lost species. [...] The cave of Nabrigas, whose extent is about 300 meters, is the most considerable of the four. [...] As for the organic debris that we observe there, here is what results from the still somewhat superficial examination that we have made of it. First of all, the bones of bears are singularly in excess, and among the hyena remains, we have only collected a single tooth and two balls of album gæcum. But fortunately, this tooth is sufficient to characterize the species to which it belonged. »

Here, Marcel de Serres uses clear stratigraphic/geological reasoning to make his point, emphasizing that « the remains of our species are found [...] buried below the layer in which we see the bones of bears of lost species », which is a crucial issue for the debate, as it is a confirmation of the antiquity of those humans. Another example of similar stratigraphical reasoning based on the relation between animal and rock debris is

the text by the Belgian catastrophist naturalist Philippe Schmerling, published in *L'Écho* no. 75 (September 4, 1835, p. 367), reproducing his article from the *Bulletin de l'Académie des Sciences de Bruxelles*:

« *This cavern, he says, is located a quarter of a league from Villers-Sainte-Gertrude [in the province of Luxembourg] on the edge of the limestone hill on the left bank of the Aisne. [...] Many existing animal bones, such as wolf, fox, pig, horse, ox, and sheep, are scattered among the stones. All these remains have been introduced there at a recent period and do not deserve our attention. What is most interesting is the very abundant silt in this cave. [...] By breaking this layer, one notices an unpleasant odor emanating from the silt **containing fossil bones, rolled pebbles of different kinds, and angular stones. Much of these bones are engaged in the underside of the stalagmite layer; others are found without order in the silt, at different heights, arranged in the same manner as I have had occasion to observe in many localities. The first search provided me with the remains of the bear misnamed by Blumembach Ursus speloeus; teeth, jaws, vertebrae, and extremity bones of this species appear most abundant there. I also found there some remains of a wolf and a metacarpal bone of the lion's little finger, smaller than that of the Felis speloea (Goldfuss) that I collected at Goffontaine.** » (emphasis added)*

Schmerling, too, is using geological reasoning, based on the stratigraphical position of the material, together with his prior experience, to demonstrate the relevance of geology in helping solve issues about the origins of humans and their possible coexistence with ancient, extinct animals.

Concerning these inquiries, sometimes *L'Écho* was even awarded samples, an indication of its involvement in those debates and its relative standing in the contemporary French scientific scene:

« *We received from Mr. Mauduyt, curator of the Poitiers Museum, a box of bones from the Lhormaizé cave. They are remains of hyenas, ox, horses, and a large species of deer. They are generally in a good state of preservation. Their ensemble announces a prehistoric era and must thus rule out the opinion expressed of an old road network. We know that the research of the most knowledgeable archaeologists has not been able*

to find traces of the hyena as a contemporary of the human race in our region. These bones must therefore be considered fossils because, on the one hand, they lie buried in the ground, which is enough to deserve this title and, in addition, they date from a prehistoric period, which, for others, is a necessary condition in the sense of this word. » (*L'Écho* no. 40, January 2, 1835, p. 166)

The publication of scientific information was intrinsic to *L'Écho*, but Boubée, as the owner and chief editor, would almost always take the opportunity to contradict visions contrary to his own, adjoining (sometimes long) comments to the published texts. In issue no. 19 (August 8, 1834, p. 75), there is a reference to a notice from the newspaper *Le Breton*, which states:

« *There are few shell beds which deserve more careful examination by geologists than the hill entirely composed of layers of oyster shells found at Saint-Michel-en-l'Herm [Vendée]. Two perfectly preserved skeletons have just been discovered there, the bones of which are of an unusual proportion and to whose skulls the hair still adheres. Their feet are pointing towards the sea. [...] Finally, here are human skeletons found pell-mell with marine fossils in regularly stratified layers. [...] What a severe ordeal, say some, for certain geological theories, especially for those whose defenders have so clearly refused to admit fossil man into the bone caves of the South of France, which, despite the most positive assertions of MM. Tourmal, Christol, Marcel-de-Serres, etc. have always evaded the fact so simple, so obvious! Thus, declaim already all the partisans around them of the fossil man; the skeletons of Saint-Michel-en-l'Herm are a good fortune for them. »*

Nonetheless, Boubée immediately adds his criticism: « *But let them beware; before supporting themselves so strongly on this new base, that they make sure of its solidity. To what formation belong the shell beds that contain these human remains? Are they anterior to the deposits which usually contain the remains of man, or are they precisely of the same age? That is the whole point. However, according to the studies of MM. Fleuriau de Bellevue, Chaudruc de Crazannes, Desnoyers, Jouannet, these shell beds [...] are part of the land called quaternary. »* Then he concludes, leaving no room for doubts and reinforcing the side to

which he was aligned: « *The discovery of the skeletons of Saint Michel-en-Lherm will therefore not be able to modify in any way the geological theory based henceforth on so many facts, on so many precise observations. On the contrary, they will be a new proof of the need to distinguish between the flood of geologists, the mosaic flood, and other less important cataclysms, a distinction that we see with joy accepted today by scholars of the highest merit. In summary, the shellfish grounds of Saint-Michel-en-Lherm, whose most characteristic fossil is the *Ostrea edulis*, which, thank God, still populates all our coasts, are post-diluvian and of the same age as those which usually contain human remains: it is therefore not surprising that similar remains have also been found there.* »

Courses and reliquia

As said previously, a special section of *L'Écho* was dedicated to reproducing courses taught at prestigious institutions in Paris by no less prestigious scholars – an extensive collection encompassing different branches of science, whether applied or not (Figueirôa, 2021). At the end of each course, all the lessons published in the journal were collected and published in a single volume, already revised by the teachers, and sold by *L'Écho*. The list of courses is long, and among them, there was one entitled « Archaeology ». Along the years 1835 and 1836, the lessons of a specific course on archaeology taught by the respected archaeologist Désiré Raoul-Rochette (1790-1854), a reputed specialist and superintendent of antiquities at the Bibliothèque Royale, were carefully transcribed, the complete record published by *L'Écho*. A specialist in Ancient Greece and Rome, Raoul-Rochette taught indeed about it, but also about Asia, to which he attached even more importance, as follows: « *Now the learned professor of the Royal Library switches the subject of his lecture again. He noticed that all eyes have been turning, for some time now, to Asia, that noble cradle of the human race, where once appeared the white man, the eldest son of the 'homo sapiens', the man of the Caucasus. [...] He, therefore, chose, as the subject of his current course, this primitive homeland of our ancestors.* » (*L'Écho* no. 62, June 5, 1835, p. 291; emphasis added)

Finally, the pages of *L'Écho* are an authentic catalog that inventories archeological findings,

paying special attention to Roman, Celtic, and Medieval times. Tombs and the objects found inside, such as skeletons of soldiers in armor, as well as potteries, coins, inscriptions, and so forth, all were detailed reported, as in the following excerpts, both on *L'Écho* no. 17 (July 24, 1834, pp. 67-68): « *During the first days of this month, workmen, digging foundations at Lons-le-Saulnier, in the courtyard of the barracks, found, at a depth of 8 or 10 feet, a large number of rimmed tiles, piled up on a layer of Roman cement; and, among the debris, fragments of pottery; one also found in the same excavations a medal in medium bronze of the emperor Adrian, presenting on the reverse the standing emperor, raising a prostrate woman; in the middle, a vase and this legend: Restitutori Achaïae (S.C.). This medal is in excellent condition.* » Also: « *We have just recently discovered at Danville-aux-Forges (Meuse) [...] several stone tombs, 8 feet in length, which contained fairly well-preserved bones. In one of them was a saber worn by oxidation, and an earthen urn, of a very elegant firmness, ornamented with several moldings in relief of perfect execution.* »

Some findings were considered to date back to the invasion of the Kingdom of the Franks, as one made by Boucher de Perthes: « *It was recently discovered in the peat bog of Estrebeuf, near Saint-Valery (Somme) [...] a canoe [...]: this boat seems to date back to the first times of navigation, or at least to the invasion of the Normans. [...] This singular monument, acquired by Mr. Boucher de Perthes, is now deposited in the meeting place of the Société d'Emulation of Amiens, which he presides.* » (*L'Écho* no. 19, August 8, 1834, p. 76). It is worth noticing that this record preceded in more than a decade the publication of Perthes' *Antiquités celtiques et antédiluviennes*, issued in three volumes in 1849, 1857, and 1864. Another one reported findings that reinforced the Roman past: « *A farmer from Vassy (Haute-Marne) has just found in a field a large number of Roman medals, small and medium bronze, bearing the effigies of the emperors Aurelian, Tacitus, Probus, Carus, Carin, Numerian, Diocletian, Maximian, Constantine, and Constance; the most recent are therefore 1.500 years old.* » (*L'Écho* no. 23, September 5, 1834, p. 91)

Boubée himself was an enthusiast of that narrative about the Midi's historical past and of the Pyrenean mythology, frequently taking the

opportunity to praise it: « *The Pyrenean mythology alone would, at another time, have fixed the attention of every learned world; and this mythology so gracious, so poetic, the author [Mr. du Mège] has found it on our old Pyrenean marbles, popular songs, ballads, etc.* » (*L'Écho* no. 19, August 8, 1834, p. 76) Boubée even included, in one of his guides for geological traveling, entitled *Bains et courses de Luchon* (published in 1843), a note referring to ancient rock inscriptions on the outside of the town's church. Indeed, the intermingling of « natural objects », mythology, and historical artifacts was at the heart of prehistory and archaeology practices in different countries and cultural sets, as was the case, for instance, in colonial India:

« *The terrestrial excavations [of the Yamuna Canal] were complemented with the study of local myths, historical texts, and ethnological accounts. The historical antiquarianism around the medieval canal system and other archaeological remains in the Doab region were infused with geological antiquity. Consequently, the Indo-Gangetic Plain appeared as the bedrock of Indian civilization and antiquity.* » (Chakrabarti, 2020, p. 2)

More than just a collecting phenomenon, the digging into ancient monuments and times responded to efforts of building up a past, a tradition rooted in the classical times – which was not difficult due to the actual Roman solid presence in the territory now turned into France. According to Sackett (2014, p. 3), « *antiquarians insisted upon peopling the few millennia that separated the Roman occupation of France and England from the Biblical beginning of humankind, with tribes and nations mentioned in historical records. For a while, Noah's descendants or even refugees from Troy held the field. But ultimately, antiquarians settled on the Celtic-speaking Gauls and Britons who had confronted the Romans. The notion of a rich Celtic past appealed to national sentiment, especially when flavored with a bit of romantic Druidomania.* »

As expected, that enthusiasm, together with the long-lasting market involving the circulation of antiques and significant amounts of money, allowed the occurrence of all kinds of fraud. *L'Écho*, thus, worried about its reputation, also provided

transcriptions of legal processes against falsifiers, a significant challenge that, as pointed out by Cohen (1999, p. 31), « *sheds light on the historical conditions for mustering evidence as proof in these disciplines* ». As an example, some issues of *L'Écho* (no. 72, August 14, 1835, and no. 79, October 2, 1835) detailed the lengthy trial of a crook who tried to sell false antiques of a Roman villa to the towns of Nérac and Toulouse – known as the « *Affaire Nérac* ».

Final remarks

To conclude, it must be said that *L'Écho* proved a fantastic historical source, where both heated, updated scientific debates and institutional information can be found alongside detailed reports of historical and archaeological discoveries. On the one hand, the news and articles make it possible to track, within the time frame in which it was published, a series of discoveries of archaeological and historical remains, both in France and other European countries, that could even help current museological work on collections. At the same time, its pages allow us to follow the fossil finds and the constitutive debates of prehistory, too. The set of news and articles published by *L'Écho* undoubtedly contributes to mapping the movement that constructed this field in time and space, particularly in its beginnings, in the transition to the 1830s, when geology played a key role – and it still does, as shown by the current subdiscipline « *geoarchaeology* ». Since then, « *this duality of the real and metaphorical digging of the earth naturalized the past, indelibly inscribing the nineteenth-century study and imagination of antiquity in the deep history of nature, landscape, and people* ». (Chakrabarti, 2020, p. 1) On the other hand, key personalities from the discipline of prehistory are present on the pages of the journal, helping us to reconstitute the network of researchers involved in the process and revealing a hinterland that pulsed and resonated far beyond the limits of Paris. Some, however, got due recognition late, perhaps precisely because they came from the provinces. As Armand de Quatrefages clearly said in 1867 (apud Guilaine & Alibert, 2016, p. 235), « *Christol and Tournal were modest provincial scholars [...]. The geologists of the Midi were barely listened to and declared convicted of errors* ». Alas!

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Prejudice on parade: Charles R. Knight's paintings and contemporary dioramas of early hominins

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Abstract. When hominin remains were recognized as belonging to a prehistoric human species, scientists debated their placement within Darwin's metaphorical "tree of life". These scientific interpretations were publicly communicated through museum displays and their accompanying paleontological art. Charles Knight (1874-1953), the prominent paleoartist of the twentieth century, began his paleontological art career under the mentorship of Henry Fairfield Osborn (1857-1935). In 1920, Knight completed murals for the American Museum of Natural History's Hall of the Age of Man: A Neanderthal family near Le Moustier cave, Cro-Magnon artists painting mammoths in Font-de-Gaume grotto, and a Neolithic community. Knight's depictions were influenced by Osborn, a eugenics supporter, who proposed Australian Aboriginal models for Knight's Neanderthals, and lighter skin colorations for Cro-Magnons and Neolithic humans. In 1926, Knight accepted a large commission at Chicago's Field Museum. The following year, he was able to visit the paleolithic sites he had previously painted. Sponsored by anthropologist Henry Field (1902-1986), Knight and his family toured early hominin sites in France and Spain, and Knight painted background landscapes of some of these sites for Field. Renowned archaeologist Abbé Henri Breuil guided his trip, which had a lasting impact on Knight. Although Knight did not paint prehistoric humans for the Field Museum, Henry Field spearheaded the construction of dioramas featuring early humans for his museum. Both Knight's murals and the Field Museum dioramas illustrated a wide chasm between Neanderthals and Cro-Magnons, a misconception more pronounced after genomic sequencing revealed *H. neanderthalensis* and *H. sapiens* interbred. While Knight's cave art illustrations evolved, his hominin stereotypes continued. He persisted in describing Neanderthals as "squat, grotesque, savage" and Cro-Magnons as "tall, intelligent, splendid".

Keywords: Charles R. Knight – paleontological art – paleoart – Cro-Magnon – Neanderthal – American Museum of Natural History – Field Museum

1. Brief Historical Context of Early Hominin Discoveries

In 1848, the first Neanderthal skull was recovered from a Gibraltar quarry, but the fossils would not be accurately interpreted until Johann Fuhlrott (1803-1877) recognized that fossil bones found in 1856 within the Neander Valley, Germany, were from an unknown human species. In 1868, the first Cro-Magnon remains were recovered in France. Prehistoric human discoveries continued; Eugene Dubois (1858-1940) led the 1891-1892 excavation of Java Man, or *Pithecanthropus erectus* (later *Homo erectus*). The Taung Child (*Australopithecus africanus*) was discovered in South Africa in 1924.

The 1840s and 1850s Neanderthal fossils did not have the benefit of being interpreted within the theory of organic evolution by natural selection, since Darwin did not publish *On the Origin of Species by Means of Natural Selection* until 1859 (Darwin, 1859). With his 1871 book, *The Descent of Man, and Selection in Relation to Sex*, Darwin applied the natural selection mechanism to humans (Darwin, 1871). Contemporary interpretations of Neanderthal and Cro-Magnon fossils emerged as a dichotomy between subhuman and early modern human within a Darwinian "tree of life" (Darwin, 1859), and this interpretation was maintained through the 1950s (Dorey, 2019). Not only did scientists understand Neanderthals as primitive savages—and the artistic Cro-Magnons

as statuesque early modern humans—but these scientific interpretations also were publicly communicated through museum displays and paleontological art to influence public perceptions and reinforce stereotypes (Clary, 2021; Rosenberg & Clary, 2018).

2. Charles Knight, Prominent Paleoartist

Charles R. Knight (1874-1953) was internationally recognized as a paleontological artist; he

may be the premier paleoartist of the 20th century (Fig. 1). As a young boy, Knight had privileged access to the American Museum of Natural History since his father was secretary to investment banker and Museum treasurer John Pierpont Morgan (Knight, 2005, p. 3-4). Two early tragedies in 1880 influenced the trajectory of Knight's life. A rock thrown on the playground struck his right eye, resulting in severely reduced vision (Czerkas & Glut, 1982; Knight, 2005, p. 6-7). Later that year, Knight's mother succumbed to pneumonia.



Fig. 1. Charles R. Knight (1874-1953) emerged as a prominent paleontological artist of the twentieth century. In this 1899 photograph, Knight is shown sculpting a *Stegosaurus* model. (Wikimedia Commons.)

Knight's father remarried Sarah Davis. At first, Knight's stepmother encouraged his artistic interest, but later became competitive and jealous (Knight, 2005, p. 10). Still, Sarah Knight initiated her stepson's artistic training, which took him from Froebel Academy to Brooklyn Collegiate and Polytechnic Institute, to the Metropolitan Art School. At age 16, Knight was enrolled in drawing classes at the Arts Students League. His first employment as an artist was at J & R Lamb, where Knight made watercolor sketches for the stained-glass windows. Following his father's death in 1882, Knight became a freelance illustrator for magazines, including *Harper's* and *McClure's* (Knight, 2005).

2.1 An Early Interest in 'Cave Men' and Animals

At the Art Students League in the 1890s, Knight enhanced his sketches of live male models with Stone Age accoutrements – including loin cloths, spears, and a long spit with roasting ribs (Czerkas & Glut, 1982). Besides his formal art training, Knight found opportunities to learn about and draw animals. His long vacations were spent at the farm of family friends, the Hazells, as well as Peck's farm at Newton. When in New York City, Knight sketched animals at the Central Park Zoo (Knight, 2005; Czerkas & Glut, 1982). He also continued to visit the American Museum of Natural

History. His friendship with the taxidermist John Rowley (1866-1928) led to his first paleontological artistic reconstruction. A museum paleontologist, Jacob Wortman (1856-1926), asked Rowley to recommend an artist who could reconstruct an

extinct animal from its fossil remains. Rowley recommended Knight. In 1894, Knight produced his first paleontological reconstruction, *Elotherium* (Fig. 2).



Fig. 2. Knight's first paleontological reconstruction was *Elotherium*, for American Museum of Natural History paleontologist Jacob Wortman. (Wikimedia Commons)

Another pivotal event for Charles Knight occurred in 1896, when he met Henry Fairfield Osborn (1847-1935), a professor at Columbia University who became the first curator of the vertebrate paleontology department at the American Museum of Natural History before eventually becoming Museum President (Milner, 2012; Knight, 2005, p. 40). Osborn introduced Knight to his mentor, Edward Drinker Cope (1840-1897) of the dinosaur Bone Wars fame (Clary *et al.*, 2008). Cope was on his deathbed, but spent several days with Knight, during which he vividly described and sketched what he thought the extinct animals might look like when alive—and how they might behave. Knight later turned these discussions and sketches into paintings, including *Leaping Laelaps*

(now *Dryptosaurus*) and *Dimetrodon* and *Edaphosaurus*. Knight's entrance into paleoart was dramatic, and well-received.

3. Charles Knight and American Museum of Natural History's Hominin Murals

Osborn wanted Knight to paint murals with prehistoric humans for the American Museum of Natural History's Hall of the Age of Man (Czerkas & Glut, 1982). Both Knight and Osborn researched these early hominins; Knight measured Neanderthal and Cro-Magnon skulls (Milner, 2012), and contacted experts, such as the Abbé Henri Breuil (1877-1961). When Knight questioned Breuil about the clothing of prehistoric peoples, Breuil

responded that these early humans likely wore no clothes. However, Osborn insisted that Knight's figures include clothing for modesty's sake.

Osborn supported eugenics and promoted a human lineage with a 'dawn man' that arose outside of Africa. The Second International Congress of Eugenics was held 22-28 September 1921 at the American Museum of Natural History, with Osborn providing the opening address (DeSalle, 2021-2022). Osborn advocated for racial politics, and had an agenda for prehistory (Rainger, 1977). Therefore, it is not surprising that Osborn wanted Knight's murals to display two distinct types of

early hominins: the shorter, brutish Neanderthals, whose skin coloration was based on Australian aborigines, and taller, lighter skinned and artistic Cro-Magnons, which were presumably our direct ancestors (Milner, 2012; Sommer, 2010). In 1920, Knight painted the Neanderthal Flintworkers of Le Moustier Cavern, Dordogne, France (Fig. 3), and the Cro-Magnon Artists of Southern France of the Font-de-Gaume grotto, Les Eyzies-de-Tayac (Fig. 4). Knight's third mural painting featured Early Stone Age Man, a Neolithic community. He later wrote that with the Neolithic community: «*We see... human beings, much like ourselves, in the first phases of civilization* » (Knight, 1935, p. 118).



Fig. 3. In 1920, Knight painted the Neanderthal Flintworkers of Le Moustier Cavern for the American Museum of Natural History. Note the posture and skin coloration of the Neanderthals. (Image #ptc 618, American Museum of Natural History Library)

Knight's paintings were not well received by everyone. J. Howard McGregor (1872-1954) of Columbia University criticized Knight's Neanderthal. On 7 January 1921, Knight wrote to Osborn that McGregor's opinions «*were entirely gleaned from a casual look at the sketch as he had never seen the large painting. This latter is, of course, not completed and my own ideas on the subject have not yet been worked out* » (Czerkas & Glut, 1982, p. 28-29). Knight remarked in the same letter that he would «*welcome any criticism from competent judges, but the artistic problems are so great that I would appreciate your letting me puzzle them out*

myself, as these problems can only be solved by an artist who should, of course, be primarily capable to producing a work of art which only comes from long and arduous study, and naturally this line of study has not been pursued by any other than the artist » (Czerkas & Glut, 1982, p. 29). Knight's reaction to McGregor's critique is consistent with his later interactions with Field Museum scientists, with whom he had a synergistic tension during the construction of the Field Museum murals, his largest paleoart commission (Clary, 2021).



Fig. 4. Knight also painted the Cro-Magnon Artists of Southern France of the Font-de-Gaume grotto, Les Eyzies-de-Tayac in 1920 for the American Museum of Natural History. Note the skin and hair coloration of the early artists. Knight's cave painting depicts a line of mammoths, which Knight later learned was incorrect. (Image #ptc 5375, American Museum of Natural History Library)

4.. Charles Knight and Chicago's Field Museum

In 1926, Knight received a \$140,000 USD commission to produce 28 murals for the Field Museum of Natural History in Chicago¹; the staggering sum is equivalent to \$2.3 million USD today. Although Knight's Field Museum murals would not include early hominins, Knight's interest in prehistoric humans continued. He became friends with Field Museum anthropologist Henry Field (1902-1986), the great nephew of the museum's founder Marshall Field (1834-1906), and nephew of the museum Director Stanley Field (1875-1964). Henry Field sponsored Charles Knight and his family (wife Annie, daughter Lucy) to travel to paleolithic sites in Les Eyzies, France and Altamira, Spain. Knight was to produce four paintings

of the sites for Henry Field, at a commission of \$1500 USD (now equivalent to \$25,000 USD).

Knight was deeply impressed with the Cro-Magnons as the first naturalist-artists (Milner, 2012) and mural masters (Knight, 1949, p. 251). Knight later reflected: «*It was, therefore, with a feeling of deep emotion that I pondered on the tremendous changes that had taken place in the world since these drawings were traced by his firm and clever fingers* » (Knight, 1935, p. 116). In 1927, Knight was able to view in person and paint the landscapes of Le Moustier (Fig. 5), Font de Gaume (Fig. 6), and Cap Blanc; he later produced the Swiss Lake Dwellers in 1929, which were «*taken directly from the small models in Zurich* » (Knight to Henry Field; Henry Field Correspondence, 9 December 1929)².

¹ The Field Museum in Chicago has existed under several different names. Founded as the Columbian Museum of Chicago, it is referenced as the Field Museum of Natural History here since this was its official name when Knight's commission was active.

² All quoted material between Charles Knight and Henry Field are from the Field Museum's archives unless otherwise noted. Archived materials examined include Henry Field Papers Prehistoric Man Correspondence 1920-1950, the Director's Papers General correspondence, and the Henry Field Near East Correspondence 1920-1950. Punctuation and emphasis included in the direct quotes are reproduced from the original documents.



Fig. 5. Henry Field sponsored Knight's visit to the European sites of prehistoric humans, and he commissioned Knight to paint small oil landscapes. This 1927 painting of Le Moustier was one of five produced for Field. (© The Field Museum, Image No. A24457_203996_Overall, Cat. No. 203996, Photographer Jamie Kelly)

Although Knight would not paint murals of Cro-Magnons or Neanderthals for the Field Museum of Natural History, he corresponded with Henry Field and offered his opinions and advice on the museum's early human exhibits. Henry Field was assembling The Hall of Man, whose dioramas he intended to show progression of prehistoric peoples, from Chelean, Acheuleen, Mousterian (including a Neanderthal skull from Le Moustier) to Aurignacian ('Old Man of Cro-Magnon'), to the Swiss Lakes Dwellers. In the 8 typed pages of the Proposed Plan for the Hall of Prehistoric Man by Henry Field 1927, Field wrote: «*The painted background at the northeast end of the hall... will show a Swiss Lake Dweller village with the water in the background and the boats setting out on a fishing trip with mountains in the background, with their*

snow-capped peaks and the horizon all lit up by that pinkish glow so characteristic of Switzerland at dawn. This will symbolize the dawn on history. » Field spared no expense. He purchased duplicate models for his exhibits from Dr. Krantz in Bonne, contracted Frederick Blaschke (c. 1881-1938) to make the hominin figures for the dioramas, and Malvina Hoffman (1865-1966) to produce sculptures of the various races of humans; Field accepted that there were more than one hundred (104) races. Interestingly, Field criticized the work of Knight's earlier nemesis, McGregor: «*Furthermore, the inaccurate reconstructions by McGregor in Stanley Field Hall detract seriously from the brilliant work of Mr. Blaschke, in Hall C, since these are bound to cause confusion in the mind of the public* » (Henry Field, 10 August 1933).



Fig. 6. Knight painted the landscape of Font De Gaume, Les Eyzies, Dordogne in 1927 for Henry Field. (© The Field Museum, Image No. A24457_203999, Cat. No. 203999, Photographer Jamie Kelly)

Throughout the construction of the Hall of Prehistoric Man, Charles Knight continued his correspondence with Henry Field. When Field wrote to Knight (7 May 1929) that «*Blaschke is here and has really done a magnificent piece of work in the entire family group of Le Moustier*», Knight cautioned Field: «*Be careful that Blaschke makes striking compositions if possible as it is not his long suit to do so—though he models the individual figures very well*» (Knight to Field, 9 December 1929). Knight and Field also shared news of contemporary anthropological discoveries. Field noted that he was «*interested in the article on the Taung skull in the Scientific American to which you called my attention*» (Field to Knight, 12 October 1929).

Field's vision for Neanderthal and Cro-Magnon reconstructions aligned with Osborn's and Knight's. In a directive to Berthold Laufer (1874-1934), Field suggested slight modifications to the Neanderthal figures including more primitive ears

for the adult male and reduction of abdominal muscles. However, he also advocated for a 'less grotesque' expression on the baby's face (Field to Laufer, 11 November 1931).

In 1929, two Neanderthal dioramas were installed in the Hall of Historical Geology at the Field Museum (Fig. 7). Field reflected: «*This was the first life-size reconstruction of prehistoric man ever made in a museum. Some months later, Madam Tussaud's in London did us the honor of attempting to copy Le Moustier*» (Field, 1953, p. 143). In 1933, the Hall of the Stone Age of the Old World opened with 8 prehistoric diorama scenes, including the lighter skinned Cro-Magnon artists of the Aurignacian Cave Art from Gargas Cave, France (Fig. 8). The exhibit highlight was the skeleton of the Magdalenian girl from the Cap Blanc Rock Shelter that was acquired by the Field Museum in 1926. In the 1970s, the Neanderthal figures were recognized as being inaccurate, including some of the figures being based on diseased human

remains. Artist Joseph Krstolich replaced the Neanderthal figures (Fig. 9), but the dioramas persisted only until 1994, when the Hall of the Stone Age of the Old World was dismantled because of

its scientific inaccuracies. However, the Magdalenian girl skeleton remains on display within the Field Museum's Griffin Halls of Evolving Planet.



Fig. 7. The Field Museum unveiled two dioramas of Neanderthals in 1929, for which Blaschke constructed the figures. Note the skin coloration, as well as the posture of the models. (© The Field Museum, Image No. CSA76895_Ac)



Fig. 8. The Field Museum unveiled additional dioramas in 1933 for the Hall of the Stone Age of the Old World. This diorama depicted a lighter skinned Cro-Magnon artist and cave art. (© The Field Museum, Image No. CSA76950c, Photographer Ron Testa)



Fig. 9. In the 1970s, Joseph Krstolich replaced the Neanderthal diorama figures because they were inaccurate. Note that the skin coloration is still dark, but the posture of the models is erect. (© The Field Museum, Image No. A102513c, Photographer Ron Testa)

5. Charles Knight's Subsequent Work on Prehistoric Humans

After Knight completed the Field Museum commission, he lost his mentor and advocate at the American Museum of Natural History. Henry Fairfield Osborn died in 1935, and Knight never received the American Museum of Natural History commissions or projects that he did when Osborn was alive. Some other commissions followed, with the Natural History Museum of Los Angeles County (1944-1946), and a final mural at the Everhart Museum of Natural History, Science and Art in Scranton, Pennsylvania. Many of Knight's artistic renditions of prehistoric humans were featured in 1930s-1940s books and magazines.

When he visited the paleolithic sites in France, Knight must have recognized that his American Museum of Natural History mural inaccurately depicted a cave decorated with a line of woolly mammoths; the original cave art featured a superimposed mammoth over a line of bison. The Cro-Magnon painting was corrected in Knight's 1942 *National Geographic* article (Cloughly & Tattersall, 2002; Knight, 1942, plate XXIII). Knight provided accurate details of the actual cave paintings in this new art, but his prehistoric humans continued as savage, dark-skinned Neanderthals and artistic,

lighter-skinned Cro-Magnons. These stereotypes had not yet been counteracted through advancing scientific knowledge. The hominin inaccuracies were perpetuated since other artists used Knight's *National Geographic* article as reference for their own art assignments (Czerkas & Glut, 1982, p. 33).

Both the illustrations and narrative in Knight's *National Geographic* article reinforced the stereotypes. Knight drew brutish Neanderthal figures with spear, bone, and rocks defending their cave. He wrote: «*Their women and a child cower in the cave behind them... These primitive men had low foreheads, thick necks, short legs, and big hands and feet*» (Knight, 1942, plate XXII). Knight further categorized Neanderthals as «*unprepossessing little fellow*» and «*tough and tenacious little savages [that] were perhaps the dominant race in Europe for many thousands of years*» (Knight, 1942, pp. 181-183). Similarly, the artistic, statuesque Cro-Magnon continued. Knight showcased light-skinned Cro-Magnons, including a red-haired female, with the artist superimposing a mammoth over the line of bison (Knight, 1942, plate XXIII). He wrote: «*The Cro-Magnons, in contrast to the Neanderthals, were a tall, long-limbed and rather spare people, much like some of our Indian tribes*» (Knight, 1942, p. 183). Knight's praise continued:

«No primitive people since their day, with the possible exception of the recent Bushmen of southern Africa and certain Australian tribes, have attempted the representation of animals with such excellent artistic results » (Knight, 1942, p. 184).

Knight's 1949 book, *Prehistoric Man: The Great Adventurer*, sustained the Neanderthal stereotype. Neanderthals were depicted as spear-carrying savages that were caught by a blizzard, and as a group taking refuge in a cave while a large feline waited to pounce from above. Knight wrote that Neanderthals were «low browed, squat, grotesque, savage, distinctly limited in his capabilities » (Knight, 1949, p. 147). Knight continued: «He was short, stocky, rugged... big-headed and clumsy... All in all, he was just what we might have expected of such an ancient creature» (Knight, 1949, p. 154).

6. Discussion

Additional data have counteracted prejudicial, stereotypical views held by Knight, Osborn, Field, and their contemporaries. The Neanderthal genome revealed that *Homo sapiens* interbred with

Neanderthals (Green *et al.*, 2010), and that interbreeding had begun 100,000 years ago (Kulhilm *et al.*, 2016). Modern scientific understanding completely reversed Knight's depiction of skin color, too. Neanderthals were lighter-skinned hominins, with some possessing red hair (Lalueza-Fox *et al.*, 2007). The Cro-Magnons who migrated northward to encounter the Neanderthals were tall and dark-skinned; multiple expansions from Africa are indicated by genetic research (Vallini *et al.*, 2022). Scientists acknowledge Knight's earlier portrayals as inaccurate. The Cro-Magnon mural (Fig. 4) was removed from display at the American Museum of Natural History (although it remains conserved in a museum repository). However, Knight's Neanderthal mural (Fig. 3) remains on display in a hallway at the museum. More recently constructed models continue to be displayed and promote the earlier misconceptions. French sculptor Elisabeth Daynes' 2013 reconstruction of the Magdalenian Girl perpetuates the Cro-Magnons as light-skinned humans (Fig. 10). The sculpture is on display at the Field Museum of Natural History, as well as Abri du Cap Blanc in Dordogne, France.



Fig. 10. The highlight of Henry Field's 1933 Hall of the Stone Age of the Old-World exhibit, the skeleton of the Magdalenian girl, remains on display in the Field Museum's Evolving Planet exhibit (left). Daynes' sculpture reconstruction depicts the woman as light-skinned (right). (Photographs by R.M. Clary)



Knight's artistic reconstructions of Neanderthals and Cro-Magnons seem logical because of contemporary interpretations and scientific understanding. Knight depicted prehistoric humans based on information that he learned from scientists, as well as his own research in preparation for his paintings. The errors include inaccurate

heights of the Neanderthals and Cro-Magnons in *Science Monthly* (Knight, 1921), and Knight continued to provide value judgments and reference "lowly Neanderthals" and the "more perfect man-type" Cro-Magnons, as well as prejudicial views toward non-Western peoples (Knight, 1935). Of Le Moustier cave, Knight wrote: «One may imagine

these primitive little fellows... eagerly scanning their limited horizon for game or possible human enemies—perhaps men of their own race, or still more to be dreaded, the tall powerful forms of the Cro-Magnon people who were later to succeed them » (Knight, 1935, p. 108)

We can consider whether Knight created paleoart according to the directives of scientists, and that his opinions emerged solely from the authorities. That scenario is contradicted, however, by Knight's interactions with the Field Museum scientists, Oliver C. Farrington (1864-1933) and Elmer S. Riggs (1869-1963). On multiple occasions, Knight challenged these scientists' critiques and even brought in his own experts to support his alternative views. The Field Museum correspondence between Knight and the Director documented many of these situations; the position of the *Zeuglodon* (now *Basilosaurus*) tail provides a particularly illuminating interaction (Clary, 2021). In the final mural resolution, Knight painted the Eocene whale's tail as requested, but not before he engaged in multiple rounds of argumentation.

With the depictions of prehistoric humans, Knight readily accepted the contemporary views on early hominins; he adopted Osborn's views on the Dawn Man. In 1949, Knight wrote: «*Some-where, perhaps in Central Asia, changes took place in our anatomical form which enabled the once lowly Neanderthal and Peking races of humanity to so tremendously advance their personalities and physical status that the truly manlike*

type as exemplified in the Cro-Magnon people at last became an actuality » (Knight, 1949, p. 158). Knight accepted the Asia origin, not the Africa one. Ironically, his comments toward modern Asians were derogatory in some of his publications (Knight, 1935). Knight claimed: «*Although the Chinese were very early seekers of petrified objects, it is evident that their activities in no way contributed to any real knowledge concerning them* » (Knight, 1935, p. 10).

Henry Field offered insight as to a possible reason for stereotypical depictions of more brutish, dark-skinned Neanderthals and artistic, light-skinned Cro-Magnons. In his biography, Field wrote: «*When completed, these two Halls [Pre-historic Man and Races of Mankind] would be the most popular, not only in the museum, but on any continent. For man is more interested in himself than anything else. The finest dramatic presentations will draw the greatest crowds for decades to come* » (Field, 1953, p. 132). Both Field and Knight promoted images of early hominins that supported the racial stereotypes of the early twentieth century. The more artistic, advanced of the prehistoric peoples, the Cro-Magnon, would reflect the Caucasians that segregated and discriminated against the formerly enslaved African peoples. Knight's murals and the Field Museum's dioramas reflect not only the contemporary scientific views, but also the cultural and societal constraints during which the art was created (Clary & Wandersee, 2011; Clary et al., 2021).

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Prehistoric archaeology in nazi Germany the role of Quaternary geologists

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Abstract. During the first half of the twentieth century, prehistoric archaeology in Germany to a large extent was undertaken by Quaternary geologists as part of their interest in changes in climate patterns and cave research. Between 1933 and 1945 funding for such scientific projects came to a considerable extent from the *Ahnenerbe*, essentially an SS institution with an ideologically tainted research agenda, which led to a boost of prehistoric archaeology in terms of public interest. Young geologists at the beginning of their career found prestigious employment. SS membership was a prerequisite for working at the *Ahnenerbe*. The paper documents contemporary correspondence and cooperation between proponents of prehistoric archaeology at the *Ahnenerbe* and mainstream Quaternary geologists at universities and geological surveys.

Keywords: Quaternary geology – prehistory – *Ahnenerbe* – national-socialism – racism – ideologically tainted research

Quaternary Geology, Prehistory and Racism

In 1936, Paul Woldstedt (1888–1973)¹, a highly respected Quaternary geologist at the Prussian Geological Survey published a paper in the *Zeitschrift für die gesamte Naturwissenschaft*², reviewing the then current main issues of Quaternary geology, thus defining the field for a non-specialist audience: Quaternary geology dealt with two central questions, *i.e.*, the causes for changes in climate patterns and the origin and evolution of mankind. To tackle these questions, it documented a stratigraphy of the Ice Age through geomorphology, soil research, sea level changes and palynology, which it correlated with human remains and artefacts.

Consequently, during the first half of the 20th century, prehistoric archaeology in Germany was largely undertaken by Quaternary geologists as part of their interest in changes in climate patterns (cf. Henniges, 2017; Seibold & Seibold, 2005) and cave research (cf. Mattes, 2020), and during the 12 years of the Nazi regime, it became especially affected by its racist ideology.

Racism and particularly antisemitism, however, had infected prehistoric archaeology already before the Nazi regime took power in Germany in January 1933 (Mahsarski, 2013). For instance, the Austrian geologist and prehistorian Oswald Menghin (1888–1973)³ gave a talk to members of the Nazi party NSDAP on the so-

¹ Woldstedt studied geology at Freiburg and Göttingen, where he obtained his doctorate degree in 1912. He then became assistant at the geographical institute of the University in Halle. In 1921, he was employed at the Prussian Geological Survey. After World War II, he became department head at the *Niedersächsisches Landesamt für Bodenforschung* in Hannover, from where he retired in 1951. In 1952, he became honorary professor at the University of Bonn (https://de.wikipedia.org/wiki/Paul_Woldstedt; accessed 6 April 2023).

² The *Zeitschrift für die gesamte Naturwissenschaft* was founded in 1935 and taken over by Nazi organizations in 1936. It was meant as the German answer to the British journal *Nature* and with an outlook more « appropriate for the German spirit ». *Nature* on the other hand was banned in November 1939 by the German Ministry of Science and Education (Hoßfeld & Olsson, 2007).

³ The Austrian Oswald Menghin studied geology in Vienna from 1906. In 1910, he obtained his doctorate degree with a prehistoric topic. Three years later, he received his *Habilitation* degree, which qualifies for a professorship. After World War I, in 1918, he became professor for prehistory at the University of Vienna. From March to June 1938, Menghin was Minister of Education, then

called « Jewish Question » already in 1923 (Urban, 2015, p. 303). After the German annexation of Austria in March 1938, Menghin was to become Minister of Education in Vienna and thus responsible for implementing the antisemitic legislation at Austrian schools and universities (Urban, 2015, p. 300–301).

The German prehistorian Lothar Zotz (1899–1967)⁴ talked on the wireless in October 1932 in an educational feature on races in prehistory as ancestors of the German people, in which he also divided humans into progressive versus primitive « races », ending in eugenic advice (Klimetzek, 2009, p. 102–103): « Specifically, Nordic blood, and with it, Nordic genetic heritage has permeated all Germans. The task of the future is to selectively breed this genetic heritage, common to us all, in a conscious choice of spouse » (Zotz in 1932, quoted after Klimetzek, 2009, p. 103).⁵

Racism in prehistory was intense enough for the *Centralverein deutscher Staatsbürger jüdischen Glaubens*⁶ to sponsor – in 1928 – a professorship for Franz Weidenreich (1873–1948)⁷ in anthropology and human races at Frankfurt University, which would counter the Nazi antisemitism with a rational, scientific concept of « races » (Hartkopf, 2020, p. 48). Whereas most of his colleagues were Neo-Lamarckians, who opted for an early subdivision and separate

evolution of human « races », Weidenreich developed the still valid « out of Africa » hypothesis based on scientific observations but also promoting an anti-racist agenda.⁸

« *We are proceeding from the expectation that Professor Weidenreich's research work, which is being carried out from a purely scientific point of view, will serve to eliminate the confusion caused by the mixing of political points of view into the race problem and to allow its treatment from a purely factual point of view* » (Max Mainzer, head of the *Centralvereins deutscher Staatsbürger jüdischen Glaubens*; quoted after Hartkopf, 2012, p. 48).⁹

Weidenreich himself noted in his book *Rasse und Körperbau* (race and body morphology; Weidenreich 1927):

« *This book is purely scientific in nature. Since it is about races, it is unfortunately necessary to emphasize such a matter of course. For some writers who deal with questions of race only pursue political purposes, which they try to substantiate better by cloaking their statements in scientific guise. Nevertheless, everything remains a trend, their conclusions are certain from the outset, and conflicting facts either remain unconsidered or*

he returned to his professorship until he was dismissed in September 1945 being considered a war criminal. In 1948, he evaded prosecution by emigrating to Argentina and became a professor in Buenos Aires. In 1956, the court case against him was dropped in Austria. He died in Argentina in November 1973 (Urban, 2015, p. 300–304; <https://geschichte.univie.ac.at/de/personen/oswald-menghin-o-univ-prof-dr>, accessed 14 March 2023).

⁴ Lothar Zotz was a soldier in World War I. Then he studied geology at the University of Freiburg i.Br., where he obtained his doctorate degree in 1924. In 1926, he became assistant at the Institute for Geology and Prehistory at Freiburg University. In 1929/30, he briefly worked as curator at the Museum for Art and Science in Hannover. In February 1930, he moved to the University of Breslau (today Wrocław, Poland). In 1933 to 1938, he worked for the *Landesamt für vorgeschichtliche Denkmalpflege* in Breslau. In 1937 he obtained his *Habilitation* degree at the University of Breslau, and in 1938 became director of the *Landesamt für Vorgeschichte* in Brandenburg. In 1939, he was appointed Professor for Prehistory at the German University in Prague, a position he lost with the end of World War II. 1946 onwards, Zotz became professor for prehistory at the University of Erlangen (https://sempub.ub.uni-heidelberg.de/proplylaeum_vitae/de/wisski/navigate/10880/view, accessed 16 March 2023; https://de.wikipedia.org/wiki/Lothar_Zotz; accessed 6 November 2017).

⁵ « [...] Gerade nordisches Blut und mit ihm nordisches Erbgut hat alle Deutschen durchsetzt. Dieses uns allen eigenes Erbgut zu pflegen und in bewusster Gattenwahl empor zu züchten ist die Aufgabe der Zukunft » (Zotz 1932 quoted after Klimetzek, 2009, p. 103).

⁶ *i.e.* national society of German citizens with Jewish faith

⁷ Franz Weidenreich studied medicine and science in Munich, Kiel, Berlin and Strasbourg and obtained a medical doctorate degree in 1899. He habilitated in Strasbourg in 1902. In 1904, he was appointed professor for anatomy. In 1918 he was dismissed by French officials due to political reasons. 1921 to 1928 he was professor of haematology at the University of Heidelberg, then moved on to the University of Frankfurt and became honorary professor of anthropology and ethnology. In 1934, he emigrated to the USA as visiting professor of anatomy at the University of Chicago. In 1935, Weidenreich emigrated to China and became visiting professor of anatomy at Beijing Union Medical College, a position he occupied until 1940. In 1940, he emigrated to the USA and became affiliated with the Museum of Natural History in New York (Strauss *et al.*, 1983).

⁸ Claudine Cohen (Paris): conference talk 2015 at INHIGEO Annual Symposium in Beijing.

⁹ « Wir gehen dabei von der Erwartung aus, dass die unter rein wissenschaftlichen Gesichtspunkten sich vollziehende Forschungsarbeit des Herrn Professor Weidenreich dazu dienen wird, die Verwirrung, die durch die Hineinmischung politischer Gesichtspunkte in das Rassenproblem gebracht wird, zu beseitigen und seine Bearbeitung unter rein sachlichen Gesichtspunkten zu bringen » (Max Mainzer; quoted after Hartkopf, 2012, p. 48).

are reinterpreted. If the authors of such writings are laymen, they also lack the basis for an independent judgment [...] It goes without saying that they are also addressing the masses with these writings, because it is not the purpose of their journalism to ascertain the truth, but to attract followers » (Weidenreich; quoted after Hartkopf, 2012, p. 49).¹⁰

In 1934, Weidenreich evaded the constant threat emanating from Nazi students at Frankfurt University by moving to the USA. One year later, he emigrated to China and conducted excavations on Peking Man, a subspecies of *Homo erectus*, at Zhoukoudian in northern China (Hansert, 2018). His institute was disbanded, and in 1935 the university of Frankfurt opened instead the institute for hereditary biology and racial hygiene, which was considerably better equipped in terms of space, finances and staff, and of course in line with Nazi ideology (Hartkopf, 2012, p. 57).

Prehistory and the SS

In 1934, Heinrich Himmler (1900–1945) founded a department on pre- and early history within the SS administration¹¹. This department was responsible for archaeological excavations and liaison with other bodies interested in prehistory such as university institutes, the Prussian Geological Survey – later renamed *Reichsamt für Bodenforschung* – and various museums. Until October 1937, the department was headed by geologist Rolf Höhne (1908–

1947)¹². The following year, he became a department director at the *Ahnenerbe* (Halle & Mahsarski, 2013a, p. 61).

The *Ahnenerbe* had been founded by Himmler in 1935 and developed from the aforementioned organization as an institution, whose task initially was to research the archaeological and cultural history of the so-called « Aryan race » in order to prove that Nordic populations had once ruled the world and had possessed superior cultures. Thus, the outcome of « research » was ideologically predetermined (Kater 1966, 1974).

Prehistory and early history were used by German national-socialists to support their nationalist and racist goals; serving as a mediator of Nazi ideologies. In popular writings, movies, propaganda, exhibitions and training events, a « blood and soil » mythology, racial theory and the « Nordic-Germanic People » were glorified with the help of archaeological finds (Klimetzek, 2009, p. 99):

« Nevertheless, we have already found a quite new result in our prehistoric ethnology: today's ethnological-geographical groups in Pomerania can be traced back with astonishing clarity to the last prehistoric Germanic settlement pattern, despite the Slavic period lying in between. This result is apparently of great value for the continued rigorous debate of folkish ethnology [Volkstum], because it proves how small the Slavic cultural power is » (GA56/9-1, letter by Hellmut Agde (1909-

¹⁰ « Dieses Buch hat rein wissenschaftlichen Charakter. Da es von Rassen handelt, ist es leider notwendig, eine solche Selbstverständlichkeit besonders zu betonen. Denn manche Schriftsteller, die sich mit Rassenfragen befassen, verfolgen dabei nur politische Zwecke, die sie dadurch besser zu fundieren suchen, dass sie ihre Ausführungen in ein wissenschaftliches Kleid hüllen. Gleichwohl bleibt aber alles Tendenz, ihre Schlussfolgerungen stehen von vornherein fest, und entgegenstehende Tatsachen bleiben entweder unberücksichtigt oder werden umgedeutet. Sind die Verfasser solcher Schriften Laien, so fehlen ihnen zudem die Grundlagen zu einem selbständigen Urteil [...] Daß sie sich mit diesen Schriften zugleich an die große Masse wenden, ist selbstverständlich, denn es ist nicht der Zweck ihrer Publizistik, die Wahrheit zu ermitteln, sondern Anhänger zu werben » (Weidenreich, quoted after Hartkopf, 2012, p. 49).

¹¹ *Rasse und Siedlungshauptamt der SS; i.e. SS Main Office for Race and Settlement.*

¹² Rolf Höhne studied geology, obtaining a doctorate degree from the University of Greifswald in 1933. Already in 1931, he had become an SS-member and a member of the Nazi party NSDAP. In February 1934, he was appointed head of department at the *Rasseamt IIIb* within the *SS-Rasse- und Siedlungshauptamt*. In March 1937, he became head of the department « Excavations » and a personal assistant to Heinrich Himmler. In February 1938, Höhne and his excavations department was transferred to the *Ahnenerbe*, where he later headed the departments for geology and mineralogy. With the beginning of World War II, he was drafted as an officer into the Waffen-SS, where in April 1941, he was promoted *SS-Obersturmbannführer*. 1941/42, he commanded a battalion of military geologists. With the end of the war, Höhne was arrested and died in the prison of Bautzen (Häusler & Willig, 2000, p. 154; Kater 1974, p. 377; https://de.wikipedia.org/wiki/Rolf_H%C3%B6hne, accessed 14 March 2023).

1940)¹³ to Wolfgang Soergel, November 25, 1937).¹⁴

Major travelling exhibitions served to popularize the concept of a « German soil » extending beyond modern national borders, thus demanding a corresponding revision of the Versailles Treaty. Consequently, prehistoric archaeology experienced a considerable boost from the Nazi elite, which contributed to a growing prestige of the subject within universities and museums (Woldstedt, 1936, p. 101):

« However, there is currently a very special situation in Germany. Prehistory has experienced a tremendous boom in recent years. German prehistory, which for decades had to fight hard for its right to exist, has now reached its goal to an extent hardly imagined before. That is certainly to be welcomed » (Woldstedt, 1936, p. 101).¹⁵

In 1938, with the restructuring of the SS Main Office for Race and Settlement, its department of karst and cave research was transferred to the *Ahnenerbe*, to be headed by Walther Steinhäuser¹⁶. The new *Ahnenerbe* department now had five sub-departments: a) general karst and cave science, b) geology of karst and general geology, c) military geology, d) prehistoric cave science, palaeontology, anthropology, and e) cave surveying, which shows the subtle connections of Quaternary geology and prehistory with racism and military issues (Kater, 1974, p. 87; Schaffler, 1991, p. 47).

Research Funding and the *Ahnenerbe*

Universities were answerable to the ministry of research, and industrial geologists were ultimately answerable to the ministry of economics or the military. Both situations guaranteed some scientific rationality even in the given totalitarian state, because the applied sciences needed to show physical results such as for instance increasing crude oil reserves in the case of contemporary petroleum geologists (Kölbl-Ebert 2018); and ultimately physical laws do not yield to ideology. The world of the *Ahnenerbe*, however, operated in accordance with different rules, because Himmler was greatly interested in esoteric practices and thus promoted « alternative » methods in institutions within his sphere of influence, but also because success of research was measured by its conformity to Nazi ideology (Kater, 1966, 1974; Kölbl-Ebert, 2017, 2018). There was, however, also significant influence of the *Ahnenerbe* on universities and museums, because between 1935 and 1945, for instance funding for research in human prehistory came to a considerable extent from the *Ahnenerbe* and thus ultimately from the SS.

In August 1937, e.g., the SS took over the excavations at the caves of Mauern in the Bavarian valley Altmühltal; the actual digging being done by – then still illegal – SS members from Austria (Kater, 1974, p. 80). The SS also funded excavations at Munzingen near Freiburg im Breisgau:

¹³ The archaeologist and prehistorian, Hellmut Agde, was a member of the Nazi party NSDAP since 1930. He obtained his doctorate degree in 1932 from the University of Halle. 1932 to 1935, he worked at the *Landesanstalt für Volkskunde* in Halle. In 1937, he joined the SS and taught at the *Hochschule für Lehrerbildung*, which Nazi ideologists had founded in Lauenburg/Pommern (today Łębork, Poland). He obtained his *Habilitation* degree in 1939, became a soldier in World War II and was killed in action one year later in France ([https://sempub.ub.uni-heidelberg.de/proplylaeum vitae/de/wisski/navigate/17396/view](https://sempub.ub.uni-heidelberg.de/proplylaeum_vitae/de/wisski/navigate/17396/view), accessed 23 March 2023).

¹⁴ « Immerhin haben wir bereits ein recht neuartiges Ergebnis in unserer Vorgeschichte-Volkskunde gefunden: die heutigen volkskundlich-geographischen Gruppen in Pommern lassen sich mit einer erstaunlichen Klarheit auf das letzte vorgeschichtliche germanische Siedlungsbild zurückführen, trotzdem die slavische [sic] Zeit dazwischenliegt. Dieses Ergebnis ist anscheinend für die in aller Härte weitergeführte Auseinandersetzung des Volkstums von grossem Wert, denn sie beweist wie gering die slavische [sic] Kulturkraft ist » (GA56/9-1, letter by Hellmut Agde to Wolfgang Soergel, November 25, 1937).

¹⁵ « Es liegt aber gegenwärtig noch eine ganz besondere Situation in Deutschland vor. In den letzten Jahren hat die *Vorgeschichte* einen ungeheuren Aufschwung erlebt. In früher kaum geahntem Umfang hat die deutsche Vorgeschichte, die jahrzehntelang schwer um ihre Daseinsberechtigung hat kämpfen müssen, jetzt ihr Ziel erreicht. Das ist gewiß außerordentlich zu begrüßen » (Woldstedt, 1936, p. 101).

¹⁶ Walther Steinhäuser (1908–1946) studied geology in Giessen, where he obtained his doctorate degree in 1936. In 1937, he found employment at the *SS Rasse- und Siedlungshauptamt* in Berlin and became head of the department of karst and cave research, founded in 1938. In 1939, he was replaced by Hans Brand. In 1940, Steinhäuser became military geologist at the *Oberkommando der Wehrmacht* in Berlin. He died of diphtheria (https://de.wikipedia.org/wiki/Walther_Steinh%C3%A4user; accessed 6 April 2023).

« Furthermore, a certain decision was made about Munzingen yesterday. The consultant at Himmler's, SS-Obersturmführer Dr Höhne was here, and together with Miss Dr Schmid¹⁷ [sic] and the SS-Standartenführer we were in the field. First of all, over the course of this winter, the area around the spring and the sediments in the pond will be examined. [...] Since the geological investigation involves much laboratory work and the field work also has to be carried out according to a uniform plan, I suggested that Miss Schmid takes care of that. The SS agrees » (GA56/472-12, letter by Georg Kraft to Wolfgang Soergel, September 22, 1937).¹⁸

The SS also provided grants for financing scientific publications. Becoming a member and having access to all these resources seemed tempting even for Rudolf Grahmann (1888–1962)¹⁹, who had a tenured job as survey geologist in Saxony.

« I gratefully accept your suggestion to have my monograph on Markkleeberg sponsored by the *Ahnenerbe*. In fact, the publication of this rich, impeccably early Riss²⁰ glacial material seems to me to be very urgent. [...] I would be very grateful, if I could soon

learn more about the organization, work, publications and the possibility of becoming a member of the *Ahnenerbe*. I would like to cooperate in all geological-prehistoric questions. Since, as a practical geologist, I have very little free time for scientific work with 51 office hours per week, a leave of absence might be considered. Will you please remember me » (GVA #3687, letter by Rudolf Grahmann to Assien Bohmers, 20 March 1940).²¹

The *Ahnenerbe* employed many young people, who were at the beginning of their career and in need of a job. But often this was not the only inducement. As can be expected in an SS institution, many if not most actually were ardent national-socialists and endorsed the underlying ideology with enthusiasm. SS membership was a prerequisite for working at the *Ahnenerbe* (Halle & Mahsarski, 2013a, p. 62).

Geology was involved as handmaiden to archaeology and prehistory. Thus, several geologists worked in leading positions at archaeological excavations sponsored by the SS even though they had little or no training in history or archaeology. Julius Andree (1889-1942)²² may serve as an example. He postulated the existence

¹⁷ Elisabeth Schmidt (1912–1994) obtained her doctorate degree in 1937 with a topic in Quaternary palaeontology from the University of Freiburg i.Br. She then worked as scientific assistant at prehistory departments of the universities in Bonn, Cologne and Freiburg, where she obtained her *Habilitation* degree in 1949 and continued to work as a prehistorian. In 1972, she became chair for prehistory at the University of Basel in Switzerland (Mohr & Vogt, 2003, p. 57).

¹⁸ « Ferner ist gestern eine gewisse Entscheidung über Munzingen gefallen. Der Referent bei Himmler, Obersturmführer Dr. Höhne, war hier, und wir sind, zusammen mit Fr. Dr. Schmid und dem Standartenführer draussen gewesen. Zunächst sollen im Laufe dieses Winters die Umgebung der Quelle und die Sedimente im Weiher untersucht werden. [...] Da die geologische Bearbeitung eine Menge Laboratoriumsarbeit in sich schliesst, und auch die Feldarbeiten nach einem einheitlichen Plane ausgeführt werden müssen, habe ich vorgeschlagen, dass Fr. Dr. Schmid das übernimmt. Die SS ist damit einverstanden » (GA56/472-12, letter by Georg Kraft to Wolfgang Soergel, 22 September 1937).

¹⁹ Rudolf Karl Grahmann studied geology in Freiburg, Halle and Leipzig, obtaining his doctorate degree in 1918. During World War I, Grahmann was first a soldier and from 1916 onwards a military geologist. 1919 to 1937, he was a geologist at the Geological Survey of Saxony in Leipzig. In 1937, he moved to the Survey offices in Freiburg. In 1947, he left for West-Germany to continue his career at the geological survey in Hannover. He then rapidly moved on to similar positions at various survey offices in Bielefeld and Koblenz. 1954 to his death in 1962, he was honorary professor for Ice-Age research at the University of Mainz (<http://gutenberg-biographics.uni-mainz.de/id/af52651e-c318-4e45-a30e-e87edab5c363>; accessed 23 February 2023).

²⁰ The second youngest glaciation in the traditional glacial classification of the Alps.

²¹ « Ihren Vorschlag, meine Monographie über Markkleeberg durch das *Ahnenerbe* fördern zu lassen, nehme ich sehr dankbar auf. In der Tat scheint mir die Veröffentlichung dieses reichen, einwandfrei frühiglazialen Fundstoffes sehr dringend. [...] Ich wäre Ihnen sehr dankbar, wenn ich von Ihnen bald Näheres über Organisation, Arbeiten, Veröffentlichungen und die Möglichkeit einer Mitgliedschaft des *Ahnenerbes* erfahren könnte. Ich würde gern in allen geologisch-vorgeschichtlichen Fragen mitarbeiten. Da ich als praktischer Geologe bei wöchentlich 51 Dienststunden nur sehr wenig freie Zeit für wissenschaftliche Tätigkeit habe, käme gegebenenfalls eine Beurlaubung in Betracht. Wollen Sie sich bitte meiner erinnern. » (GVA #3687, letter by Rudolf Grahmann to Assien Bohmers, 20 March 1940).

²² Julius Andree studied science with a focus on geology/palaeontology from 1910 to 1914, when he volunteered for military service in World War I. In 1917, he became a military geologist and obtained his doctorate degree in the same year during a leave of absence. From 1919 onwards, he worked as assistant at the geological institute in Münster. For a year and a half, he studied prehistory in Berlin, then he returned to Münster, where he obtained his *Habilitation* degree in 1924. In 1933, he was forced to give notice due to incompetence. However, he quickly found a lectureship on prehistory in Berlin. From 1935 onwards, he undertook excavations at Externsteine. In December 1938, he became affiliated with the University of Halle. In 1941, he went on

of a 250,000-year-old advanced culture at Externsteine in Germany, from which it allegedly spread, seeding cultural advancement throughout the globe, which – needless to say – was no more than national-socialist fantasy (Kater, 1974, p. 300).

Andree was a particularly shady character. In January 1933, he was dismissed from Münster university due to scientific incompetence. In 1935, he spent three months in prison, being found guilty of having levelled false accusations against employees of the Münster State Museum. The University of Halle refused to take him on, but eventually was ordered to do so by the authorities in December 1938. In Halle, Andree mainly taught racial history. In 1941, he was given leave to study Stone-Age finds in Belgium and France. At the same time, he worked for the Rosenberg Office²³, which at that time was busy stealing cultural treasures throughout the territories occupied by the German military (Eberle, 2002, p. 151, 402).

Andree was supported by Fritz Wieggers (1875–1955)²⁴, another geologist and head of the department of prehistory at the *Reichsamt für Bodenforschung* in Berlin and in 1944 appointed professor of prehistory at Göttingen University. Wieggers was an ardent Nazi, who did not hesitate to inform party officials on politically « unreliable » colleagues (Kühn & Rohrbeck, 1987, p. 32; Willig, 2008, p. 72; Röhling *et al.*, 2022).

Geologist Assien Bohmers (1912–1988)²⁵, a Dutch nationalist endorsing a pan-Germanic ideology, worked for the *Ahnenerbe* since 1937,

and became head of its prehistory department in 1939, when Höhne switched to the department of geology and mineralogy, where Himmler tasked him to prospect for gold in the river Rhein (Eickhoff, 2013; Halle & Mahsarski, 2013b, p. 136).

Another notable figure was the palynologist Rudolf Schütrumpf (1909–1986)²⁶, who since April 1938 was responsible for chemical, sedimentological and palynological investigations at the various *Ahnenerbe* excavation sites (Kater 1974).

Thus, there were the Quaternary geologists and prehistorians – mostly younger people – at the *Ahnenerbe* itself and on the other hand established Quaternary geologists and prehistorians at the universities, museums and geological surveys; on average older than the first group. For all of them, however, the *Ahnenerbe* was an important source for funds, which had implications for research interests, cooperation, methods and quality control.

Paul Woldstedt prostituted his science in his 1936 review paper, lobbying for Ice-Age research by offering Quaternary geology to the Nazi regime as an auxiliary science for racial studies and ideologically tainted prehistoric archaeology:

« At the end of the Ice Age, blond, white people appeared along the rim of the last European ice – a race of people that later gained enormous importance in the development of the world. Is their white colour

leave to investigate Stone-Age finds in Belgium and France for the Rosenberg Office. While in Paris, he died suddenly, apparently of natural causes (Eberle, 2002, p. 402).

²³ The *Amt Rosenberg* was an official body for cultural policy and surveillance within the Nazi party NSDAP, headed by Alfred Rosenberg. It was established in 1934 with offices in Berlin (cf. https://de.wikipedia.org/wiki/Amt_Rosenberg; accessed 6 April 2023).

²⁴ Fritz Wieggers studied geology in Göttingen and Halle, where he obtained his doctorate degree in 1899. 1897–1901, he worked as scientific assistant at the Technical University in Karlsruhe. He then moved to the Prussian Geological Survey in Berlin until 1939. From 1944 to 1946, when he was dismissed due to denazification, he was professor for prehistory at the University of Göttingen (<https://service.ub.ovgu.de/mbl/Biografien/1435.htm>, accessed 14 March 2023).

²⁵ Assien Bohmers, a Dutch citizen, studied geology-palaeontology at the University of Amsterdam, where he obtained his doctorate degree in 1936. From 1937 onwards, he worked for the *Ahnenerbe*. In 1939, he became head of its research department in prehistory. Apparently, around that time he was based at the University of Vienna. After World War II, he worked at the University of Groningen in the Netherlands (Halle & Mahsarski, 2013b, p. 136; Kostrhun, 2009, p. 131)

²⁶ Rudolf Schütrumpf was born in Austria and studied botany, zoology, chemistry and geology in Frankfurt a. M. (Germany) and Innsbruck (Austria). In 1936 he obtained his doctorate degree specializing in Quaternary palynological studies, and continued to work as palynologist for prehistoric excavation sites around Hamburg and in Brandenburg. In April 1938, he became head of the newly founded *Ahnenerbe*'s palynological laboratory. He was drafted into the military shortly after the beginning of World War II. In 1940, he became member of the SS and was promoted *SS-Obersturmführer* in 1942. During this time, he worked at the entomological institute of the Dachau Concentration Camp. After the war, he was interned for some time. He then worked for a museum in northern Germany. In 1958 he became head of the palynological laboratory at the institute for prehistory at the University of Cologne. There, he obtained his *Habilitation* degree in 1969. He retired in 1974 (https://de.wikipedia.org/wiki/Rudolf_Sch%C3%BCtrumpf; accessed 14 March 2023; Halle & Mahsarski, 2013a, p. 63).

related to the great glaciation? Have they, as E. von Eickstedt (in 1934) assumes, become bleached and hardened in the face of the great ice? Here, too, the answer is: Possibly – but we don't know. – » (Woldstedt, 1936, p. 94).²⁷

« It meant a tremendous advance in knowledge – and an unimagined expansion of the field of vision, when *in Germany* [...] proof was provided that man with a certain primitive culture at least *already experienced the previous Ice Age, so that the cultural development of mankind began tens of thousands of years earlier* » (Woldstedt, 1936, p. 94; his italics).²⁸

« The entire basis of our life today developed in the *Quaternary, i.e., the Ice Age and the Post-Ice Age.* [...] Thus, Ice-Age research forms the essential basis not only for *racial research*, but above all for *prehistory* that has flourished so much in recent years. It must have its firm basis in Ice-Age research. [...] where do we come from, whereto are we going? *This problem affects us particularly closely in Germany* » (Woldstedt, 1936, p. 101; his italics).²⁹

From a letter he wrote to Edith Ebers³⁰ in January 1939, his motivation becomes clear: He planned to convince politics to fund a new, specialized institute for Ice-Age research in Berlin, an endeavour for which he hoped to find support from powerful Nazi officials such as Fritz Todt³¹,

who was an acquaintance or even friend of Ebers from their common time as students in Munich:

« I must have told you last summer about my plans for an Ice-Age research institute. At that time, I had submitted my proposals to both the Ministry of Science and the Kaiser Wilhelm Society. In the case of the latter, the matter does not appear to be entirely hopeless. In any case, the matter is being seriously examined. [...] In order to carry out such a thing, it is of decisive importance today whether a few prominent personalities can be interested in it. One of the personalities primarily coming into question here would be Dr Todt. Do you think it would be possible to win him over to the plan? In my opinion, in a letter to him or, even better, in an oral discussion, one should mainly explain the following: Most building projects, especially road construction, are mainly concerned with Quaternary beds. These are of such outstanding importance that it seems necessary to set up a special research institute for this purpose. A special department of this institute could also deal with the special question of landscape design, *i.e., the fitting of the buildings into the landscape.* Would you believe that such an appeal to Dr Todt might fulfil its purpose? » (GVA #22386, letter by Paul Woldstedt to Edith Ebers, 29 January 1939).³²

²⁷ « Am Schlusse des Eiszeitalters treten in der Umrandung des letzten europäischen Eises blonde, weiße Menschen auf – eine Menschenrasse, die später in der Entwicklung der Welt eine ungeheure Bedeutung gewann. Hängt ihre weiße Farbe mit der großen Vergletscherung zusammen? Sind sie, wie E. von Eickstedt (1934) annimmt, im Angesicht des großen Eises gebleicht und abgehärtet worden? Auch hier lautet die Antwort: Möglich – aber wir wissen es nicht. – » (Woldstedt, 1936, p. 94).

²⁸ « Es bedeutete einen gewaltigen Fortschritt in der Erkenntnis [...], als *in Deutschland* [...] der Nachweis geführt wurde, daß der Mensch mit einer bestimmten primitiven Kultur zum mindesten *bereits die vorhergehende Eiszeit miterlebt* hat, daß also *die Kulturentwicklung der Menschheit um Zehntausende von Jahren früher eingesetzt hat.* » (Woldstedt, 1936, p. 94).

²⁹ « Die gesamten Grundlagen unseres heutigen Lebens haben sich im *Quartär*, d.h. der Eiszeit und Nacheiszeit, entwickelt. [...] So bildet die Eiszeitforschung die unerlässliche Grundlage nicht nur für die *Rassenforschung*, sondern vor allem für die in den letzten Jahren so sehr aufgeblühte *Vorgeschichte*. Diese muß ihre feste Basis in der Eiszeitforschung erhalten. [...] woher kommen wir, wohin gehen wir? *Dieses Problem geht uns in Deutschland ganz besonders nahe an* » (Woldstedt 1936: 101).

³⁰ Edith Ebers, née Heirich, studied geography and geology 1913 to 1919 in Heidelberg and Munich. In 1925, she obtained her doctorate degree. She was married to the artist and writer Hermann Ebers (https://de.wikipedia.org/wiki/Edith_Ebers; accessed 6 April 2023).

³¹ Fritz Todt was a building engineer with a doctorate degree (Dr. Ing.) from the Technical University of Munich. 1925 to 1933, he worked for the building industry, among others in road building. He was an NSDAP member since 1922. In July 1933 he became General Inspector for German roads. In May 1938 he founded the Organization Todt. It was used during World War II, e.g. in the construction of the West Wall, the Atlantic Wall, the construction of submarine bases on the French coast and in other German occupied territories. In December of the same year he became General Manager for the construction industry. From March 1940, as Reich Minister for Armaments and Munitions, he was in charge of the entire German war economy. At the end of July 1941, he also became General Inspector for Water and Energy. He died in a plane crash (https://de.wikipedia.org/wiki/Fritz_Todt, accessed 6 April 2023).

³² « Im letzten Sommer erzählte ich Ihnen wohl schon von meinen Plänen betreffs eines Eiszeitforschungs-Institutes. Ich hatte damals meine Vorschläge sowohl dem Wissenschaftsministerium wie der Kaiser-Wilhelm-Gesellschaft eingereicht. Bei der letzteren scheint nun die Sache nicht ganz aussichtslos zu sein. Jedenfalls wird die Angelegenheit ernsthaft geprüft. [...] Für die Durchführung einer solchen Sache ist es heute von ausschlaggebender Wichtigkeit, ob es gelingt, ein paar prominente Persönlichkeiten dafür zu interessieren. Eine der hier in erster Linie in Frage kommenden Persönlichkeiten wäre Herr Dr. Todt.

Publishing on Prehistory

With the *Zeitschrift für die gesamte Naturwissenschaft* the Ahnenerbe had its own journal beyond the reach of contemporary scientific quality control, but it was by no means the only journal, where politics became an issue. At least for foreign colleagues, to get things published, the author's political attitude towards Nazi Germany became increasingly important, apparently much more than the actual content or scientific quality of the submitted paper:

« Mr Blachowski's³³ work could probably be printed in the journal of the Geographical Society in Berlin. Before doing so, however, I must address a somewhat delicate question to you. I know you as a reliable scholar who endeavours to keep the relationship between Polish and German researchers as close as possible. Can you say the same about Mr Blachowski? We don't know him yet and we just want to know whether he might have come out against Germany in public. [...] You will understand, when a German editor inquires in advance so as not to expose himself to later inconveniences » (GVA#3197, letter by Rudolf Grahmann to Rajmund Galon, 12 June 1936).³⁴

Similar problems arose with German scholars, who did not conform to the racist agenda of the Nazi regime:

« Confidential! [...] As co-editor of the journal *Quartär* [i.e., Quaternary] I recently received the reprimand that colleague Zeuner³⁵ be Jewish related and an emigrant. Acceptance of Zeuner's contributions thus may cause difficulties. I know that Zeuner has a non-Aryan wife » (GA56/283-23, letter by Rudolf Grahmann to Wolfgang Soergel, 28. November 1938).³⁶

The regime also tried to exert its influence on international conferences, e.g., on the occasion of the International Anthropological Congress in Denmark, August 1938, where German authorities tried to prevent Franz Weidenreich from participating:

« Yesterday, we received a letter from the German embassy, asking if Dr W. [Weidenreich] knows that his participation in the Copenhagen Congress is undesirable!!! But it's too late, W. is already on his way to Copenhagen and fortunately we can't do anything about it. But what a scandal, what a shame [...] If he is prevented from giving his talk by this moral pressure, it will lead to

Glauben Sie, dass es möglich wäre, ihn für den Plan zu gewinnen? In einem Schreiben an ihn oder noch besser in einer mündlichen Besprechung müsste man meines Erachtens hauptsächlich folgendes ausführen: Die meisten Bauvorhaben, vor allem die Strassenbauten, haben es in der Hauptsache mit den Schichten des Quartärs zu tun. Diese spielen an Wichtigkeit eine so überragende Rolle, dass es notwendig erscheint, hierfür ein besonderes Forschungsinstitut ins Leben zu rufen. Eine besondere Stelle dieses Institutes könnte sich auch mit der besonderen Frage der Landschaftsgestaltung, d.h. der Einpassung der Bauwerke in die Landschaft befassen. // Würden Sie glauben, dass ein solcher Appell an Herrn Dr. Todt Zweck hätte? » (GVA #22386, letter by Paul Woldstedt to Edith Ebers, 29 January 1939).

³³ Unidentified Polish Quaternary geologist.

³⁴ « Die Arbeit von Herrn Blachowski könnte voraussichtlich in der Zeitschrift der Gesellschaft für Erdkunde zu Berlin gedruckt werden. Zuvor muß ich jedoch noch eine etwas heikle Anfrage an Sie richten. Ich kenne Sie als zuverlässigen Gelehrten, der bemüht ist, zwischen den polnischen und deutschen Forschern möglichst enge Beziehungen aufrecht zu erhalten. Können Sie das gleiche auch von Herrn Blachowski sagen? Wir kennen ihn noch nicht und wollen nur wissen, ob er nicht etwa vielleicht gar in der Öffentlichkeit gegen Deutschland hervorgetreten ist. [...] Sie werden es verstehen, wenn sich ein deutscher Schriftleiter im voraus erkundigt, um sich nicht späteren Unannehmlichkeiten auszusetzen. » GVA#3197, letter by Rudolf Grahmann to Rajmund Galon, 12 June 1936).

³⁵ Friedrich Eberhard [Frederick Everard] Zeuner (1905–1963) studied geology in Berlin, Tübingen and Breslau, where he obtained his doctorate degree in 1927. 1925 to 1931, he was assistant at the institute for geology and palaeontology at the University of Breslau. In 1931, he moved to the University of Freiburg. In the same year, he married Ilse Levin, with whom he had two sons. In 1934, he was dismissed, because his wife was of Jewish ancestry. The family emigrated to the UK. 1934 to 1936 Zeuner was research associate for palaeontology at the Natural History Museum in London, 1936, he joined the faculty at the University of London as lecturer in geochronology at the Institute of Archaeology, 1946, he was promoted professor of environmental archaeology and head of the department of geochronology. He retired in 1963 (Strauss *et al.*, 1953, p. 1278).

³⁶ « Vertraulich! [...] Als Mitherausgeber des Jahrbuches „Quartär“ erreichte mich kürzlich der Vorwurf, dass Kollege Zeuner jüdisch versippt und Emigrant sei. Eine Aufnahme von Beiträgen Zeuners könne daher unter Umständen zu Schwierigkeiten führen. Ich weiss, dass Zeuner eine nichtarische Frau hat. » (GA56/283-23, letter by Rudolf Grahmann to Wolfgang Soergel, 28. November 1938).

international consternation » (letter by Teilhard de Chardin³⁷ to Gustav von Koenigswald, 26 July 1938, quoted after Hartkopf 2012: 68).³⁸

The *Ahnenerbe* collected all sorts of people from mere amateurs to esoteric crackheads to trained scientists as quality was measured by conformity to the Nazi ideology. Over time, however, pressure increased on scientific standing particularly for the young SS-officers within the *Ahnenerbe*. In November 1938, Himmler ordered « to introduce the scientific goals and the scientific men into the universities to gain a foothold there » (Kater, 1974, p. 286)³⁹. Thus, ideologically steadfast SS-scientists were supposed to infiltrate the universities, thereby increasing the Nazi party's influence even more. As a consequence, and with few exceptions, non-PhDs were slowly pushed out of the *Ahnenerbe*. Rolf Höhne (1908–1947), e.g., who had been department head for excavations now was deemed too esoteric and unscientific. In March 1938, he was replaced, transferred to another department and with the beginning of World War II silently dropped from the *Ahnenerbe* (Kater, 1974, p. 81–82). After 1939, the young *Ahnenerbe* scientists were pressured to obtain a *Habilitation* degree, i.e., to additionally qualify for a professorship, which only few – such as Assien Bohmers – achieved (Kater, 1974, p. 286).

In March 1939, the *Ahnenerbe* department for karst and cave research was transferred from Salzburg to Munich (Schaffler, 1991, p. 39), which also involved the replacement of the teacher Hans Brand (1879–1959)⁴⁰ as department head with the capable, young geologist Florian Heller (1905–1978)⁴¹, who was to become first an SS-member and then appointed to a newly established professorship at the University of Munich for « Scientific Karst and Cave Research ». Heller was to head « an organization in a new spirit, which primarily demands character, purity of attitude and German manner » (Hans Brand quoted after Schaffler 1991: 47).⁴² Apparently, however, matters dragged on unsuccessfully, and Heller was denied SS-membership in November 1942 and again in June 1944 (Kater, 1974, p. 430).

As part of increasing the *Ahnenerbe*'s scientific reputation, it was also trying to clean up its self-made mess in terminology, by organizing committees for nomenclature and by commissioning model descriptions of objects, which would lead to a standardized vocabulary.

« As is well known, there is currently a confusing lack of clarity in Germany concerning terminology of Palaeolithic and Mesolithic chronology and locality designations. The

³⁷ Pierre Teilhard de Chardin (1881–1955) was a French Jesuit, palaeontologist, anthropologist and philosopher. He was a member of several research expeditions to Asia and Africa. In China, he participated in the excavations as Zhoukoudian. As a theologian and philosopher, he attempted to synthesize the theory of evolution and Christian salvation history (https://fr.wikipedia.org/wiki/Pierre_Teilhard_de_Chardin; accessed 6 April 2023).

³⁸ « Wir haben gestern einen Brief von der deutschen Botschaft erhalten, in dem sie sich erkundigt, ob Dr. W. weiß, daß seine Teilnahme am Kopenhagener Kongress unerwünscht ist!!! Doch es ist zu spät, W. ist bereits auf dem Weg nach Kopenhagen und wir können glücklicherweise nichts tun. Aber, welch ein Skandal, welche Schande [...] Falls er unter diesem moralischen Druck daran gehindert wird zu sprechen, führt das zu internationaler Bestürzung » (letter by Teilhard de Chardin to Gustav von Koenigswald, 26 July 1938, quoted after Hartkopf 2012: 68).

³⁹ « ... die wissenschaftlichen Ziele und die wissenschaftlichen Männer in die Universitäten hineinzuführen, um dort Fuß zu fassen » (Heinrich Himmler, November 1938, quoted after Kater, 1974, p. 286).

⁴⁰ Hans Brand was a mining engineer, who obtained a doctorate degree with at topic in the geology of ore deposits from the University of Munich in 1905. He then worked as a teacher in various schools in Holzminden, Friedberg and Munich, becoming interested in karst and cave research. Sometime before World War I, he was active as ore geologist in various European, African and Asian countries. He became an SS member in 1939, heading the *Ahnenerbe*'s karst and cave research. From 1942, he was a trainer of the military SS karst battalion, which during World War II committed numerous atrocities against the civilian population in Northern Italy and Slovenia ([https://de.wikipedia.org/wiki/Hans_Brand_\(Geologe\)](https://de.wikipedia.org/wiki/Hans_Brand_(Geologe)), accessed 17 March 2023; Schaffler, 1991, p. 39).

⁴¹ Florian Heller studied geology in Erlangen, Munich and Heidelberg. He obtained his doctorate degree in 1929 from the University of Erlangen and became assistant at the Institute for Geology and Palaeontology at the University in Halle. From 1930 onwards, he held the same position at the University in Gießen, where he also obtained his *Habilitation* degree. In 1935, he moved to Heidelberg as collection curator and lecturer. In 1942, he was promoted professor at the University of Heidelberg. He also briefly worked as military geologist. In 1945, he was dismissed during denazification. It took him until 1951, to regain a university position in Erlangen. In 1961, he was appointed full professor for palaeontology at the University of Erlangen ([https://de.wikipedia.org/wiki/Florian_Heller_\(Pal%C3%A4ontologe\)](https://de.wikipedia.org/wiki/Florian_Heller_(Pal%C3%A4ontologe)), accessed 11 May 2023; GVA #4331, letter by Max Pfannenstiel to the mayor of Mainz, 12 December 1950; Tichy, 1993).

⁴² « ...eine Organisation im neuen Geiste, die in erster Linie Charakter, Sauberkeit in der Gesinnung und deutsche Art fordert » (Hans Brand, quoted after Schaffler, 1991, p. 47).

systems of de Mortillet⁴³, Wiegers, Birkner⁴⁴, Riek⁴⁵, Menghin, Breuil⁴⁶ and Peyrony⁴⁷ are used alternately. The designations of Mühlhofer⁴⁸ and Andree will be added shortly. It is obvious that this makes scientific work extraordinarily difficult; in addition, this state of affairs gives other countries reason to scoff at German prehistoric research.

To remedy this situation, some German scholars [...] have set up a provisional system for the German chronological stages.

This system [...] should be made the starting point for joint consultation. The result of this consultation should be a system that can be acknowledged by all participants and will in fact be used in the future » (GVA#10210, letter by Wolfram Sievers⁴⁹ to Rudolf Grahmann, 17 May 1939).⁵⁰

And yet, as, e.g., Karl Hermann Jacob-Friesen (1886-1960)⁵¹, director of the State Museum in Hannover, implied in a letter to Rudolf Grahmann, it was not about an internationally recognized terminology concerning hand-axes in general; it was all about German hand-axes:

« Please be so kind as to tell me where the hand axe from Zehmen is located. I would like to have an exact cast of it, as I have been commissioned by the SS to work out a description of the terminology of German hand

axes » (GVA#5080, letter by Karl Hermann Jacob-Friesen to Rudolf Grahmann, 23 October 1939).⁵²

War Time Research

During World War II, prehistory as handmaiden to Nazi ideology lost its immediate importance, and the *Ahnenerbe* too had to contribute to the war effort. Thus, the focus shifted more into geology and its applications. Already since 1938, the *Ahnenerbe* had a Department for Geology and Mineralogy and a Department for Karst and Caves, the latter including sub-departments, e.g., on military geology, palaeontology and prehistory (Kater, 1974, p. 87).

With the advent of the war and its massive escalation over the following years, people turned their interests to military geology; karst and caves as natural bunkers, hiding places and storage facilities; theft of cultural objects, natural history specimens, maps and books from private collection, museums and libraries in the German occupied territories; all the way to participating in so-called « medical research » on concentration camp prisoners, depending on personal interests, abilities and lack of scruples.

Rudolf Schüttrumpf exchanged palynology with entomology, joining the *Ahnenerbe*'s Entomo-

⁴³ Louis Laurent Gabriel de Mortillet (1821–1898), French prehistorian (https://fr.wikipedia.org/wiki/Gabriel_de_Mortillet; accessed 6 April 2023).

⁴⁴ Ferdinand Birkner (1868–1944), German prehistorian (https://de.wikipedia.org/wiki/Ferdinand_Birkner; accessed 6 April 2023).

⁴⁵ Gustav Riek (1900–1976), German prehistorian (see below).

⁴⁶ Henri Breuil (1877–1961), French prehistorian and Catholic priest (https://fr.wikipedia.org/wiki/Henri_Breuil; accessed 6 April 2023).

⁴⁷ Denis Peyrony (1869–1954), French prehistorian (https://fr.wikipedia.org/wiki/Denis_Peyrony; accessed 6 April 2023).

⁴⁸ Franz Mühlhofer (1881–1955), Austrian cave researcher (see below).

⁴⁹ Wolfram Sievers (1905–1948) studied history, philosophy and religious studies at the Technical University of Stuttgart. He was *Reichsgeschäftsführer* [managing director] of the *Ahnenerbe* 1935 to 1945. In this capacity, he was also responsible for cruel « medical experiments » on and murder of prisoners at Dachau Concentration Camp. He was executed for crimes against humanity (Meier-Hüsing, 2017).

⁵⁰ « Auf dem Gebiet der paläolithischen und mesolithischen Zeitstufen- und Fundgruppenbezeichnungen herrscht bekanntlich zur Zeit in Deutschland eine verwirrende Unklarheit. Man bedient sich abwechselnd der Systeme von de Mortillet, Wiegers, Birkner, Riek, Menghin, Breuil und Peyrony. Dazu werden in kurzem noch die Bezeichnungen von Mühlhofer und Andree kommen. Es liegt auf der Hand, dass dadurch die wissenschaftliche Arbeit ausserordentlich erschwert wird; es kommt hinzu, dass dieser Zustand dem Ausland Anlass gibt, über die deutsche Urgeschichtsforschung zu spötteln. // Um diesem Missstand abzuwehren, haben einige deutsche Gelehrte [...] für die deutschen Stufen ein vorläufiges System aufgestellt. // Dieses System [...] soll zum Ausgangspunkt einer gemeinsamen Beratung gemacht werden. Das Ergebnis dieser Beratung soll ein System sein, das von allen Teilnehmern anerkannt werden kann und in der Zukunft auch angewandt wird » (GVA#10210, letter by Wolfram Sievers to Rudolf Grahmann, 17 May 1939).

⁵¹ Karl Hermann Jakob-Friesen (1886–1960) studied geology, geography, ethnology and history in Leipzig, where he obtained his doctorate degree in 1909. 1910 to 1912, he was curator at the Ethnological Museum in Leipzig. In 1913, he moved to the Provincial Museum in Hannover. In 1917, he was promoted director of the department of prehistory, in 1920, he became the Museum Director. 1932 to 1947, he was honorary professor at the University of Göttingen (https://sempub.ub.uni-heidelberg.de/propylaeum_vitae/de/wisski/navigate/9175/view; accessed 16 March 2023).

⁵² « Seien Sie doch bitte so freundlich und teilen Sie mir mit, wo der Faustkeil von Zehmen liegt. Ich würde gerne einen genauen Abguss davon haben, da ich im Auftrag der SS eine Beschreibung der Terminologie der deutschen Faustkeile auszuarbeiten habe » (GVA#5080, letter by Karl Hermann Jacob-Friesen to Rudolf Grahmann, 23 October 1939).

logical Institute at Dachau concentration camp, which was founded in 1942 but luckily was not ready to function before the end of 1944. Human experiments, e.g., on malaria were planned, but were no longer executed (Deichmann, 1995, 233; Benz *et al.*, 2005, p. 304).

Franz Mühlfhofer (1881–1955)⁵³, president of the Austrian *Verein für Höhlenkunde* (i.e., society for cave research), which had been amalgamated with the *Ahnenerbe* after the Annexation of Austria, conducted racist anthropological studies in cooperation with the Vienna Natural History Museum on ethnically diverse prisoners of war of European, African and Asian origins (Abrahamczik, 1955, p. 30).

Rolf Höhne left the *Ahnenerbe* to become head of the Waffen-SS military geologists in 1939 (Willig, 2003).

Julius Andree, whose scientific reputation by then was too low even for the *Ahnenerbe*, moved on to the Rosenberg Office, for which he plundered museums in occupied Belgium and France (Eberle, 2002, p. 221).

Lothar Zotz, professor of prehistory at the German university in Prague, as well felt no qualms when he had the Palaeolithic Moravian Venus in his pack fleeing westward in 1945. It took until 1967 for the little statue to be returned to Slovakia (Klápště, 2009, p. 123).

Basically, all younger prehistorians were drafted into the military; Bohmers, on the other hand, was a Dutch citizen and thus continued to perform archaeological excavations, particularly in

occupied territory, e.g., at Dolní Věstonice (or Unterwisternitz as the Nazis called it) and Moravany on the Váh River (Kater, 1974, p. 146; Eickhoff, 2013). These excavations still had a political agenda in aiming to proof a connection of the so-called « Aryan race » with territory that was of geopolitical interest to the Nazi regime (Kostrhun, 2009, p. 131). In October 1939, the *Ahnenerbe* gave some of the newly excavated finds including a small sculpture of a wisent as a birthday present to Heinrich Himmler (Eickhoff, 2013, p. 598).

Anyone visiting countries under German occupation, particularly in eastern Europe – among them, of course, also Quaternary geologists and prehistorians – must have seen the terror regime inflicted on the local population. However, they did not write about it for fear, their letter might be opened. What was said in private conversation, we can only imagine:

« I have just returned from a business trip to Poland. [...]

Yesterday, I finally got news from Klimaszewski⁵⁴ from Kraków. He is alive and has not yet been arrested, while this happened to most members of the university.

I saw and heard much in Poland, so I could tell you a lot »

(GVA #22601, letter by Paul Woldstedt to Edith Ebers, 12 December 1939).⁵⁵

After-War Apologetics

Assien Bohmers was assisted by his colleague Lothar Zotz, who came to Prague in September

⁵³ Franz Mühlfhofer was an Austrian military officer. As a young lieutenant, he was stationed in Trieste, where he became interested in karst caves, partaking in excavations. 1911/12, he was a member of an Austrian expedition into the Sahara Desert dealing with karst features and « anthropological » studies in northern Africa. World War I saw him in action. He also undertook karst studies on the Crimean Peninsula. His time as Soviet prisoner of war, he spent in Mongolia. After the war, he continued his military career in the Austrian army, eventually reaching the rank of *Oberst* (colonel). From 1922 onwards, he was President of the *Verein für Höhlenkunde* (Abrahamczik, 1955).

⁵⁴ Mieczysław Marian Klimaszewski (1908–1995) graduated as geographer and geomorphologist from the Jagiellonian University, Kraków, in 1931. Until 1939 and in 1945, he was a researcher at the Jagiellonian University. He obtained his doctorate in 1933 and his *Habilitation* degree in 1945. In 1946, he became associate professor and in 1957 full professor. Apparently, he worked intermittently at the Jagiellonian University in Kraków and at the University and the University of Technology in Wrocław. 1964–1972 he was Rector of the Jagiellonian University. 1965–1972, he was also a member of the Sejm of the People's Republic of Poland. In June 1965, he was elected a member of the Council of State, and in December 1965, he became deputy chairman of the Council of State, a position he held until March 1972 (https://pl.wikipedia.org/wiki/Mieczys%C5%82aw_Klimaszewski; accessed 12 May 2023).

⁵⁵ « Ich komme eben von einer Dienstreise nach Polen zurück. [...] // Gestern bekam ich endlich Nachricht von Klimaszewski aus Krakau. Er lebt und ist bisher nicht verhaftet, während dies den meisten Angehörigen der Universität widerfahren ist. // In Polen habe ich viel gesehen und gehört, sodass ich Ihnen eine Menge erzählen könnte » (GVA #22601, letter by Paul Woldstedt to Edith Ebers, 12 December 1939).

1939 as professor for prehistory in the course of replacing the Czech faculty with German professors (Klápště, 2009, p. 119, 123).

"Shortly before my appointment to Prague, I had the opportunity, in a one-hour conversation conducted alone and personally with Reichsführer SS Himmler, to also discuss the task of the area of expertise I represent in the Carpathian-Sudetenland region, and consequently the Reichsführer particularly agreed to my assignment in Prague » (letter by Lothar Zotz to the rector of the University of Prague, 24 May 1940; quoted after Klápště 2009: 119)⁵⁶

After the war, he would claim to have been appointed already under the former Czech government⁵⁷, which, however, is clearly a lie intended to whitewash his involvement with the Ahnenerbe. After 1945, he successfully negotiated for support from victims of Nazism by adding false context to their memories (cf. Picard, 1996, p. 98) or by styling himself as a victim of post-war prosecution, inadvertently exposing his personal antisemitism:

« My situation here⁵⁸ has become even more precarious in that Preidel⁵⁹ now wants to qualify as a professor here and has tried to

blackmail and threaten me. Preidel not only has a Jewish wife, but also strong connections in the Munich Ministry. Today, both mean about the same as if you used to be a member of the SS and had connections in the ministry. I'll tell you that quite frankly, but this man is very dangerous, as was also confirmed to me by a colleague » (GVA#18513, letter by Lothar Zotz to Max Pfannenstiel, April 17, 1948).⁶⁰

German prehistorians in general distanced themselves from former Nazi affiliations by blaming all on a few convenient scapegoats such as Hans Reinerth (1900-1990)⁶¹, who had worked not for the *Ahnenerbe* but for the Rosenberg Office (Stobel, 2010; Schöbel, 2008):

« Shortly before the German retreat from the East, all the museums in Crimea, Ukraine and northern Russia were evacuated and taken to Germany, allegedly to save them from destruction. This measure resulted in severe reprisals when the Russians invaded Germany. [...] There is an urgent suspicion that the order for this forced evacuation came from a central authority. In fact, only the department of prehistory in the Rosenberg Office, which Reinerth headed, comes into question. [...] German archaeology and prehistory demand that Mr Reinerth must never again play a role

⁵⁶ « Ich habe kurz vor meiner Berufung nach Prag Gelegenheit gehabt, in einem einstündigen, allein und persönlich mit dem Reichsführer SS Himmler geführten Gespräch auch die Aufgabe des von mir vertretenen Fachgebietes im Karpathen-Sudetenraum zu besprechen, und der Reichsführer war deshalb mit meinem Einsatz in Prag besonders einverstanden » (letter by Lothar Zotz to the rector of the University of Prague, 24 May 1940; quoted after Klápště 2009: 119).

⁵⁷ cf. GVA#23275, letter by Max Pfannenstiel to Hans Günther, 18 March 1947.

⁵⁸ At Erlangen University.

⁵⁹ Helmut Preidel (1900–1980) studied history, German language and literature and ethnography in Prague, Berlin and Halle. He obtained a doctorate degree in 1923. In 1927, he married Marianne Wimmer, with whom he had two daughters. Helmut Preidel worked as a school teacher in Czechoslovakia. In 1938, after annexation of the *Sudetenland* by Germany due to the Munich Agreement, Preidel was expelled, because his wife was Jewish and he refused to divorce her. Preidel found employment at the departments of prehistory in museums in Saaz [Žatec] and Komotau [Chomutov], having been interested in prehistoric research already since at least 1924. In 1947, Preidel moved to Munich, where he became director of the *Landesamt für Vorgeschichte* until 1952. 1949 to 1965, he was editor in chief of the *Stifter Jahrbuch* (https://de.wikipedia.org/wiki/Helmut_Preidel; accessed 6 April 2023).

⁶⁰ « Meine hiesige Lage ist insofern noch prekärer geworden, als jetzt Preidel sich hier habilitieren will und mich glatt zu erpressen und zu bedrohen versucht hat. Preidel hat nämlich nicht nur eine jüdische Frau, sondern auch dicke Verbindungen im Münchener Ministerium. Beides bedeutet heute etwa dasselbe, wie wenn man früher der SS angehörte und Verbindungen im Ministerium hatte. Ich sage Ihnen das ganz offen, aber dieser Mann ist, wie mir auch von einem Kollegen betätigt wurde, sehr gefährlich » (GVA#18513, letter by Lothar Zotz to Max Pfannenstiel, April 17, 1948).

⁶¹ Hans Reinerth studied at Tübingen University first protestant theology from 1918 onwards, but then quickly switched to prehistory. In 1921, he obtained his doctorate degree. He went on to *Habilitation* in 1925 at the University of Freiburg i.Br. 1925 to 1933, he worked as *Privatdozent* for prehistory at the University of Tübingen. 1933/34, he became professor at the *Reichsamt für Vorgeschichte*. In 1934, he became professor for prehistory at the University of Berlin; a position and title he lost in 1946 due to denazification. 1946 to 1948, he was kept in custody. 1953, when denazification was officially concluded, he was rehabilitated and became director of the prehistorical museum in Unteruhldingen at the Lake of Constance, a position he clung onto until his death (Stobel, 2010; <https://www.sammlungen.hu-berlin.de/objekte/-/443/>; accessed 25 May 2023).

in German science » (GVA#18381, transcript of a letter by Wolfgang Kimmig⁶² to Max Pfannenstiel, November 24, 1948).⁶³

Reinerth had been interested in national-socialism and its implications for prehistoric research since 1929.⁶⁴ He involved himself in fierce disputes against the perceived « establishment » of prehistoric research in southern Germany. As a consequence, his early career became stunted, which led to increasing radicalization and verbal aggression. In December 1931, he became a party member of the NSDAP and worked for the establishment of a department of prehistory for Alfred Rosenberg's *Kampfbund für deutsche Kultur* [*i.e.*, battle alliance for German culture], later known as the Rosenberg Office (Stobel, 2010, p. 331–5). His particular rival became Gustav Riek⁶⁵, his former colleague from Tübingen, who was closely involved with the *Ahnenerbe* (Stobel, 2010, p. 337). Reinerth, who had been infected with poliomyelitis during his childhood⁶⁶, was considered unfit for military duties, which allowed him in the war years, particularly after 1942, to act as *Beauftragter für die Vor- und Frühgeschichte in den besetzten Ostgebieten*⁶⁷, *i.e.*, he was tasked with stealing prehistoric objects but also blundering scientific libraries from countries in eastern Europe that fell

under German military occupation, particularly Ukraine⁶⁸.

Alfred Rosenberg, his superior, jogged with Himmler for Adolf Hitler's favours in a process which the British Historian Ian Kershaw named « Working Towards the Führer » (Kershaw 1993), hence the two organisations, the Rosenberg Office and the *Ahnenerbe*, had been in constant rivalry. Possibly even less scientific than the *Ahnenerbe*, particularly during the war years and exceedingly active in stealing cultural treasures all over Europe, the Rosenberg Office made a convenient culprit, rendering the university prehistorians by comparison if not innocent, so at least less guilty.

Conclusion

German Quaternary geologists were genuinely interested in prehistory and prehistoric archaeology as part of their interest in karst and cave studies, Ice-Age research and changes in climate patterns. When in 1933, the Nazi regime was established in Germany, prehistoric research came into the focus of ideologically tainted research institutions such as the *Ahnenerbe*, as it was deemed capable to offer a nationalistic and

⁶² Wolfgang Kimmig (1910–2001) studied pre- and early history in Marburg and Freiburg, where he obtained his doctorate degree in 1935. In the late 1930s, he travelled and undertook research mostly in the eastern Mediterranean region. In 1942, he obtained his *Habilitation* degree from the University of Freiburg. He was drafted as a soldier and wounded. After recovery, he was delegated as an officer to the *Stab Graf Metternich*, and tasked with « protection and securing archaeological collections in French museums ». In 1946, Kimmig became professor for pre- and early history at the University of Freiburg. In 1955, Kimmig became director of the Institute for Pre- and Early History at the University of Tübingen (https://de.wikipedia.org/wiki/Wolfgang_Kimmig; accessed 6 April 2023).

⁶³ « Kurz vor dem deutschen Rückzug aus dem Osten wurden sämtliche Museen der Krim, der Ukraine und die von Nordrußland evakuiert und nach Deutschland verbracht, angeblich um sie vor Zerstörung zu retten. Diese Maßnahme hatte schwerste Repressalien beim Einmarsch der Russen in Deutschland zur Folge. [...] Es besteht der dringende Verdacht, daß der Befehl zu dieser gewaltsamen Evakuierung von zentraler Stelle aus gegeben worden ist. In Frage kommt eigentlich nur das Amt Vorgesichte im Stabe Rosenberg, das Reinerth leitete. [...] Die deutsche Archäologie und Urgeschichte fordert, daß Herr Reinerth nie mehr eine Rolle in der deutschen Wissenschaft spielen darf » (GVA#18381, transcript of a letter by Wolfgang Kimmig to Max Pfannenstiel, November 24, 1948).

⁶⁴ <https://www.sammlungen.hu-berlin.de/objekte/-/443/>; accessed 25 May 2023

⁶⁵ Gustav Riek (1900–1976) had studied geology in Halle and Tübingen. He worked as assistant at the institute for prehistory at the University of Tübingen, where he obtained his *Habilitation* degree in 1934. The following year, he became professor and director of the institute for pre- and early history in Tübingen. In 1929 he became a member of the NSDAP and was active in various party organizations. In 1937, he became a member of the SS. He was *Dozentenbundführer* in Tübingen, a position involving review and even dismissal of « politically unreliable » lecturers. Riek also became a member of the *Sicherheitsdienst* (Security Service) or SD, the intelligence agency of the SS. For the *Ahnenerbe*, Riek undertook prehistoric research. In March 1941, he became a member of Himmler's personal staff. January 1940, Riek was drafted into the Waffen-SS, where – until March 1942 – he was responsible for political « education » of the prisoners at the SS-Sonderlager Hinzert. In autumn 1941, Riek was involved in the sanctioned murder of seventy Soviet prisoners of war. From March 1942 onwards, he served as military geologist of the Waffen-SS. 1944 or 1945, he became prisoner of war first in Soviet then in Polish custody. Upon his return in 1948, he was briefly interned by French authorities. In 1956, three years after conclusion of denazification he became professor of prehistory at the University of Tübingen. He retired in 1968 (<https://www.ns-akteure-in-tuebingen.de/biografien/bildung-forschung/gustav-riek>, accessed 12 May 2023; Stobel, 2010, p. 339–340). For SS-Sonderlager Hinzert see <https://www.gedenkstaette-hinzert-rlp.de/>.

⁶⁶ https://sempub.ub.uni-heidelberg.de/propylaeum_vitae/de/wisski/navigate/7744/view, accessed 25 May 2023

⁶⁷ *i.e.* commissioner for the pre- and early history in the occupied eastern territories.

⁶⁸ <https://www.sammlungen.hu-berlin.de/objekte/-/443/>, accessed 25 May 2023

racist narrative that allowed to argue for an alleged general cultural and biological superiority of Germans and also was later – during World War II – used to found territorial claims and to justify imperialistic aggression. Thus, prehistoric archaeology quickly became a booming field of research, heavily supported and funded by the *Ahnenerbe* and other organizations, providing abundant new job opportunities for early career geoscientists, access to third-party funding for established researchers, and an opportunity to raise the scientific profile and prestige of Quaternary geology as a whole. Thus, the field attracted numerous people, who readily fell in line with national-socialism ideology in order to exploit this unique opportunity.

When with World War II the boom subsided somewhat, many people had already committed themselves so deeply, or where in full agreement with the dealings of the regime anyway, that a large number continued their opportunistic connections with the SS in general, the *Ahnenerbe* in particular or also with the Rosenberg Office. They were ready to further implicate themselves without regard to moral

consequences by providing expertise to the Waffen-SS, to the forays of the Rosenberg Office or all the way to lending a helping hand in tormenting and murdering concentration camp prisoners.

After the war, mentioning of a former association with the *Ahnenerbe* became taboo. A general white-washing of the disciplines of Quaternary geology and prehistoric archaeology set in by concentrating the collective guilt on a few convenient scapegoats – but even those eventually, by the mid-1950s at the latest, were allowed to continue their careers as if nothing worth mentioning had happened.

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From Louis XIII (1620) to the Inhigeo Symposium (2022): four centuries of Miocene palaeontology and stratigraphy at Sainte-Croix-du-Mont (Aquitaine, France)

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Abstract. In September 2022, 402 years after the visit of Louis XIII, the participants of the INHIGEO Symposium visited the amazing site of Sainte-Croix-du-Mont (Guyenne, Western France), first described in 1622 by Pierre de L'Ancre. Known for his condemnation of alleged witches to the stake, de L'Ancre included one of the earliest memoirs on the geology of Aquitaine in his book on demonology, *L'incrédulité et mescreance du sortilege* (1622). In this discourse, of which large extracts translated into English are included in the appendix, he described the Miocene shelly sediments of Sainte-Croix-du-Mont and reminded his readers of Louis XIII's visit to this site in 1620. Regarding the origin of these shells, he hesitated between an in-situ generation of the fossils (*i.e.*, *lusus naturae*), their deposition in an ancient sea and their transport by the biblical Flood. He described the layers (called « stages ») from the bottom to the top, thus probably understanding their chronological succession and the principle of superposition, before Steno formally stated it (Steensen, 1669). In 1718, Jules Bellet and Isaac Sarrau de Boynet, of the Academy of Bordeaux, studied the same outcrop; they suggested an organic origin because of the scar left by the adductor muscle on the shells and the effervescence of the latter in vinegar. Sarrau de Boynet, however, refused to admit that the sea had reached this place and adopted the surprising thesis of an anthropic accumulation of oysters, which Montesquieu was reluctant to accept. In his famous manuscript *Telliamed*, Benoît de Maillet assumed a marine origin for these fossils, as did other scientists in the second half of the 18th century, such as Nicolas Desmarest. The systematic study of the shelly sediments of this region began in the 1830s, with the detailed work of Jean-Pierre Sylvestre de Grateloup. These studies, carried out mainly in the Saucats area, about 25 km from Sainte-Croix-du-Mont, led to the definition of two Miocene stratotypes, the Aquitanian by Karl Mayer in 1858 and the Burdigalian by Charles Depéret in 1892.

Keywords: Miocene – Burdigalian – Aquitanian – origin of fossils – Pierre de L'Ancre – Louis XIII – Steno – Telliamed

1. Introduction

The small village of Sainte-Croix-du-Mont dominates the right bank of the Garonne River, 40 km upstream from Bordeaux (Fig. 1). Renowned for its sweet white wine, it is also famous for its spectacular deposit of fossil oysters of the Burdigalian (Lower Miocene). This fossiliferous deposit was visited by the King of France, Louis XIII, on 2 October 1620, and described in 1622 by Pierre de L'Ancre who noted the sequence of superimposed layers which he called « estages » (*i.e.*, « stages »), many years before Steno's

Prodromus (Steensen, 1669) was written. The site was further described in the 18th century by the *Académie de Bordeaux*, mentioned by Benoît de Maillet in his famous *Telliamed*, and finally studied in detail in the 19th and 20th centuries. The site thus allows us to trace the evolution of ideas about the origin of fossils over four centuries, from the *lusus naturae* (game or sport of nature) and transport by the biblical Flood to a deposit by the Atlantic Ocean during the Burdigalian transgression.

On 24 September 2022, 402 years after Louis XIII, the participants in the 47th Annual Symposium

of the International Commission on the History of Geological Sciences (INHIGEO) had the opportunity to visit this site. This article is a modified

version of the unpublished excursion guidebook, to which we have added in Appendix the English translation of Pierre de L'Ancre's text (1622).

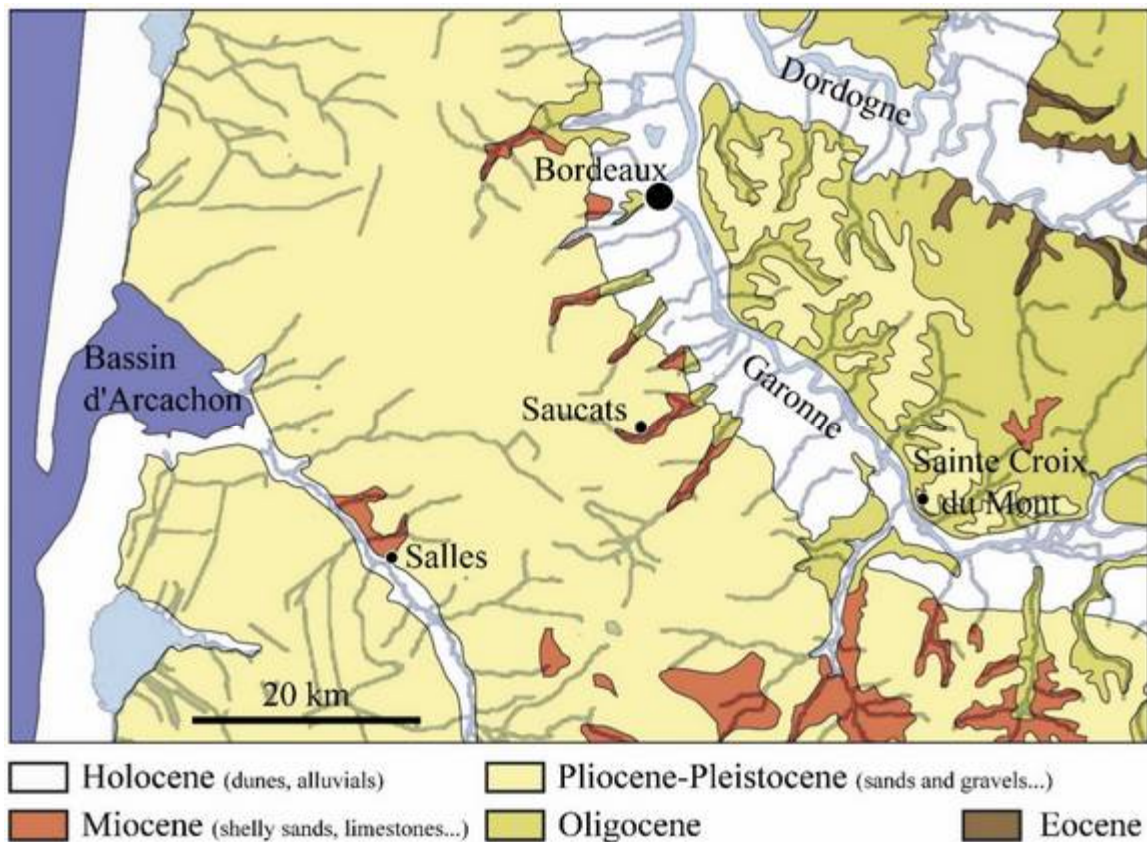


Fig. 1. Geological sketch map of the Bordeaux region

2. Pierre de L'Ancre gives Louis XIII a lesson in geology (1622)

Pierre de Rosteguy de L'Ancre (1553–1631), a counsellor to the Parliament of Bordeaux¹, is known for his books on demonology (L'Ancre, 1612, 1617, 1622, 1627) and for having persecuted and condemned to the stake the alleged witches of Labourd (Basque country) (e.g., Communay, 1890; Français, 1910, pp. 150-159). He is remembered as a fanatical and cruel judge – an obvious criminal by today's standards –, as rec-

ently highlighted by a French television series (*Filles du feu*)², broadcasted in 2023, which deals with his story and that of his victims.

In 1622, in order to convince the sceptics of the merits of his policy of terror against witches, he published *L'incrédulité et mescreance du sortilege plainement convaincue* (L'Ancre, 1622; Fig. 2), a rare book that was printed in 40 copies (Climens, 1884), but which is now available online³. With the exception of Auguste Petit-Lafitte (1846, 1867), naturalists and geologists did not pay any atten-

¹¹ Before the French Revolution, parliaments were courts of justice that enacted laws and administered justice on behalf of the king. The main parliament was in Paris, but there were others in Aix-en-Provence, Dijon, Rouen, Rennes, Bordeaux, etc., so the law was not uniform throughout the kingdom. In each parliament, justice was administered by "counsellors", who were appointed, not elected.

² Available for streaming (6 × 52 min) at: <https://www.france.tv/france-2/filles-du-feu/> (accessed 13 September 2023).

³ <http://gallica.bnf.fr/ark:/12148/bpt6k763251>

tion to this book, although its *Advertissemens* contain one of the earliest, if not the first, memoirs on the geology of Aquitaine, devoted to the famous fossil oyster deposit of Sainte-Croix-du-Mont. Although this topic was completely unrelated to the subject of the book, the author included it because he was proud that King Louis XIII, to whom the book was dedicated, had visited the oyster deposit at his home of Loubens two years earlier. Pierre

de L'Ancre, although very disappointed to have been absent on that occasion, was obsequious enough to display a « Prayer for the King » in his private chapel of Notre-Dame at Loubens (Communay, 1890, pp. 34-35)⁴. Because of its interest for the history of geology, we have already transcribed this text (Godard, 2018a), of which we provide an English translation here (see Appendix).



Fig 2. Title page of *L'incréduité et mescreance du sortilège...* by Pierre de L'Ancre (1622). © *Bibliothèque nationale de France*; the title can be translated as « The incredulity and unbelief of witchcraft, plainly guilty... ».

⁴ According to Communay (1890), Pierre de L'Ancre was buried in the church of Sainte-Croix-du-Mont, in front of the high altar, where we can still see the site of an ancient tomb. However, at an unknown date, the burials of the church were transferred to an ossuary under the cross located outside the church, to the left of the nave; it is therefore probable that Pierre de L'Ancre's ashes are there.

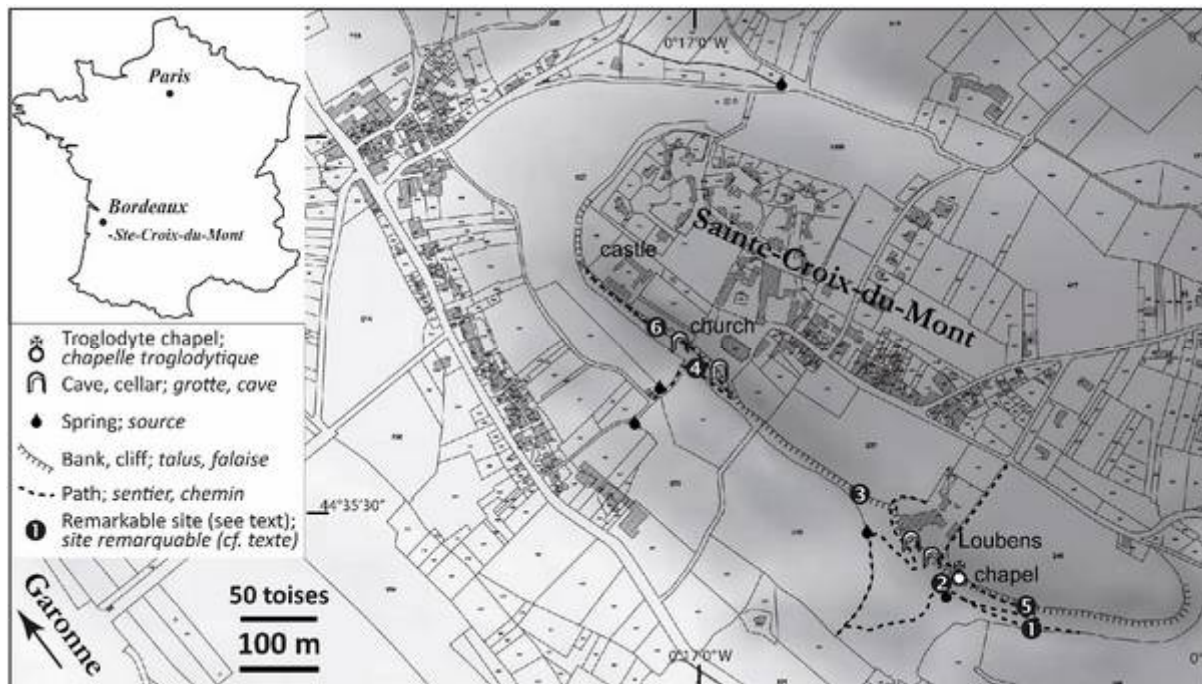


Fig. 3. The surroundings of Sainte-Croix-du-Mont. According to the cadastral map, superimposed on a digital terrain model from the *Institut Géographique National*.

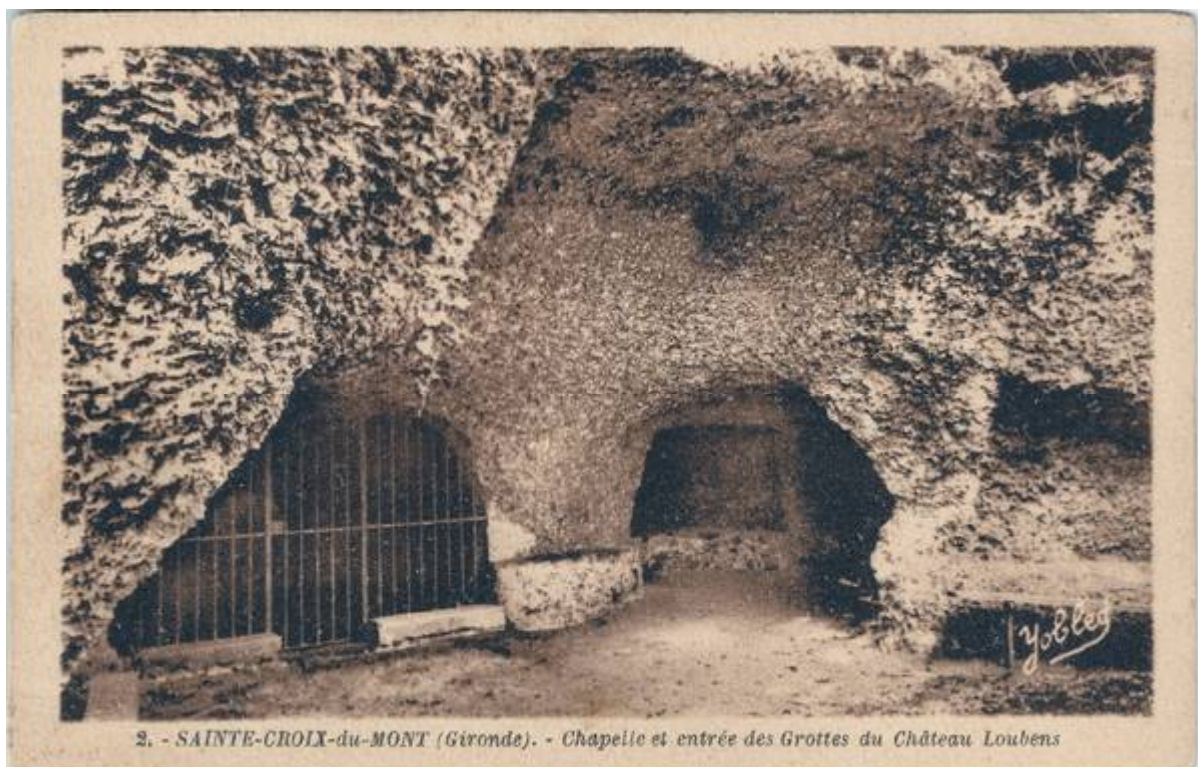


Fig. 4. The troglodyte chapel of Loubens, visited by Louis XIII in 1620. Early 20th century postcard. The chapel was excavated in the Burdigalian oyster level, the base of which is about 40 cm above ground level. The « Prayer for the King » (*i.e.*, Louis XIII) has apparently been removed, but the portraits of Pierre de L'Ancre and his wife, though very faded, can still be seen inside the chapel.

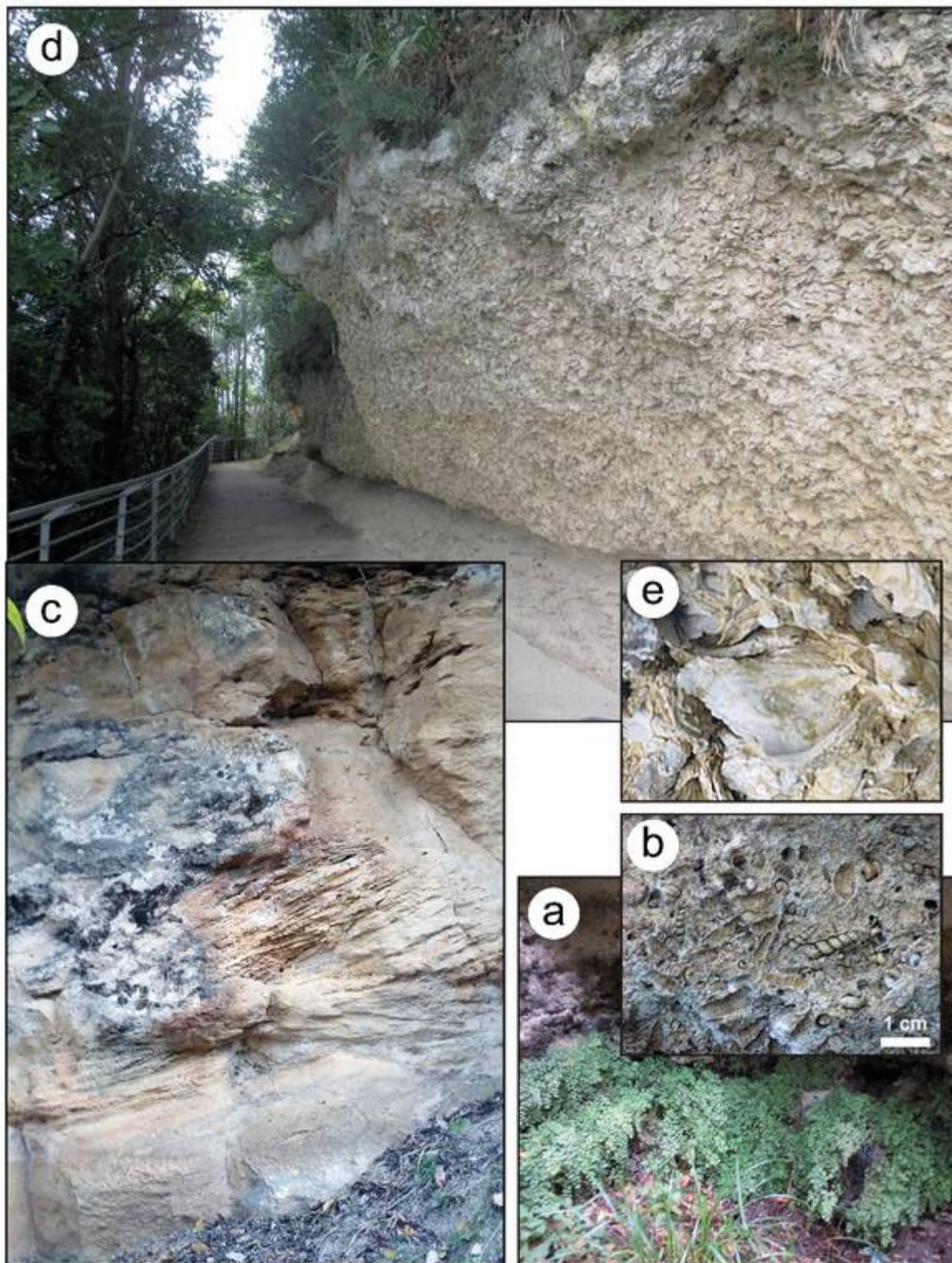


Fig. 5. Some outcrops along the cliff at Saint-Croix-du-Mont. From bottom to top: (a) One of the springs at the foot of the Loubens cliff, which gushes out at the Oligocene-Miocene boundary, showing the fern *Adiantum capillus-veneris* also observed by Abel Brunyer in 1620 (see notes 18, 20-22; 2 in Fig. 3); (b) The fossil gastropods (« *limassons entortillez* ») from the second stage of Pierre de L'Ancre (1622), observed at the same level as the springs; (c) Base of the cliff made up of crossbedded calcareous sandstone, with *Parascutella bonali* and *Amphiope ovalifera*; (d) At the top of the cliff is the « third stage of stacked oysters » described by Pierre de L'Ancre, here below the castle of Sainte-Croix-du-Mont (6 in Fig. 3); (e) Detail of oyster shells, showing adductor muscle scars (centre), which in 1718 were the key argument for an organic origin.

In 25 pages, interspersed with many digressions, the author describes the shelly sediments – now known to be of Miocene age – that occur on the slopes of Sainte-Croix-du-Mont (L'Ancre, 1622, pp. 17-42 of the *Advertissemens*), where Pierre de L'Ancre owned the estate of Loubens, including the troglodyte chapel dug into the level of fossil oysters (Fig. 4). After recounting the visit made by Louis XIII and his young brother Gaston d'Orléans to this site on their way to Béarn in October 1620, he describes « *huïstres* [oysters...], *coquillages* [shells...], *langues de serpent* [*Glossopetrae*, i.e., shark teeth], & *limaçons à plusieurs retortillons* [gastropods] ».

Pierre de L'Ancre wondered about the origin of these oysters. He was undecided between a transport by the biblical Flood and an in-situ generation by a sport of nature, which he called « *esbatement de la nature* », while also considering that marine sediments which emerged after the withdraw of the sea could have been consolidated over long ages (« *par de longs siecles* », p. 35). He wrote: « we see [...] the seas which are in constant motion, some receding, others flooding, and

the shape of innumerable places changing »⁵. He quoted many ancient authors, more to demonstrate his classical culture than to enlighten the debate, and reported on observations made during a tour of Italy between 1574 and 1579, during which he visited Calabria, Naples, Florence, Ravenna and Venice. After lengthy discussion and numerous reservations, he did not reach a clear and definitive conclusion.

The text is mainly worthy of note for the passage (p. 40; see Appendix) in which the author described the sequence of layers: he enumerated them from bottom to top and names them « *estages* » (i.e., stages). This rudimentary geological cross-section was observed at Loubens, where an embankment some 25 metres high is crowned by the famous fossil oyster level and extends north-westwards as far as the castle of Sainte-Croix-du-Mont (from 1 up to 6 in Fig. 3). Pierre de L'Ancre's description is precise enough to assign these « stages » to the various formations described by modern geologists (e.g., Alvinerie & Dubreuilh, 1978; Tastet *et al.*, 2003; Londeix *et al.*, 2014; Londeix, 2018; see Fig. 6, and Table 1).

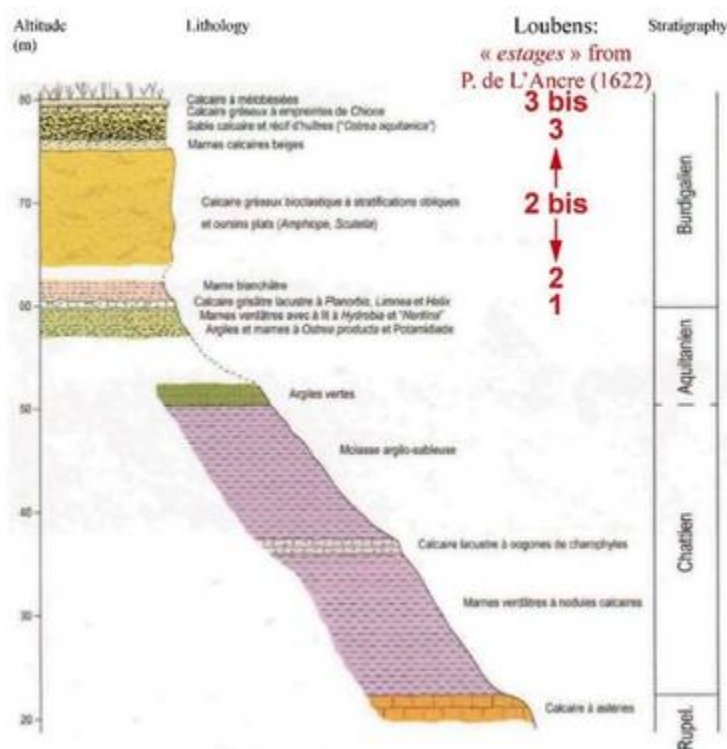


Fig. 6. Stratigraphic sequence at Sainte-Croix-du-Mont. Based on Dollfus (1913), Tastet *et al.* (2003) and Londeix (2018). The position of the « *estages* » of P. de L'Ancre has been added (see text and Table 1, and p. 40 of Appendix).

⁵ L'Ancre (1622, p. 35): « nous voyons tous les jours croistre les Montagnes & Rochers, & les lieux fossoyez & creusez se remplir d'eux mesmes, & d'autres se diminuer & changer: Et les Mers qui sont en perpetuelle agitation, les unes se reculer, les autres inonder; & la face d'une infinité de lieux se diversifier ».

Fig. 6	Description of the different « estages » by Pierre de L'Ancre (1622, p. 40)	Modern geological description of the same levels
3 bis	« Above and almost at the top of the scabrous boulders, there are large oyster shells attached » (« <i>Et encores au dessus & presque au sommet des pieces de Rocher scabreuses, [...] il y a de grandes Escailles [d'huîtres] attachées</i> »).	The roof of the troglodytic chapel and cellars is made of a hardened layer inlaid with oysters, crowning the cliff.
3	Then comes « a third stage of other stacked oysters » (Fig. 5d, e; « <i>un troisieme estage d'autres Huîtres amoncellées</i> »). The troglodyte chapel visited by Louis XIII at Loubens was excavated in this level (Fig. 4; near 2 in Fig. 3).	This famous oyster bed of the Burdigalian (Lower Miocene) is rich in <i>Ostrea aquitanica</i> MAYER (now <i>Hyotissa undata</i>), and can reach a thickness of 4 m (Fig. 5d, e; 5 and 6 in Fig. 3). Some cellars and caves were dug in this level, at Loubens and under the church and the castle of Sainte-Croix-du-Mont.
2 bis	« Above, there is another bed of hard stone, and after there is a high cliff » (Fig. 5c; « <i>Au dessus il y a encore une couche de Pierre dure: & apres se trouve une grande levée</i> »).	The 15 m thick cliff, with meter-thick strata of cross-bedded calcareous sandstone (Fig. 5c; 3 and 4 in Fig. 3), contains Burdigalian (Lower Miocene) <i>Parascutella bonali</i> and <i>Amphiope ovalifera</i> .
2	« The second stage, upwards, contains shells in the shape of small twisted snails, which Tertullian calls <i>Buccinae</i> » (Fig. 5b; « <i>Le second estage allant à mont, est d'un coquillage en forme de petits limassons entortillez, que Tertullien appelle Buccinae</i> »): L'Ancre insists that this « stage » contains « another kind of shells, smaller and all different » from the oysters of the highest levels (p. 19: « <i>il s'y trouve encor une autre sorte de coquilles plus menues, & toutes differentes des premieres</i> »).	These small « twisted » gastropods could be <i>Potamides</i> , very abundant in the sandy clays of the Aquitanian (Lower Miocene), which pass into sandstones rich in numerous internal moulds of lamellibranches and gastropods (Fig. 5b). Pierre de L'Ancre observed this level at the foot of the Loubens cliff, along the path walked by Louis XIII, which de L'Ancre called « <i>Allée des Fontaines</i> » because it is lined with springs formed in relation to the underlying clay levels (Fig. 5a; 2 in Fig. 3).
1	« The base and the foot of the Rock are of hard and clean stone, without any other mixture » (« <i>La base & pied du Rocher est de pierre dure & nette sans autre meslange</i> »).	This could be a fluvio-lacustrine limestone with traces of <i>Planorbis</i> dated to the Upper Oligocene. We have not been able to identify this first « stage » of « hard stone » with certainty, but it seems to outcrop near the small stream below the cliff.
	Not described by Pierre de L'Ancre.	The Oligocene is represented by marls and clays, resulting in a gentle topography of meadows and vineyards.

Table 1. The different « estages » visible at Loubens, according to Pierre de L'Ancre (1622) and their modern stratigraphic descriptions. The first column refers to the levels in Figure 6.

Describing the rocks and fossils shown to Louis XIII at Loubens, Pierre de L'Ancre (1622) used the word « *estage* » (*i.e.*, stage) long before it was introduced by Alcide d'Orbigny (1840–1867) to indicate a chronostratigraphic division. Whereas Louis XIII and his entourage went through this geological section from top to bottom, L'Ancre listed these stages in the opposite direction, from bottom to top, as a modern geologist would, suggesting that he had intuitively assimilated the principle of superposition and the chronological order of the strata before Nicolas Steno formally stated them (Steensen, 1669).

In the 16th and 17th centuries, there were two main opposing theses on the origin of fossils (*e.g.*, Rudwick, 1972; Ellenberger, 1994). The « sport of nature » or *lusus naturae* thesis, which Pierre de L'Ancre charmingly called the « *esbatement de la nature* », attributed the origin of fossils to

spontaneous formation from the rock masses; the second hypothesis, that of an organic origin, clashed with the remoteness of the sea and therefore (it was thought) required the transport of the shells, for example thanks to the biblical Flood, which seemed to be a convenient mechanism. Pierre de L'Ancre (1622), as well as Louis XIII's entourage (according to his reports), was undecided between the two theses, whereas a more recent manuscript, written around 1650 on the shelly sands of Salles, 50 km to the west (Fig. 1; formerly Sallomacian, now Serravallian), clearly supported the *lusus naturae* origin (Godard, 2019). Although very cautious and somewhat confused in his conclusions, L'Ancre was audacious enough to imagine sea-level fluctuations, which were rarely invoked at the beginning of the 17th century. He imagined the mobility of the seas over « long centuries » in addition to a possible transport by the Flood (L'Ancre, 1622, p. 35; see Appendix),

suggesting a dynamic evolution of the Earth: « every day we see the mountains and rocks growing, the depressions and hollows filling up [with sediments] by themselves, and others shrinking and changing ». He quoted Ovid's famous verses: « I have seen myself what was once solid land become the sea. I have seen earth made from the waters, and seashells lying far away from the sea, and an ancient anchor has been found on a mountaintop » (Metamorphoses 15, 262-265), to end with a bit of humour: he was himself an ancient anchor (L'Ancre means « the anchor », in French), ready to welcome the reader at the top of his « mountain » of Loubens to show him these shells.

3. The studies of the Bordeaux Academy (1718) and the opinion of de Maillet

At the beginning of the 18th century, the *Académie royale des belles-lettres, sciences et arts de Bordeaux* began to discuss the origin of the oyster shells of Sainte-Croix-du-Mont (Godard, 2018a, 2018b). A memoir on this deposit, sent by Jules Bellet, priest of Cadillac, was read at the meeting of 8 May 1718⁶. Father Bellet did not doubt that it was made up of « marine oyster shells ». He quoted ancient and modern authors who had reported the presence of such shells on land, and was convinced that the sea was once present in the area and « left [the shells] here when it retreated ». On the basis of ancient texts, he stated that the presence of the sea at Sainte-Croix-du-Mont dated back to the Flood, which he believed to have occurred 4115 years ago – the author covered the margins of his manuscript with numbers relating to this calculation. In the rest of the memoir, Father Bellet briefly described some of the out-

crops, recalled Louis XIII's visit to Loubens in 1620 and transcribed the « Prayer for the King » composed for the occasion by Pierre de L'Ancre.

Bellet's report aroused the curiosity of the Academy. During the summer of 1718, several members of the Academy travelled to Sainte-Croix-du-Mont, and on 25 August 1718, Isaac de Sarrau de Boynet read a new manuscript on the subject before the Academy⁷. He described the outcrops and the « vein of shells » between two « beds of hard stone ». He also studied the fossil shells, noting their effervescence in vinegar and the scars left by the adductor muscle, and concluded that the fossils were similar to modern marine shells. Convinced of the organic origin, Boynet hesitated between transport by the Flood and deposition by the sea, which was difficult to imagine given the altitude of the area. Finally, he suggested that, for some (admittedly obscure) reason, ancient men could have transported the oysters to their present location⁸. This surprising thesis reflected Boynet's frustration with the incomprehensible. Montesquieu, who chaired the meeting, disingenuously expressed apparent satisfaction: « When one cannot be sure of the truth », he declared, « it is good to have something that resembles it »⁹.

A copy of Bellet's memoir was sent to the regent Philippe d'Orléans in 1718, together with a map drawn up by Barrelier de Bitry, chief engineer at the Bordeaux fortress of Château-Trompette. This map, entitled *Vüe de la Coste de Ste Croix du mont*, is now kept in the *Bibliothèque de l'Institut* in Paris¹⁰ (Fig. 7), where there is no trace of the accompanying memoir. However, it is almost certain that copies of this memoir were circulating in Paris, since it is mentioned in the famous manu-

⁶ *Mémoire sur les coquilles d'huîtres de Sainte-Croix du Mont*, by l'abbé Jules Bellet, read on 8 May 1718, *Bibliothèque municipale de Bordeaux*, ms 828/017 (n° 5), 16 p.; see Godard (2018b).

⁷ *Mémoire touchant les coquillages de Ste Croix du Mont*, by Isaac Sarrau de Boynet, read on 25 August 1718, *Bibliothèque municipale de Bordeaux* {BmB}, ms 828/002 (n° 6), 24 p.; *Mémoire sur les coquillages de Ste Croix du Mont*, by Sarrau de Boynet, 25 August 1718, BmB, ms 828/016 (n° 24), 12 p.; see Godard (2018b).

⁸ Although seemingly extravagant, the hypothesis of an anthropogenic origin of oyster masses has been demonstrated for other deposits, notably the famous km-long shell middens of Saint-Michel-en-l'Herm in western France (see historical review in Godard, 1995). In the latter case, however, the deposit, resulting from medieval oyster farming, is neither hardened nor stratified like that of Sainte-Croix-du-Mont.

⁹ *Résomption de la dissertation de M. de Sarrau sur les coquillages de S^{te} Croix du Mont*, by Montesquieu, *Bibliothèque municipale de Bordeaux*, ms 828/006 (n°7), 1 p.; see Godard (2018b).

¹⁰ *Vüe de la Coste de Sainte-Croix-du-Mont*, colour map by Barrelier de Bitry presented to the *Académie Royale des Belles-Lettres... de Bordeaux*, 1718, *Bibliothèque de l'Institut de France*, Paris, ms 2721/51, 51.55 cm × 53.55 cm, scale of 59.54 cm for 100 toises.

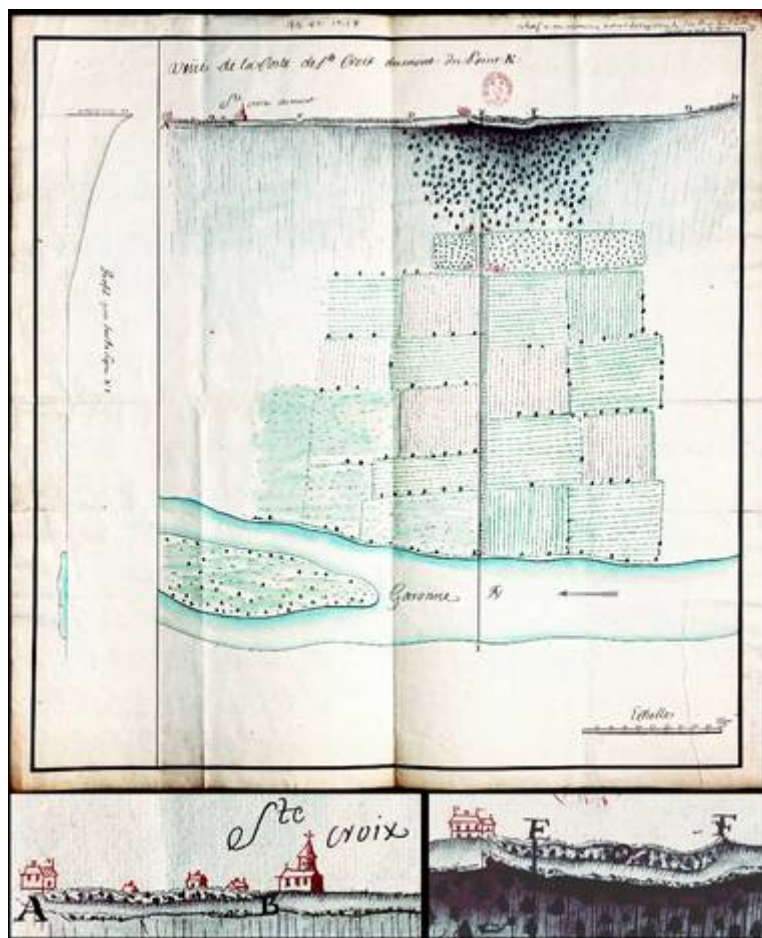


Fig. 7. « Vue de la Coste de S^{te} Croix du mont » (1718)
 Manuscript 2721/51 from the *Bibliothèque de l'Institut de France*, Paris. Map and perspective view made by Barrelier de Bitry in 1718; 51.5 cm × 53.5 cm at a scale of about 1/2100, with the topographic profile (left) from I to E. The cliff (at the top) is shown in perspective view from point K; the marbling represents the oyster level (e.g., between A and B, between E and F); A, castle; B, church; C, gorge (?); D, E, F, Loubens; O (between E and F): troglodyte chapel; K: place where Louis XIII landed in 1620. Enlargements: Sainte-Croix-du-Mont, bottom left; Loubens, bottom right.

script *Telliamed*, written in secret by Benoît de Maillet who put forward bold theories on the origin of fossils and the history of the Earth (translated from Maillet, 1748; written after March 1719): Oyster shells can be seen « six leagues from Bordeaux in the parish of Sainte Croix du Mont [...]. There, on the crest of a rather high mountain, [...] between two beds of stone, the upper of which may be five or six feet thick, one sees a deposit of oysters that is twenty or twenty-four feet thick, and which is visible for an extent of about one hundred fathoms [*i.e.*, about 200 m], the rest being hidden in the rock. A chapel has been built there, fifteen feet deep, where mass is celebrated. Most of these oysters are closed and contain a small amount of clay. This is probably the substance of the oyster that has deliquesced. These oyster shells are united in this bed by a sand, which, mixed and petrified with them, now makes them a

single substance. The scholars who work in Bordeaux on the history of the Earth will undoubtedly be able to tell you how this layer came to be, if the prejudices in which they were brought up do not prevent them from seeing the reason for this phenomenon. For me, it is impossible not to be convinced by the sight of these layers of oysters [...] that they were all oyster beds when the sea completely covered them, similar to those it contains today in an infinite number of places from which we collect the oysters we eat. »

Father Jules Bellet continued to send to the Bordeaux Academy handwritten chronicles, proudly entitled *Voyages littéraires*, describing fossil occurrences in the region¹¹. Other members of the Academy, notably Godefroy de Baritault and Jacques-François Borda d'Oro [1718–1804], described fossils from Aquitaine and had no doubts

¹¹ *Voyage littéraire à Sainte-Foy...*, par l'abbé Jules Bellet, 1736, *Bibliothèque municipale de Bordeaux*, ms 828/017 (n° 7), 20 p.; *Observations d'histoire naturelle extraites des voyages littéraires de M. l'abbé Bellet*, by Sarrau de Boynet, 1736, *Bibliothèque municipale de Bordeaux*, ms 828/016 (n° 14), 12 p.; see Godard (2018b).

about their organic origin (see Courteault, 1909; Godard, 2018b). In the mid-eighteenth century, the Academy of Bordeaux organised two essay competitions (Courteault, 1909): the first, in 1743, on the « origin and formation of figured stones [*i.e.*, fossils] having a regular and determined figure, both internally and externally »; the second, in 1745, on the « figured stones ». The postulants unanimously accepted the idea of an organic origin, but did not consider the shelly sediments of the region. One of them, Pierre Barrère, surprisingly expressed some of the concepts of uniformitarianism as early as 1745 (Godard, 2018b).

4. The rise of modern geology

Dezallier d'Argenville, one of the contributors to Diderot's *Encyclopédie*, briefly mentioned the fossils of Sainte-Croix-du-Mont in his *Enumerationis fossilium* (Dezallier d'Argenville, 1751, p. 53): « In a place called Sainte Croix du Mont, in front of the castle gates [*i.e.*, between 6 and 4 in Fig. 3], a large oratory has been dug into a cliff of oysters; the vault and the pillars supporting it are constructed of the same material. »¹²

In 1761, Nicolas Desmarest, then working for the intendant of Bordeaux, wrote a travel journal of two journeys from Bordeaux to Périgueux and from Bordeaux to Agen, in which he described the (Cenozoic) sediments of these regions¹³. He only mentioned the « *pierres aux huîtres de Sainte Croix* », but elsewhere described fossil « *madrepores* », shells, sea urchins, etc., which he clearly attributed to a marine origin. Desmarest later reproduced some of these observations in his *Encyclopédie méthodique*, devoted to physical geography and geology (Desmarest *et al.*, an III-1828). Authors of the second half of the 18th century, like Desmarests, had no doubts about the marine origin of the fossils and explained their presence in Aquitaine by some invasions of the Atlantic Ocean (*e.g.*, Godard, 2018b).

The systematic study of the shelly sediments (called « *faluns* ») of Aquitaine actually started in the 1830s, with the beginning of modern geology, in particular with the detailed work of Jean-Pierre

Sylvestre de Grateloup (*e.g.*, Lesport *et al.*, 2012). These studies eventually led to the definition of two Miocene stratotypes, the Aquitanian (23.03–20.44 Ma) and the Burdigalian (20.44–15.97 Ma), which are still internationally recognised. It was in 1857 that the Aquitanian stage was created by Karl Mayer (or Mayer-Eymar) (Mayer, 1857; see Cahuzac in Londeix *et al.*, 2014, for the historical details). The name Aquitanian comes from *Aquitania*, the Latin name for the Gallic province of Aquitaine, as mentioned in the writings of Caesar and Pliny. In 1892, Charles Depéret created the Burdigalian stage, which he named after the city of Bordeaux (*Burdigala* in Latin). He defined it as « the horizon of the faluns of Saucats and Léognan », and placed it stratigraphically above the Aquitanian (Depéret, 1892). These stratotypes, protected within the Saucats-La Brède geological Reserve (see Saucats in Fig. 1), have overshadowed Sainte-Croix-du-Mont, some 25 km away, because of their scientific interest and the numerous studies they have given rise to. However, Sainte-Croix-du-Mont remains an exceptional site for its spectacular oyster beds and for its relevance to the history of geology.

5. Conclusions

The 17th and 18th century memoirs on the fossils of Sainte-Croix-du-Mont (Aquitaine Basin, France) echoed the debates of the time on the origin of the « figured stones » – which we now call fossils. The authors were undecided between an organic origin with transport of the shells by the biblical Flood and an in-situ origin resulting from an « *esbatement de la nature* » (a game of nature). A few authors however endorsed more original ideas. The most notable was Pierre de L'Ancre, a learned and cultured man, but also a fanatical and cruel judge. His text (L'Ancre, 1622), although marred by his untimely digressions, considered, in addition to the two hypotheses mentioned above, that seas could be mobile and that sediment consolidation took place over « lengthy ages » after the retreat of the sea; he also described the superposition of layers, which he called « *estages* » (« stages »), which suggests that he had an intuit-

¹² « *in loco dicto Satte [sic] Croix du Mont, ex adverso portarum Castelli, facellum magnum in monticulo Ostreis composito incisum est: testudo & columnæ, quæ eam sustentant, eâdem materiâ constructæ sunt.* »

¹³ *Voyage dans une partie du Bordelois et du Périgord, suivi d'une Tournée du Bazadois, du Condomois et d'Agenois*, initiated on 27 October 1761, *Bibliothèque municipale de Bordeaux*, ms 0721, 317 p. + 40 f.; see Godard (2018b).

tive understanding of the principle of superposition before Nicolas Steno formally stated it (Steensen, 1669). In 1718, Isaac Sarrau de Boynet, secretary of the Academy of Bordeaux, demonstrated the organic origin of fossil oyster shells on the basis of the scar left by the adductor muscle, but he did not adopt the idea of the intrusion of the Atlantic Ocean into Aquitaine, as Benoît de Maillet did in his *Telliamed*. In 1761, Nicolas Desmarest was also convinced of the marine origin of the fossils found in northern Aquitaine, an idea that was definitively accepted with the rise of modern palaeontology at the beginning of the 19th century.

These writings on Aquitaine show us that the history of geology is richer than we might think at first sight. Alongside famous scientists such as Galileo, Steno, Woodward, Buffon, Hutton, Lyell and others, there were a number of humble

scholars, whose contributions remained unpublished and unknown. After centuries in the shadows, their writings, brought to light by the modern means of digitisation, cataloguing and diffusion, are shedding new light on the history of geology.

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Appendix: *L'incrédulité et mescreance du sortilege* (1622)

Below we have translated into English and annotated large extracts from the *advertissemens* of *L'incrédulité et mescreance du sortilege* (L'Ancre, 1622). We have removed the numerous digressions not clearly related to geology. An annotated version has been published in French by Godard (2018a), and the full original version is available on Gallica (<https://gallica.bnf.fr/ark:/12148/bpt6k763251>).

[...; p. 17] Please know, dear reader, that in 1620, around the 2nd of October, the King [Louis XIII], having come to Guyenne, stopped for a few days in the parish of Preignac. Waiting for news from Béarn, he crossed the Garonne River, and I do not know by what good fortune, while he was going hunting, he saw in passing and was led to a house that I have on the Garonne, called Loubens¹⁴, which I hold in faithful homage to him, and which His Majesty could well see from the place where he was lodged, because it is on the top of a hill. When the King had climbed to the top, he did not stop and passed on; but on the way back, they [p. 18] showed him what was unique about this house.

I won't mention the gardens and the orchards [...¹⁵]. I will only say that, from the entrance, His Majesty saw an avenue of about five hundred steps, where there is a pine tree every six toises, with an echo so good and so clear that no other could be in a better situation. From there, he was led down to a place where there were caves and a chapel composed of oysters, piled and heaped up, which I value more than the oysters and mother-of-pearl from which were taken the pearls of Lollia Paulina, of Cleopatra, and those that this great Caesar gave to his favourite Servilia [Cepione], mother of Brutus, and where Monseigneur the Constable¹⁶ had stopped to inquire to those who showed him these singularities, whether these oysters or shells had formerly been brought by the Flood, or whether it was a mere amusement of Nature, [p. 19] which,

wishing to form hard stone, had ceased, and had formed only shells, in which were found serpent's tongues¹⁷, snails with several turns¹⁸ and an infinity of other kinds of shells; even that during the excavation of the chapel, a stag's antler had formerly been found among these oysters.

The main topic of conversation among the countless princes and lords who were close to the King was to contemplate these oysters and this chapel, and, further down, to see another walkway lined with springs¹⁹, where there is still another kind of shell, smaller and all different from the first. They admired an infinite number of medicinal plants that grow in the springs and testify to the goodness and excellence of the waters.

His Majesty, despising these little pleasures in order to think of the war that was to follow²⁰, went down on foot at an extraordinary speed and crossed the Garonne again. The reason for this was that His Majesty was anxiously waiting at Preignac for the latest news from Béarn, where the inspiration of God had urged him to go to bring happiness and blessing. And when he arrived there [at Preignac], the recommendation of the place, which came from his royal mouth, had such an effect that in less than five or six days that he remained in that village, there was such a great influx and concourse of people to visit that hill, that there was not a prince or lord who did not very willingly undertake the task. And indeed, the King's brother Monseigneur [Gaston d'Orléans]²¹, with all his household, went there the next day to look at

¹⁴ In the present commune of Sainte-Croix-du-Mont (Gironde). Mr. Arnaud de Sèze welcomed us in this house during the Inhigeo excursion.

¹⁵ Digressions on the crops, fountains and landscape of the place follow.

¹⁶ In October 1620, the office of constable was vacant, but Charles d'Albert, Duke of Luynes [1578–1621], who took part in the king's expedition to Béarn in 1620, was constable from 31 March until his death on 15 December 1621, during the probable writing of the book, which was published in 1622.

¹⁷ *Glossopetrae* (*i.e.*, shark teeth).

¹⁸ Gastropods, probably of the *Potamidae* group (Fig. 5b).

¹⁹ There is a small aquifer in the Miocene sandstones and limestones, which emerges at the Oligocene-Miocene boundary, forming an « *Allée des Fontaines* » (alley of springs) under the Loubens cliff (2 in Fig. 3; Fig. 5a).

²⁰ Louis XIII arrived to Pau on 15 October 1620 to apply the Edict of Nantes and restore Catholic worship in the small kingdom of Navarre (Béarn), of which he was king as well as king of France.

²¹ Gaston d'Orléans was 12 years old; he went on to build a famous cabinet of curiosities, including a collection of « very rare shells », which was unfortunately lost (Schnapper, 1988).

this pile of oysters at length, and to see the rest of the singularities. The physician who takes care of his health²², having discovered *Capilli veneris*²³ in very large quantities, was very happy to find himself in [p. 20] a position of make syrup for half the court. These are the hairs of my fountains, which are reborn almost as soon as they are plucked or shorn.

And that wasn't all: As pleasure turned to devotion, the chapel, located in a natural cave, was considered by many to be a holy place, so much so that lords and gentlemen gave *pistoles*²⁴ to the priests of the village where the King was staying, to come and say mass, and give them communion there. Many of them did this as devoutly as if it were a pilgrimage or a solemn vow, and they will remember for the rest of their lives that they were in the chapel of Notre Dame de Sainte Croix du Mont²⁵, for it bears that name.

There was nothing for me to wish for, except that this royal visit should have been accompanied by the eye of the master of the house. I was then in the city of Bordeaux, grumbling and tormented by a furious and violent attack of gout (which unfortunately visits me whenever it pleases), which deprived me of the good and honour of seeing my King, my sovereign Prince (whom I do not hope to see again), on the Mount Parnassus of my muses. Though many would wish, on such an occasion, to avoid the crowd of a court so large and populous as it was then, I have no displeasure more bitter than this [...]²⁶.

[p. 24] But I do not wish to close this discourse without giving some satisfaction to those who wish to know whether the oysters or shells which we see on the top of the mountains were carried there by the Deluge or by the runoff of water; or whether it is a trick of nature²⁷, or of some other greater labourer who has produced them of himself.

Therefore, it can be said that the rocks that are on earth sometimes have wonders and admirable singularities, but those that are in the abysses and depths of the sea seem to have even more. I am not going to mention the examples because they are too long-winded [...]²⁸; p. 25]. What will seem stranger and more unheard of: to find oysters or shells bearing pearls of such high value at the bottom of the sea, or to find only priceless shells on the tops of the mountains, the places closest to the sky and furthest from the sea? [...]²⁹

[p. 27] But let us look for the reason of these oysters, or shells, which are seen on the top of my mountain [at Loubens], and which set the whole court in turmoil when is Majesty deigned to cross the Garonne to see them. Everyone, both learned and ignorant, has searched for it on the spot, and I do not know whether they have found it, nor whether I shall find it myself, although I have searched for it in the books, which have spoken of it only very soberly, leaving it rather among the wonders of nature, the secrets of which we must not delve into any further, and among the number of doubtful things, of which we can find neither the truth, nor the reason, nor the clarification [...].

It seems, therefore, that we must ascribe it: Or to the Deluge, which changed the face of the Earth, and made the sea and the rivers stretch out and rise, and lifted up the abyss and the things that were at the bottom thereof, to set them up and lift them up in the highest of the mountains. Or to nature, which has tried and succeeded in creating great heights that are sometimes neither earth nor rock.

Among those who ascribe it to the Deluge, which brought the deepest things over the mountains and changed the face of the Earth, Tertullian seems to have said it clearly in these words, rebuking Plato for believing the opposite:

²² Abel Brunyer [1572–1665] was the physician of Gaston d'Orléans. A specialist in botany, he published the catalogue of Gaston's garden in Blois, in which he mentions « *Adiantum solii Coriandri Bauh. in pin. Capillus Veneris versus Ger* » (Brunyer, 1653, p. 4; see note below).

²³ The Venus' hair fern (*Adiantum capillus-veneris*) grows on shady, damp walls. It was used for infusions and syrups. The same fountains of Loubens are still lined with them (Fig. 5a).

²⁴ A currency of the time.

²⁵ Troglodytic chapel dug into the oyster bed, near the Loubens house (Fig. 4).

²⁶ Three pages of apologetic speech about Louis XIII follow.

²⁷ « *esbatement de la Nature* » in the original text.

²⁸ Digressions follow on the magnet, various marine wonders and the seasickness that prevents their observation.

²⁹ New digression on pearls.

« *Mutavit & totus orbis aliquando aquis omnibus obsitus: adhuc maris Conchæ & Buccinæ peregrinantur in montibus, cupientes Platoni probare, etiam ardua fluitasse: sed & enatando rursus in forma mutavit, rursus orbis alius idem mutat, & nunc localiter habitus cùm situs læditur.* »³⁰

Now, that the Flood changed the face of the Earth in such a way that what was in the depths of the sea is sometimes found on the highest summits of the mountains, anywhere in the world, the Holy Scripture formally testifies it in Genesis 6: « *Ecce ego adducam aquas diluvii super terram, ut interficiam omnem carnem, in qua spiritus vitæ est subter cælum, & universa quæ in terra sunt consumentur.* »³¹ And on the seventh day our Lord said: « *Adhuc [enim] & post dies septem, ego pluam super terram quadraginta diebus, & quadraginta noctibus, & delebo omnem substantiam quam feci, de superficie terræ.* »³²

Where do these great cavities in the rocks come from, and these perforated and scabrous boulders, and these long openings in the mountains, through which even great rivers pass and flow with such rapidity? Though from afar and under cover, they eventually find their way out and resume their course; sometimes, they only divide themselves into two, but they do not fail to hide one of their branches, so as to keep the larger one in its straight path, so as not to disturb navigation, and not to be useless to the cities, for the trade of which Nature seems to have intended them from their origin.

What does Freculphus, the Bishop of Lisieux, mean when he says, in speaking of the philosophers' view of the Flood, that there is a place which the Armenians call « *Egressorium, ubi Arcæ solutæ reliquias provinciales ostendunt. Huius autem diluvii indicium hactenus videmus in lapidibus, quos in remotis montibus Conchis & Ostreis scabros, etiam sæpe cavatos aquis visere solemus* »³³?

But no one should speak of the Deluge, or of what such a great and universal flood [p. 30] left upon the mountains, lest they should be like Ovid, whom Seneca honestly mocked, in his third book of Natural Questions³⁴, while pretending to praise his brilliant mind [...³⁵; p. 31].

Alexander ab Alexandro³⁶ went a little further, but still left the question open as to whether these oysters found on the tops of the mountains were the work of the Flood or the freak of Nature. Curiosity, he says, has so aroused the minds of many that they have wanted to know the origin and causes of Nature, and what is the principle of this great universe in which we live [...³⁷].

It may have happened that, in such a great machine, several things of different forms and kinds were joined together and incorporated in the ground. What we see proves that the ground, which is formless, changes, contracts, hardens and becomes stone by length and lapse of time, and several things of different kinds become even bodies in the insides of the stones, and are condensed together in all eternity. This good

³⁰ Tertullian [155–ca. 220], *De pallio* 2: « The whole world has changed, for it was once all covered by the waters. Even now, sea shells and whelks are lying around on the mountains, no doubt to prove to Plato that even high places were under water. When the waters receded, the globe, modified but still the same, returned to its original shape. Its appearance still changes accidentally when a region is disturbed. »

³¹ Genesis 6.17: « And I will bring a flood of waters upon the Earth, to destroy every living creature under the sky; everything on Earth will perish ».

³² Genesis 7.4: « Seven days more, and I will send rain upon the Earth forty days and forty nights, and I will destroy from the face of the Earth all the creatures that I have made ».

³³ Fréculf (*Freculphus Lexoviensis*) was bishop of Lisieux, Normandy (France), from 825 to 852; *Chronica* 1.1.25.2: « *Quem locum egressorium Armenii vocant, illic enim arcæ solitæ reliquias provinciales ostendunt. Huius enim diluvii indicium hactenus videmus in lapidibus, quos in remotis montibus conchis et ostreis scabros etiam sæpe cavatos aquis visere solemus.* » (The Armenians call this place « the landing place »; in fact, the inhabitants of the country show there the relics of the Ark [of Noah]. Even today, we see there a proof of the Flood by the presence, on the mountains isolated, of shells and oysters in rocks often ravaged by water). This text, roughly quoted by P. de L'Ancre, is inspired by the book of Raban Maur (*Rabanus Morus*), *De Universo*, itself inspired by Paulus Orosius (5th century), *Adversus paganos historiarum libri septem* (Histories against the pagans) 1.3.

³⁴ *L. Annei Senecæ Naturalium quaestionum libri VII*, III.27.

³⁵ Long digression on the ideas of Seneca and Ovid on the Flood.

³⁶ A. degli Alessandri (1532, lib. 5, cap. 9).

³⁷ Digression on Epicurus and atomism.

working Nature always gives things different aspects [...³⁸; p. 32].

Or, as some have said, because the waters were brought from various places, or the sea was overflowing and the rains were abundant, the world was flooded by some deluge. And then, after all things had mingled with the sea and the waves, and the storm had ceased, and the earth had dried up after so many overflows and torrents, the firm and solid land was discovered and appeared, so that now we find in the mountains, though very far from the sea, many things that are usually found on its shores and which, although half terrestrial, nevertheless appear to be maritime [...³⁹; p. 35].

If this property [of petrification] is given to the waters, either by their own faculties or by the advice of God (who makes and orders the rest of the wonders of the universe), to consolidate and harden sand, clay, and other similar things: How much probable is it that the mother of things, Nature, has been able, over many centuries, by virtue and physical reason, to consolidate distinct and separate bodies of various kinds? For every day we see the mountains and rocks growing, the depressions and hollows filling up by themselves, and others shrinking and changing. And the seas, which are in constant motion, some receding, others flooding, and the shape of innumerable places changing.

Albert the Great [... said] that the intelligences that move the heavens influence the seeds of things here below. But as all things that depend on these influences are agitated by the winds and other inconstancies of the air, it often happens that what should fall on the sea falls on the earth; and for this reason, shells and other fish figures formed in the mountains and rocks are sometimes found in places far from the sea.

[...⁴⁰] Truly I do not know if there is a [Hermit Crab] in the shells of my Rock, seeing that in those which are closed, when we open them, in some

there is something inside, which we cannot say whether it is one of these small dried-up fish, or the oyster itself, or some other small animal which wanted to be housed in this way [...⁴¹; p. 37]. Nevertheless, for some of the reasons which we have given above, that it comes from the Deluge, there is much more reason to believe that it is rather a game of Nature, which wanted to make stone, and made oysters or shells mixed with stone and cemented with earth, and left her work unfinished. And let us carefully consider all the other rarities which are found in the good authors, and which everyone says he has seen: There is not a man in his right mind who does not say that this is rather the work of this ingenious worker [*i.e.*, Nature] than of the runoff of the waters.

It is strange to see shells of all kinds enclosed in hard stone, and fish enclosed in shells. Is it not also strange to see a lizard which has chosen its tomb in a large piece of yellow amber, as I have seen in the collections of the Grand Duke of Tuscany, where it is enclosed on all sides, without any appearance of opening? [...⁴²; p. 39] So the Flood did not make all these enclosures; on the contrary, Nature seems to have had more of a hand in them. As there are an infinity of sacred mysteries which Nature has enclosed in the hardest marbles, to the honour and glory of the Creator of the world, it would be almost better not being able to give any plausible reason for it (not even probable) from this diversity of opinion of the ancient philosophers, to attribute them not to the length of centuries, nor to hazard, nor to the Flood, nor to Nature herself, but to the sole Author and Master of Nature, to ascribe and consider all these wonders among his least and smallest works [...⁴³; p. 40].

That is to say, in the presence of so many ancient philosophers, each of whom has attributed different origins to these shells, and with all those princes, cardinals and lords who accompanied His Majesty when he saw my mountain composed of different shells, and who did the same, having

³⁸ A few sentences about marbles of different colours, which are rich in their variety, follow.

³⁹ Dissertation on marbles and their induration, in particular the fossiliferous marbles of Calabria, observed by the author during his tour.

⁴⁰ Quote from Pliny the Elder, and digression about shells and hermit crabs.

⁴¹ Digression on grey amber.

⁴² Scholarly digressions on Cleopatra, the King of Rome Servius Tullius and the Emperor Nero.

⁴³ Text on the marbles of the churches of Saint-George in Venice and Saint-Vital in Ravenna, whose marbling seems to represent holy images.

clearly seen that the base and the foot of the cliff are of hard and clean stone, without any other mixture, that the second stage, upwards, contains shells in the shape of small twisted snails, which Tertullian calls *Buccinae*. Above this, there is another bed of hard stone, and after this, there is a high cliff, and like a third stage of other stacked oysters, the nacre of which appears in some cases as white as the most natural and common ones, and some of them are closed and complete, showing only their rough and unpolished exterior. And again, above and almost at the top of the scabrous boulders, there are large shells, attached like those on the rocks often found in the sea. I must frankly confess that it is easier to list several opinions than to find one that is true. For to believe that [p. 41] all that part of my mountain made of oysters could be made of that stone which Pliny [the Elder] calls ostracite, consisting entirely of oyster shells, I believe that there are not so many in the whole world.

So, I remain in suspense, not daring, after so many serious and different authors as irresolute as myself, to decide or say absolutely whether it is an effect of the Flood, or a game of Nature; or if we must attribute it to God alone, who made a mockery of all those philosophers and naturalists, leaving them more to doubt and admire than he gave them the insight and presumption to explain these wonders and a hundred thousand other greater ones. Anyone who attributes it to anyone

other than the Omnipotent Creator of all things seems to want to deprive him of his true name, or at least change it. To put it in Christian terms, with Seneca⁴⁴: « *Sive hunc Naturam vocas, seu Fatum aut Fortunam, omnia ejusdem Dei nomina sunt, variè utentis sua potestate* [⁴⁵]. *Num intelligis, cùm hæc dicis, te mutare nomen Dei?* »⁴⁶. The order of things comes and is given by Nature, but God alone is the author of that which gives that order.

If anyone knows better reasons or thinks he can explain it better, let him take the trouble to come to the scene, where he will see more closely what a poet [Ovid] seems to have said about it: « *Vidi ego quod fuerat quondam solidissima Tellus. Esse fretum, vidi factas ex æquore terras. Et procul à pelago Conchæ jacuere marinæ, Et vetus inventa est in montibus Anchora sumis.* »⁴⁷. He will certainly find on my mountain an old ANCHOR, which is myself⁴⁸, ready to receive him and his good advice with all the honour, applause [p. 42] and courtesy he could desire. I hope that before he leaves, the mere sight of it will throw him into such different opinions that he will be compelled to return as perplexed and irresolute as I am forced to leave him by this bad discourse, which I very humbly ask him to receive in such a good way and with such affection that I present it to everyone, especially to those who have already been there and who will still want to take the trouble to return.

⁴⁴ Seneca was obviously not a christian but a monotheist.

⁴⁵ Seneca, *Lucius Annaeus, De beneficiis* 4.8: « Whether you call God nature, destiny or fate, these are only different names for the same God, who changes himself in the various exercises of his omnipotence ».

⁴⁶ *Ibidem* 4.7: « Do you understand that by speaking in this way you are only changing the name of God? » (Pierre de L'Ancre has combined two quotations from Seneca into one).

⁴⁷ Ovidius Naso, *Publius* [Ovid], *Metamorphoses* 15, 262–265: « I have seen myself what was once solid land become the sea. I have seen earth made from the waters, and seashells lying far away from the sea, and an ancient anchor has been found on a mountaintop ».

⁴⁸ L'Ancre means « the anchor », in French.

Chibanian, Middle Pleistocene

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Abstract. In Japan, studies and researches of the earth started in the late 19th Century after the opening of the doors to the western countries. Japanese had to learn most geological concepts discovered in the western countries. A few concepts such as tsunami, Wadati-Benioff zone and Brunhes–Matuyama reversal have been given Japanese or partly Japanese names.

From the late 20 Century, the International Union of Geological Sciences (IUGS) tried to brush up the new geologic time scale based on the development of plate tectonics, especially the history of earth's magnetic field. In the Quaternary Era, IUGS invited type locality of new Epoch. Japanese geologists proposed Chibanian, type locality of which is in the Boso Peninsula, near Tokyo. At the type locality, the strata thickly continued without break, because plate tectonics of Japanese Islands made rapid stratification of Quaternary sediments. It was very unique around the world. The Chibanian section includes good tuff clay layers, abundant microfossils and good evidences of the change of the Earth's magnetic field. It is currently estimated to span the time between 0.770 Ma and 0.126 Ma (770–126 ka). The beginning of the Chibanian is the Brunhes–Matuyama reversal, in which the Earth's magnetic field last underwent reversal. Chibanian ends with the onset of the Eemian interglacial period.

The Chibanian name was officially ratified in January 2020. The Japanese Government has designated Chibanian section as a natural monument.

Keywords: Chibanian – M. Matuyama – Brunhes-Matuyama reversal

1. Geological terms in Japanese

After the opening of the doors to the western countries in 1854, studies and researches of the earth started in Japan. In the Index of the book "*Thinking about the Earth: A History of Ideas in Geology*" (Oldroyd, 1969), there are only one Japanese word and only one Japanese person's name, Tsunami and Wadati, Kiyoo. Tsunami is now used around the world. Wadati was an early seismologist at the Central Meteorological Observatory of Japan researching deep (subduction zone) earthquakes. His name is attached to the Wadati–Benioff zone. It was Wadati (1928)'s paper on shallow and deep earthquakes, comparing maximum below surface displacement against distance from the epicentre.

Wadati–Benioff zone (also Benioff–Wadati zone or Benioff zone or Benioff seismic zone) is a

planar zone of seismicity corresponding with the down-going slab in a subduction zone. Wadati and Benioff independently discovered the zones. This concept led to that of subduction in plate tectonics.

2. Matuyama's magnetic reversal

Brunhes–Matuyama reversal was not mentioned in Oldroyd (1969)'s book, but it is very important for Chibanian.

Matuyama, Motonori (1884-1958) (Fig. 1) was a Japanese geophysicist who was (in the late 1920s) the first to provide systematic evidence that the Earth's magnetic field had been reversed in the early Pleistocene and to suggest that long periods existed in the past in which the polarity was reversed. He remarked that the Earth's field had later changed to the present polarity

Matuyama was the first person to document clearly from basalts in the Genbudō (basalt caves), Japan (Matuyama, 1929).

Brunhes-Matuyama reversal (Fig; 2), the reversed magnetic polarity interval from 2.58 to 0.773 Ma that we now call the Matuyama Reversed Polarity Chron was proposed in 1964 (Cox et al.).



Fig. 1. Matuyama, Motonori (Yamasaki, 2005)

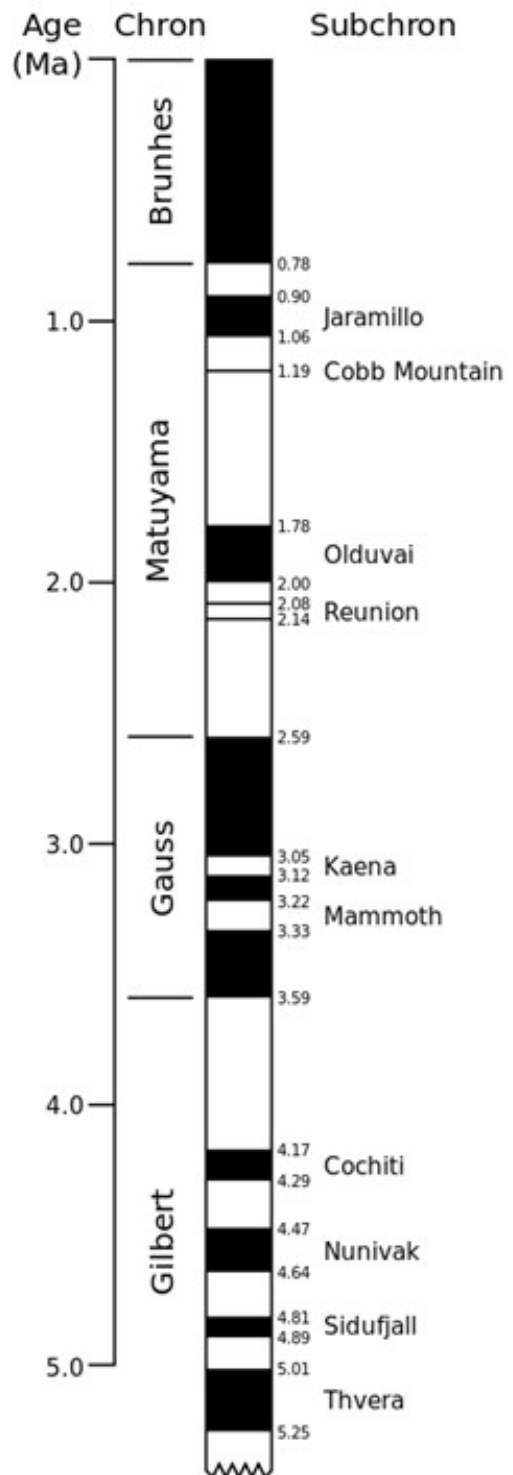


Fig. 2. Brunhes-Matuyama reversal (Wikipedia)

3. Proposal of New Epoch

From the late 20th Century, the International Union of Geological Sciences (IUGS) tried to brush up the new geologic time scale based on the development of plate tectonics, especially the history of earth's magnetic field. In the Quater-

nary Era, IUGS invited type locality of new Pleistocene Epoch.

Three places, two places in Italy and one place in Japan, were proposed for the Brunhes–Matuyama reversal. From Japan, Chibanian was proposed.

4. The strata of Chibanian (Fig. 3)



Fig. 3. The locality of Chibanian (Okada, 2023). Stop 4 is type locality of Chibanian.

Japanese geologists proposed to name “Chibanian” the geological time period ranging between from 1.29 to 0.774 Ma. Type locality is in the Boso Peninsula, 60km SE from Tokyo (Fig. 4). The Boso Peninsula is composed of thick Quaternary strata deposited in the Paleo Tokyo Bay. The type locality of Chibanian shows more than 5000 m depth of basement. The paleo Tokyo Bay opened to north and was larger than

Recent Tokyo Bay (open to south). Sediments stratified very thickly without gap in the Paleo Tokyo Bay. At the type locality, the strata thickly continued without break in the paleo Tokyo Bay, because plate tectonics at Japanese Islands made stratification of Quaternary sediments rapid in Japanese islands. It was very unique around the world.

The Chibanian section includes good tuff and clay layers, abundant microfossils and good evidences of the change of earth's magnetic field. Mt Fuji and many volcanoes erupted many times in the

Quaternary in Japan. The Jet stream blows from west to east. The strata of the Boso Peninsula have many pyroclastic flows which shows good dating.



Fig. 4. Golden spike on the boundary of Chibanian. Makoto Okada (front) is the president of the Geological Society of Japan and main person proposing the Chibanian. (For the courtesy of Okada, this figure is given)

5. The name of Chibanian

Chiba owes its name to then Chiba family. For example, Boso Peninsula is in Chiba Prefecture. So new epoch name should be Chiba + ian = Chibian. But Chibi means Lilliputian in Japanese, and Japanese People do not like the word Chibi. So Japanese people think Chiba no (of Chiba) + ian = Chiba n + ian = Chibanian.

All Japanese people are glad to hear the news of Decision of Chibanian. The Chibanian name was officially ratified in January 2020. The

Japanese Government has designated Chibanian section as a natural monument. In 2022 golden spike (Fig. 4) was settled on the outcrop of Chibanian (METI, 2020).

6. Anthropocene?

In the Quaternary Era, IUGS invited type locality of new Epoch of Anthropocene. Japan will propose the sediment of Oita Bay for type sediment, but there will be no Japanese name as geological term.

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The significant objects of the Quaternary formations studied by A. K. Giedraitis (1848-1909) and their changes over time

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Abstract. Duke A. K. Giedraitis (1848–1909) – a geologist with a renowned professional career, evidenced by his extensive inquiry reports and publications in German, Polish, and Russian (Duke..., 2023). He is well known in Lithuanian and neighbouring countries' scientific history. A. K. Giedraitis created the first geological map of such a large region by international standards, well understood the characteristics of Quaternary deposits, and took at that time an audacious position that previously the area had been covered by two or three glaciations. A standard label and an authorized stratigraphic chart, as well as his observations were used to create the M 1:420 000 geological map. A. K. Giedraitis's summary publication with the map, however, did not appear until 1895 (Гедройц, 1895).

The objects of his investigations were relief, outcrops, springs, boreholes, and mines. All of them have undergone different changes over time. Some outcrops significant for Quaternary geology have been destroyed or overgrown with trees, or entered the Cultural Heritage System, and others have become stratigraphic standards, etc.

Keywords: A. K. Giedraitis – Quaternary – Polyglacialism – Geological mapping – Lithuania

Introduction

Antanas Karolis Giedraitis (1848–1909) was the first to create a geological map of a such wide region based on the international requirements of geological mapping, using the internationally accepted conventional legend and ratified stratigraphic scheme recognized at that time. In 1895, he compiled all the research and described the results of the study on the Nemunas, Neris, Šventoji, and other river valley outcrops, where he discovered and identified numerous new Cretaceous and Tertiary formations (Гедройц, 1895). The results of the observations and research show that A. K. Giedraitis had a good understanding of the properties of sediments in Quaternary deposits.

In the second half of the 19th century, the theory of continental glaciation was published. It was found that boulders found on the surface of the Earth were brought in by the continental glaci-

ers. The first knowledge about it appeared during the study of the Alpine mountains. At first, it was thought that there was only one glaciation (monoglacialism), later, it was found that there were many glaciations (polyglacialism). A. K. Giedraitis was well-acquainted with and was a supporter of the newly formed theory of polyglacialism (Dalinkevičius et al., 1969).

Today a look at the objects investigated by A. K. Giedraitis shows that they have much changed during the last 130–140 years. Some of them have been transformed into vast quarries, others are now hidden by scree on their slopes or by advancing forests. Some have become items of natural and cultural heritage or served as inspiration for the creation of artists.

We present several geological objects explored by A. K. Giedraitis, whose studies enriched the knowledge of Lithuanian geology.

Materials and Methods

The research in this study is supported by new findings from numerous archives and literature sources. The authors drew on the research and writings of A. K. Giedraitis as well as information on his studies from other scientists. The study material for the work was gathered by the authors themselves from the Upper Pleistocene till complex in the Jiesia River (Rokai outcrop and other) and the distribution zones of chalk and Jurassic system slabs (blocks) in southern Lithuania (Akmuo Village and other)

Results

Among the explored outcrops, mention should be made of Grodno and Nemunaitis (outcrop by the Nemunas River), Pamerkiai (outcrop by the Merkys River), Rokai (outcrop by the Jiesia River), Plikakalnis (outcrop by the Neris River), Bekešas Hill (outcrop by the Vilnia River), and many other outcrops, as well as drinking water springs and the first artesian boreholes in Vilnius (Fig. 1). According to recent studies, many of A. K. Giedraitis's conclusions reached more than a century ago, are confirmed.

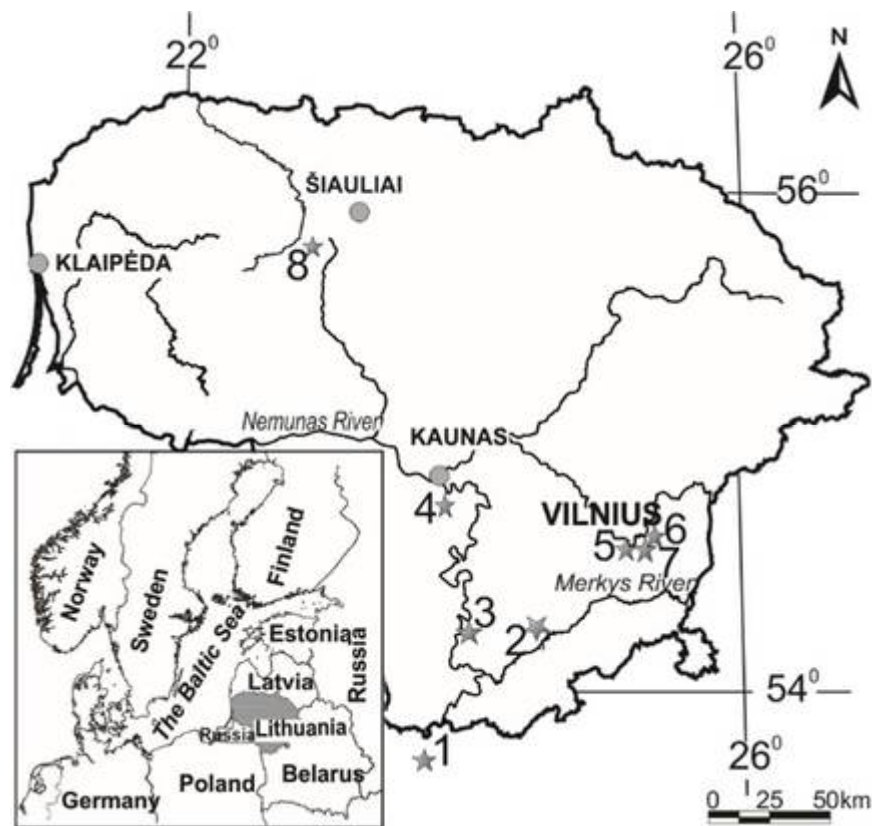


Fig. 1. Study site: 1 – The Grodno Chalk Quarry; 2 – the outcrops with chalk layers not *in situ* at the villages of Pamerkiai and Akmenis; 3 – the limestone tuff (spring limestone) outcrop at the Nemunaitis Village; 4 – the Jiesia River outcrops; 5 – the Plikakalnis outcrop; 6 – the Bekešas Hill outcrop; 7 – the “Pogulianka” borehole; 8 – the Venta-Dubysa Channel

The Nemunas River outcrops

A. K. Giedraitis researched the area around Grodno (Belarus) and described of the Nemunas River outcrops with chalk layers. The Cretaceous rocks that A. K. Giedraitis described were even-

tually mined and then transformed into a sizable industrial quarry. Its extensive extraction of chalk didn't start until after World War II and hasn't stopped until today. The portion of Grodno's exploited chalk quarries has been transformed for recreational use (Fig. 2).



Fig. 2. The Chalk Mine in Grodno, 1959 (<https://www.ksm-grodno.by/pictures/virtua-ksm/index.html>)

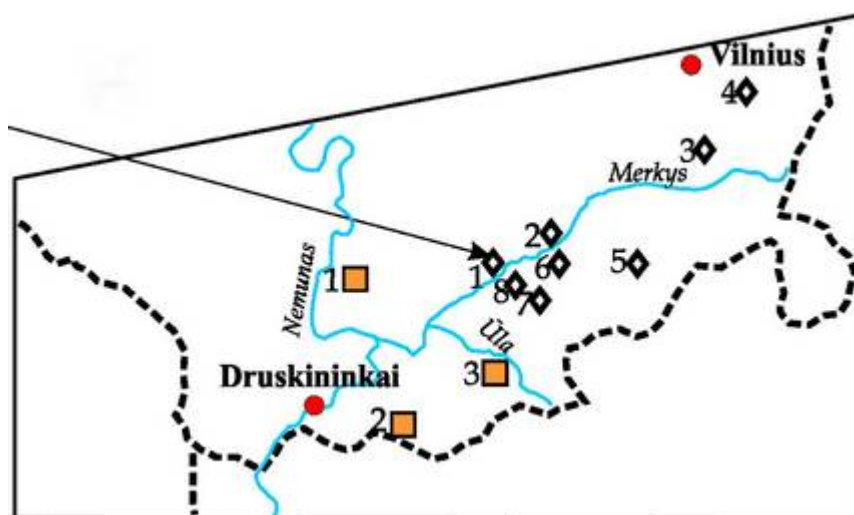


Fig. 3. Distribution of the chalk deposits and the Flint Mines in southern Lithuania. The chalk deposits: 1– Akmuo, 2 – Kuktiškės, 3– Juodžiai, 4– Naujoji Vilnia, 5– Tetėnai, 6– Mielupis, 7– Šarkiškės, 8– Matuizos. The Stone Age Flint Mines: 1– Ežerynas, 2– Margionys, 3– Titno ežeras (Baltrūnas *et al.*, 2006)

One of the most interesting and one of the largest outcrops in Lithuania (Alytus district) that formed during the Holocene – the Nemunaitis outcrop (Fig. 4). This is a sediment of mineral springs – limestone tuff (spring limestone). These deposits typically range in size from a few hundred to a few thousand cubic meters and are smaller than lake limestone. The limestone deposit at the Nemunaitis Springs was discovered to be composed of three lenses of calcareous tuff that can occasionally reach thicknesses of 6 to 8 meters through the examination of boreholes (Fig. 5) (Lietuvos geologija, 1994).

This Holocene-aged rock is heterogeneous and porous, includes plant impressions and remnants, and is tinted yellow or brown by iron compounds. It is nearly a kilometer long and dips into the abrasive sand along the Nemunas shore. A. K. Giedraitis found 11 mineral water springs

nearby during the investigation, but only one of them still exists now.

The Merkys River outcrops

The first chalk system deposits were discovered and reported by A. K. Giedraitis in South Lithuania in 1895 at Merkys River outcrops close to the villages of Pamerkiai and Akmuo. But the mining of chalk there never took place – World War I put a stop to plans to mine the chalk in Pamerkiai Village. Before World War II, geologists from Vilnius University were interested in these deposits. After this war, studies on them continued (Paškevičius, Baltrūnas, 1978), and with the help of recent studies, it is better to understand the sinking character and occurrence of the slabs of the Jurassic and Cretaceous systems and according to the palaeontological data to know more about their stratigraphic dependen-

cy. The studies of the fossils from the carbonated rocks (chalk and marl) allowed us to identify layers. Foraminifera *Gaudryina laevigata* Franke, *Textularia turris* d'Orb, bivalve mollusks (*Inoceramus cardiformis* Sow.), sea urchins (*Terebratulina striatula* Mant), and sea urchins (*Cidaris vesiculosus* Gold et al.) testified the deposits from the Konjac and Santon levels of the Cretaceous system near Akmuo Village (Paškevičius, Baltrūnas, 1978). It is interesting that between the stratigraphic units of the Cretaceous system,

there is a fixed rock formation, the stratotype of which is in the Žiogeliai borehole near Druskininkai (The Formation..., 1999).

A. K. Giedraitis' conclusion about the subsidence of chalk layers *not in situ* (i.e., glacioidislocations) was confirmed by all later investigations. Interestingly, subsequent research revealed that chalk flints were already exploited in South Lithuania at prehistoric times too (Fig. 3) (Akmens amžius..., 2001).



Fig.4. The Nemunaitis outcrop. Photo by R. Šečkuvienė

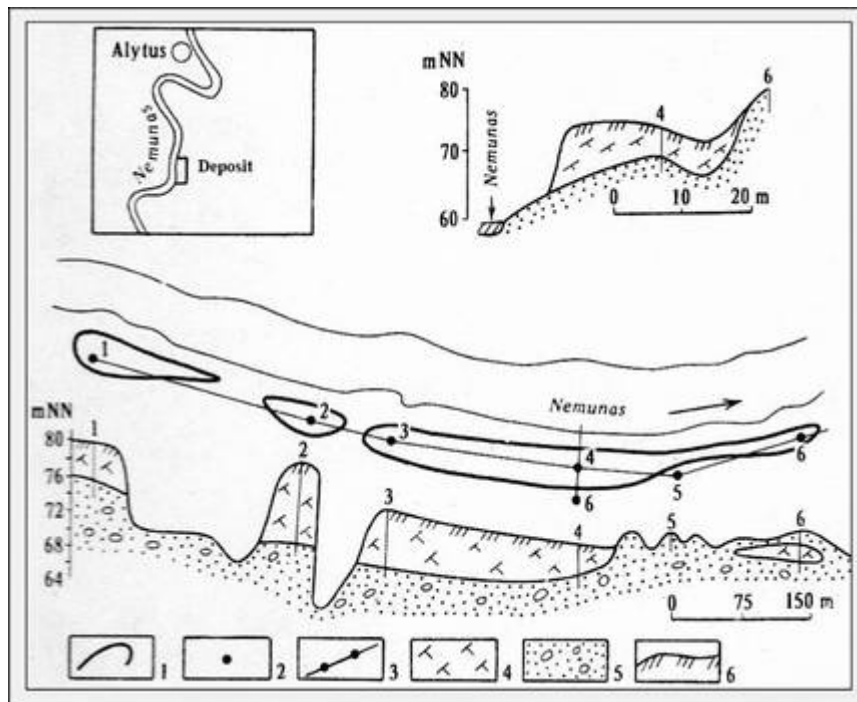


Fig. 5. The limestone tuff deposits of the Nemunaitis outcrop. 1– limit of deposit; 2– borehole; 3– cross-section; 4– limestone tuff; 5– sand with pebble; 6– soil (Lietuvos geologija, 1994)

The Jiesia River outcrops

There were many outcrops in the Jiesia River during the time of A. K. Giedraitis' investigation and up to 1958 when the Kaunas hydroelectric power plant was built. Only a few outcrops, which are crucial for understanding Upper Pleistocene stratigraphy, are left today. At the present river level, rocks from the Cretaceous period are also visible. Data about the investigation of the Jiesia River may be found in the "account" of the geological expedition carried out by the University of Lithuania in 1925–1926 (Kaveckis, 1928) and the summary of the geological research of 1927–1930 (Kaveckis, 1931) (Fig. 6).

They also provide the initial findings about the distribution and chemical composition of chalk deposits. The following number of components (%) were found in the intervals 0.65–7.6 m and 7.6–11.0 m of drilled well No. 1 (1926): heating loss: 38.11 and 32.78; CaO: 46.10 and 38.40; Al₂O₃ + Fe₂O₃: 3.52 and 8.99; SiO₂: 11.33 and 18.9; MgO: 0.92 and 0.73. This information about the chalk under study indicated that it was fit for usage (Kaveckis, 1931). Above the often disintegrated (dislocated) chalk sediments there are the deposits of the Quaternary system, which have

been visually described by A. K. Giedraitis in 1895. Remained his description of the 40-meter outcrop of the Jiesia River.

At the end of the 20th century and the beginning of the 21st century, the Quaternary sediments of the Jiesia River outcrops were evaluated in palaeogeographic, stratigraphic, and geochronological aspects using various analytical methods (petrographic, lithological, palynological, and geochronological, OSL, C14) (Baltrūnas, 1995; Gaigalas, 2001; Gaigalas et al., 1994; The Rokai..., 1996; Гайгалас, 1971; etc.) (Fig. 7). They showed the structure of the Middle and Upper Pleistocene deposits in the valley of the Jiesia River at Rokai locality and allowed us to substantiate the stratigraphy of the Upper Pleistocene in Lithuania. A large column of the Nemunas limno-fluvial deposits got the OSL dates from 63 000±6 000 to 32 000±4 000 years (Gaigalas et al., 1994). These OSL dates correlated well with the radiocarbon dating stated. According to these dates, the maximum of the Late Pleistocene Glaciation took place in South Lithuania in the Late Nemunas (Late Weichselian) stadial. Normally, the till of the Late Nemunas covers the deposits of the Rokai Mega-interstadial (Gaigalas et al., 1994; The Rokai..., 1996) (Fig. 8).

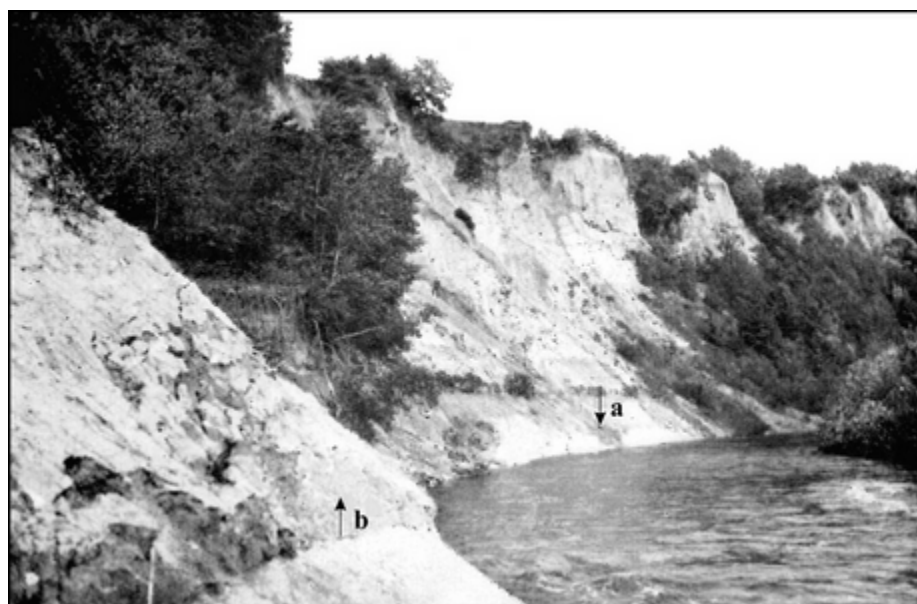


Fig. 6. The high Jiesia River outcrops, 1925: a– marl; b– clay (Kaveckis, 1928)



Fig. 7. The Jiesia River outcrop today. Photo by V. Baltrūnas

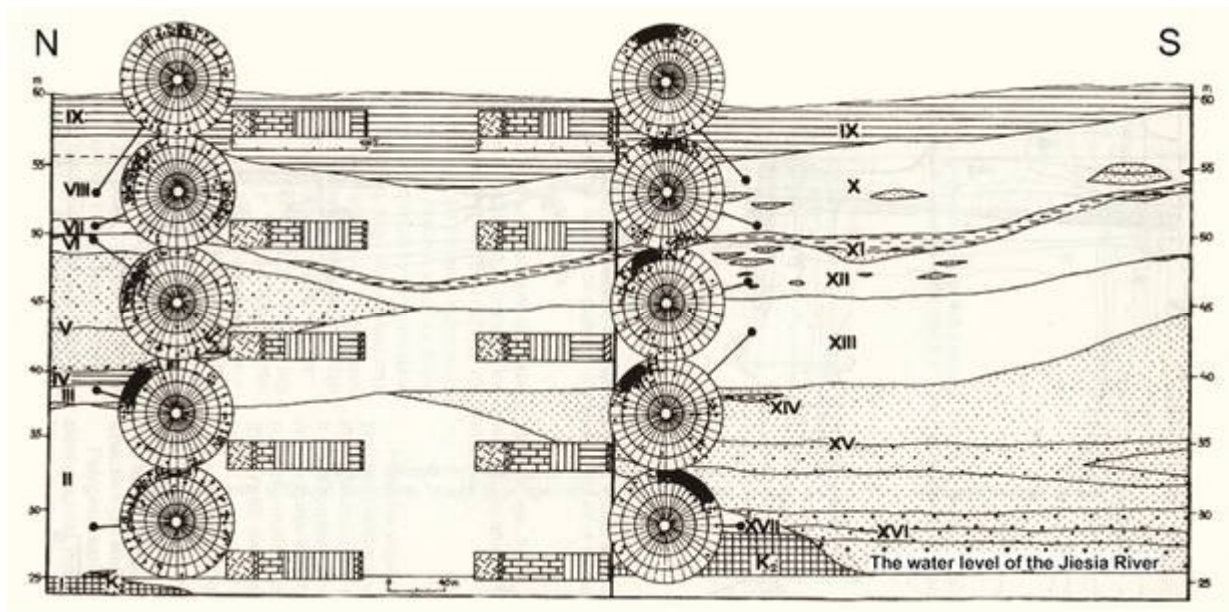


Fig. 8. Structure of Middle and Upper Pleistocene deposits of the Jiesia River near Rokai Village. The stereograms of orientation and inclination of macro-clast in till and diagrams of petrographic composition of macro-clasts by A. Gaigalas and V. Baltrūnas. I– marl and chalk (K_2); II, XVII– Middle Pleistocene till; III, XIII– Upper Pleistocene Grūda till; IV– clay; V– fine and various sand; VI, VII, XII– Upper Pleistocene Baltija till; VIII, X– South Lithuania Phase till; IX– varved clay; XI– silt and fine sand; XIV– soil; XV– fine and various sand; XVI– gravel (Baltrūnas, 1995)

The Neris River Plikakalnis outcrop (Bare Hill)

It is known as *Lysa Gora* (*in Polish*) in literature too. A. K. Giedraitis described it in detail and a cross-section of this outcrop (height – 204.5 feet or 60 m) from top to bottom (with corrected sediment names): till (red) – 8.5 m; silt – 0.46 m; sand – 8.2 m; till (grey) – 7.3 m; sand, with interlayers of silt – 21.3 m; sand (claying) – 8.5 m; sand (very fine) – 5.2 m (Гедройц, 1895). In the section of the outcrop, can be seen the till (glacial deposits) of two glaciations and below them the thick layers of sand, that are typical of Vilnius City and can also be seen in other outcrops. Scientists from Vilnius University, notably A. Halicka (Antonina Jaroszewicz-Kyszyska-Halicka), examined this outcrop in the interwar period (Fig. 9)) and these investigations earned her the M. S. degree.

To make studying numerous samples simpler, A. Halicka applied B. Ryzdewski's petrographic

method (Kosmowska-Ceranowicz, 1986; Pas-sendorfer, 1946). She examined petrographically the coarse-grained part of all three till layers that were distinguished by A. K. Giedraitis too. The four layers have the same index values, so they were defined by the author as the bottom of oscillating moraines belonging to one glacier. Detailed studies of the Plikakalnis outcrop were carried out by A. Gaigalas and his colleagues (Гайгалас *et al.*, 1984). Two moraines of the Middle Pleistocene Age (Žemaitija and Medininkai) were identified (Fig. 10). The Medininkai moraine complex consists of two layers. In the lower layer, there are interlayers formed by two receding lobes of one glacier (Гайгалас *et al.*, 1984).

The outcrop is now heavily overgrown, and difficult to access. It belongs to the landscape reserve. Geological research can no longer be conducted there.



Fig. 9. The Plikakalnis outcrop. Photo by J. Wojciechowski (Jaroszewicz-Kłyszyska, 1938)

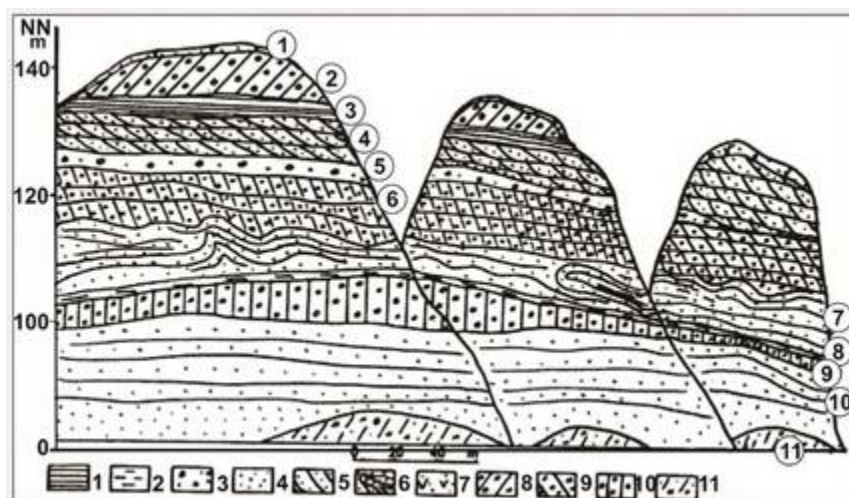


Fig. 10. The cross-section of the Plikakalnis outcrop. 1 (in the scheme) and 7 (in legend)– soil (pd IV); 2 and 8– Medininkai till (g II md); 3 and 1– clay (lg II md); 4 and 5– fluvioglacial sand (f II md), gravel and pebble; 6 and 9– Medininkai till (g II md); 7 and 6– sand of Snaigupėle Interglacial (II sn); 8 and 2– glaciolacustrine silt (lg II žm); 9 and 10– Žemaitija till (g II žm); 10 and 4– sand of Butėnai Interglacial (II bt); 11 and 11– Dainava till (g II dn) (Gaigalas, Melešytė, 1993)

The Vilnia River outcrop – Bekešas Hill

This outcrop was constantly exposed to severe erosion. It was given the name Bekešas after the Hungarian military leader Gáspár Bekes (1520–1579). He was buried atop the hill because he practiced Arianism faith and would not be allowed in Vilnius City's cemeteries. An octagonal tower served as a monument to his burial. The Bekešas Hill outcrop's cross-section reveals two glacial till layers as well as the distinctive Vilnius City sand layers in the lowest half of

the section. The 143 feet (about 43 m) outcrop from top to bottom (with corrected sediment names): sand, with interlayers of clay – 14.6 m; gravel – 1.2 m; till (red) – 1.8 m; sand (various) – 1.2 m; clay – 1.8 m; sand (various) – 3.4 m; till (grey) – 8.5 m; sand (fine) – 0.6 m; sand (greenish grey), with glauconite – 10.4 m (Гедройц, 1895).

Currently, the remains of the Bekešas Hill outcrop are covered with trees and is not accessible for direct investigation and it belong to the Cultural Reserve of Vilnius Castles (Fig. 11).



Fig. 11. The Bekešas Hill outcrop, 1873–1881. Photo by J. Czechowicz

The artesian boreholes

At the end of the 19th century, the natural springs that had previously supplied Vilnius City with water were replaced with artesian wells, one of which was investigated by A. K. Giedraitis in 1883 ("Pogulianka" borehole in Vilnius) (Fig. 12). It was equipped for the needs of the Russian tsarist army. "Pogulianka" was the first borehole in Vilnius that reached the deep layers of the Earth (D2), which are sinking under the cover of glacial deposits. Sections of borehole (from top to bottom): 0–12.78 m – sand (various) [Q3]; 12.78–24.50 m – till (grey) [Q2]; 24.50–51.32 m – sand (fine) [Q2]; 51.32–59.74 m – till [Q2] (without samples); 59.74–71.32 m – sand, with gravel [Q2]; 71.32–75.90 – till (grey) [Q2]; 75.90–78.18 – sand glauconitic [K1]; 78.18–79.55 – sand, with interlayers of carbon [K1]; 79.55–106.07 – sand glauconitic [K1]; 106.07–117.65 – clay (grey), with interlayers of sandstone [D2] (Гедройц,



Fig. 12. The "Pogulianka" borehole in Vilnius. Photo by V. Baltrūnas

1895). The geological data of this borehole entered the “Gold Fund” of Lithuanian geology. Based on these data, the creators of geological science, A. K. Giedraitis, P. Jodelė, M. Kaveckis, and J. Dalinkevičius explained the regularities of the geological structure of eastern Lithuania and the history of geological development.

The place of “Pogulianka” borehole is marked by the octagonal tower and today it is included in the Cultural heritage system.

The Venta-Dubysa Channel

It is another interesting object studied by A. K. Giedraitis. First, in a few words about one significant fact of our country's history. In 1569 one of the largest countries in Europe Polish–Lithuanian Commonwealth was formed, which united the Kingdom of Poland and the Grand Duchy of Lithuania. It ended its existence in 1795 when three countries – Prussia, Austria, and Russia third (last) time divided Commonwealth among themselves. The Polish–Lithuanian Commonwealth had been completely erased from the map of

Europe (Poland and Lithuania re-established their independence, as separate countries, only in 1918 after World War I). After partition Lithuania fell into the clutches of the Russian Empire, which wished to increase its power in international trade and seize control of the ports. The Nemunas River was the sole route from Lithuania to the Baltic Sea, but at that time, the mouth of the Nemunas River was controlled by Prussia. As a result, the concept of creating channels to connect the Nemunas River Basin with the Baltic and Black Seas emerged in Russia (Fig. 13). The Venta-Dubysa Channel was one such, and work on it started in 1824. However, the building was halted in 1831 when a rebellion occurred in Lithuania. Many years later, A. K. Giedraitis researched the abandoned channel and paid a lot of attention to the possibilities of using peat from the drained swamp. Channel mining works resumed in the 20th century, but the outbreak of World War I put an end to them. Currently, almost all of it belongs to Kurtuvėnai Regional Park, but only the remains of the channel and several locks (Fig. 14).

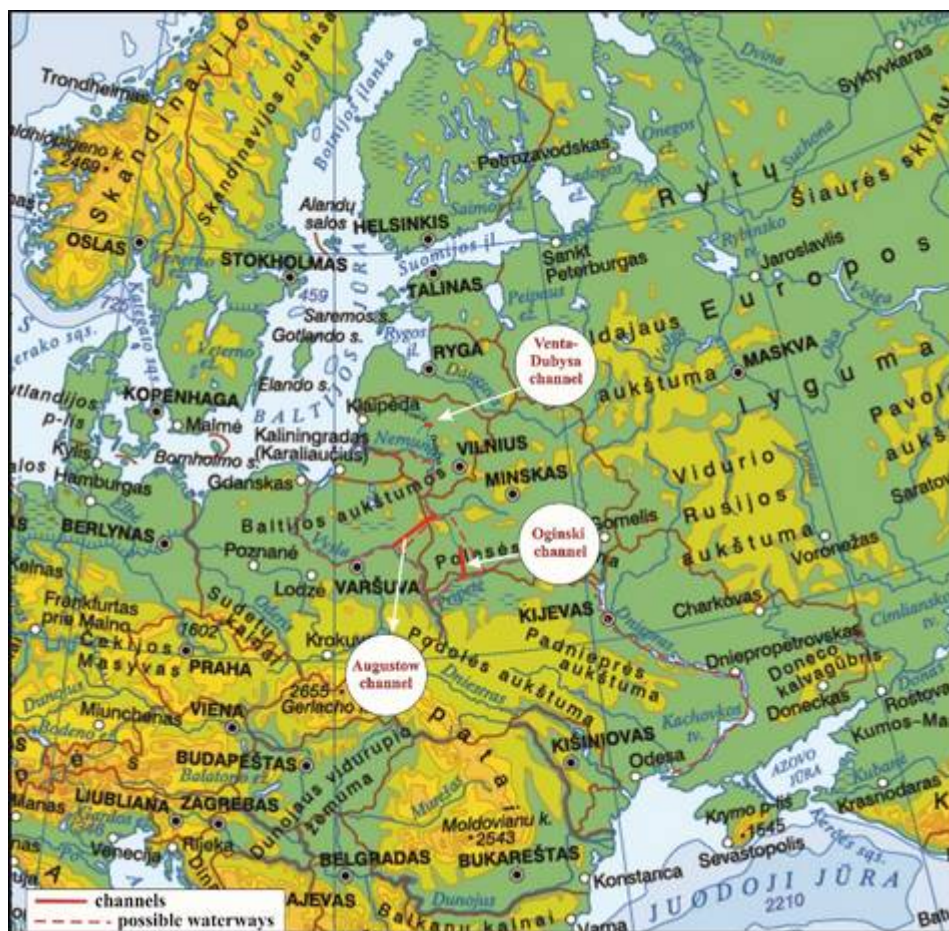


Fig. 13. The channels connecting the Nemunas River Basin with the Baltic and Black Seas on the map of Europe

(https://lt.wikipedia.org/wiki/Ventos%E2%80%93Dubysos_kanalas#/media/Vaidzas:VentosDubysoskanalas1.JPG)



Fig. 14. The Venta-Dubysa Channel near Žadvainiai Village (Kurtuvėnai Regional Park, Šiauliai district)

Generalization and Conclusions

In this overview of the Quaternary objects studied by A. K. Giedraitis, we wanted to show the primary investigations, facts, and observations made 130–140 years ago and their significance of obtaining for future research. A. K. Giedraitis himself wrote about this purpose of his research in the introduction to his work, emphasizing that he aims to <<*publish his observations to facilitate the work of future researchers*>> (Гедройц, 1895). Based on this overview of the A. K. Giedraitis geological works on the territory of Lithuania and other neighbouring countries and on the conclusions that he presented, it is safe to say that A. K. Giedraitis is the first modern Quaternary researcher in Lithuania, who used the theory of continental glaciation in Quaternary studies (Paškevičius, 2023). In the Merkys River Valley, he skillfully recorded the

phenomenon of the deployment of Cretaceous and Jurassic system rocks *not in situ*, *i.e.*, recorded the phenomenon of their deployment during glaciations – glacioidislocations. His observations were supported by further research. In Lithuania, several of the outcrops he repaired and investigated later served as supporting sections for Quaternary sediments, enabling him to recreate the palaeogeographical circumstances that led to sediment production and associated geochronology.

Acknowledgments

The authors thank the organizing committee for the mention of the 175th anniversary of A. K. Giedraitis in 2023, which encouraged us to take a deeper look at the Quaternary research works of geologist Duke A. K. Giedraitis.

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Investigations of the lithuanian quaternary deposits of duke Antanas Giedraitis in 1878-1895 and his approach to the theories of continental glaciation and polyglacialism

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Abstract. Vilnius College was founded in 1570 and Vilnius University in 1579. The Faculty of Philosophy teaches Aristotle's physics, often called natural philosophy or natural science. Geological knowledge was also provided. In the 18th century, scientific works on natural philosophy appeared at Vilnius University, which also dealt with geology. The Department of Natural History was founded in 1781, with the aim of linking science with practice and economic needs. Expeditions were organised to study the resources of the region, and collections of minerals, rocks and fossils were made. The most successful and distinguished professors were Ž. E. Žiliberas (*Joan Emmanuel Gilibert*, 1741-1814), J. G. Forsteris (*Johan Georg Forster*, 1754-1795) and St. B. Jundzilas (*Stanislaw Bonifacy Jundziłł*, 1761-1847).

The Department of Mineralogy was established in 1803. R. Simonavičius was its first head and organiser. He taught mineralogy until 1813, assembled a huge collection of mineralogy, created a classification of mineralogy, and is considered the pioneer of geological science in Lithuania. He was succeeded by Feliksas Dževinskis, who taught mineralogy from 1814 to 1817, Ignotas Horodetskis 1817-1824, Juozapas Jundzilas 1824-1825, Ignotas Jakovickis 1825-1832. After the closing of Vilnius University in 1832, a part of geognosists still worked in Vilnius Medical Surgery Academy, until its closing in 1842.

Geology as a science stopped to develop in Lithuania. For 80 years Lithuanias' geology saw only episodic interest from other universities', scientific societies', Geological committees' (since 1882) geologists. Tsarist government had no interest in prospecting local minerals. That is why geologists who originated in Lithuania tried to organise geological expeditions in an attempt to fill the gaps in the geological survey of Lithuania. Most notable example of such attempts are the geological researches in 1878, 1883, 1884 and 1885 by Antanas Giedraitis (Antoni Karol Giedroyc, 1848–1909).

Results were published in 1886 and 1887 (Giedroyc 1886a; 1886b; 1887). A summary of all research together with geological 10-verst scale map was published in 1895 (Гедройц, 1895).

Since 1882, A. Giedraitis was an associate of the Geological committee. This allowed him to carry out these geological expeditions, which (as he writes) began from his homeland, Korvio (Karvio) manor in Maišiagala region near Vilnius. He performed three main expeditions. Two were in the meridian direction. One in latitude direction. More than a third of all the expeditions are in current territory of Lithuania.

A. Giedraitis' drawings and descriptions of the observed outcrops' layers as well as the interpretation of the information suggests that he was very well acquainted with the newly established continental glaciation theory and was proponent of the theory.

He discovered there had been more than one glaciation. Some outcrops had visible sediment from two glaciations at different periods, in others even three. By supporting the polyglacialism theory he stated that he lacks data to precisely name the number of past icings. In A. Giedraitis opinion the polyglacialism theory is also supported by aging surface relief from north to south.

Keywords: Vilnius University – Continental Glaciation – Polyglacialism – Duke A.K. Giedraitis – Quaternary Deposits.

After the last division of the Republic of Both Nations in 1795 until the First World War, Lithuania was occupied by the Russian Empire, and in 1915 - German. Only in 1918 February 16 Lithuania was restored as a democratic state.

When the population came under the influence of the Russian government, they expressed dissatisfaction with conspiracies and uprisings. Vilnius University students and teachers actively participated in the particularly important uprisings of 1830-1831 and 1863-1864, which were brutally suppressed by the tsarist authorities. After each defeat, the conditions of the political and cultural life of Lithuania worsened, and the persecutions of the Russian authorities became more and more severe. The centre of Lithuanian science - Vilnius University - was closed in 1832, and geology, like other sciences, stopped developing.

After the closing of Vilnius University in 1832 a part of geognosists still worked in Vilnius Medical Surgery Academy, until its closing in 1842.

For 80 years Lithuania's geology saw only episodic interest from other universities', scientific societies', Geological committees' (since 1882) geologists.

Tsarist government had no interest in prospecting local minerals.

That is why geologists who originated in Lithuania tried to organize geological expeditions in an attempt to fill the gaps in the geological survey of Lithuania.

The most striking example of such attempts is the geological research of Duke A.K. Giedraitis. (Antoni Karol Giedroyc, 1848–1909) (Fig. 1 and 2).

Antanas Karolis Giedraitis was born 1848 on the 20th February and baptized on the 21st.

Antanas Karolis Giedraitis died on November 8th, 1909. He was buried in the Karvis¹ cemetery (Figs. 3, 4 and 5).

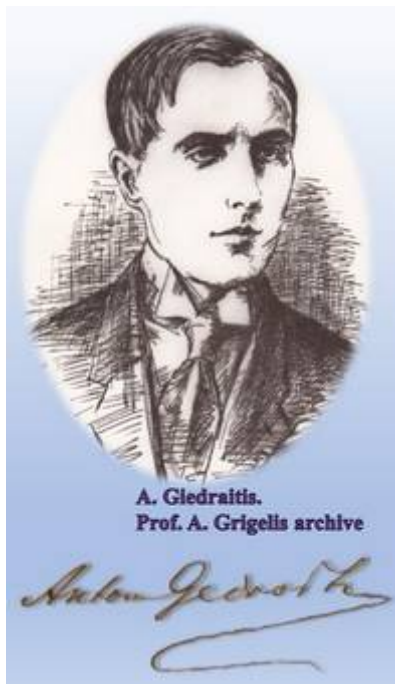


Fig. 1. Antanas Karolis Giedraitis (Antoni Karol Giedroyc, 1848–1909). Drawing, 1962. From the archive of A. Grigelis

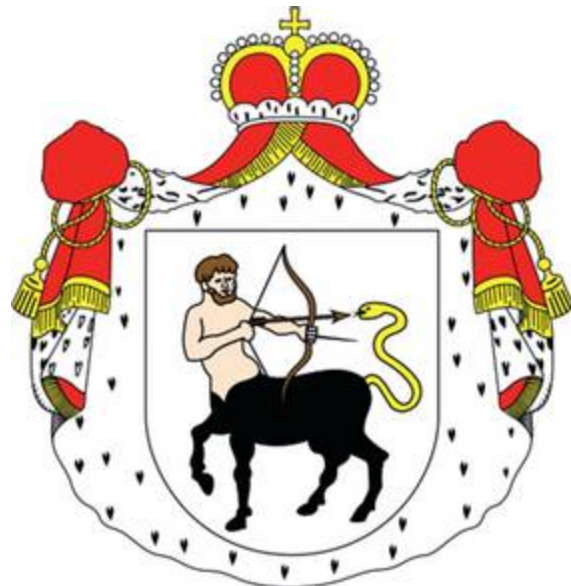


Fig. 2 Coat of arms of the Giedraičiai family (XIIIth century)

¹¹Vilnius district village in Maišiagala ward, on the south bank of Karvi's lake. In historical sources, Karvis manor first mentioned in 1691. For some time it belonged to the Giedraičiai family. There are the remains of the manor house.



Fig. 3. Karvis Church, built in 1865, with a cemetery



Fig. 4. The graves of A.K. Giedraitis and his father Edmundas have been newly arranged (photograph by E. Genutis)



Fig. 5. The Priest consecrates the renovated tombstone. 19/05/2023 (photograph by V. Baltrūnas)

Most notable example of such attempts are the geological researches in 1878, 1883, 1884 and 1885 by Antanas Karolis Giedraitis (Antoni Karol Giedroyć, 1848–1909).

Results were published in 1886 and 1887 (Giedroyć 1886a; 1886b; 1887).

A summary of all research together with geological 10-verst scale (1:420,000) map was published in 1895 (Гедройц, 1895).

Since 1882, A. Giedraitis was an associate of the Geological committee. This allowed him to carry out these geological expeditions, which (as he writes) began from his homeland, Korvio (Karvio) manor in Maišiagala region near Vilnius. He performed three main expeditions. Two were in the meridian direction. One - in latitude direction. More than a third of all the expeditions are in current territory of Lithuania.

Having established relations with the Petersburg Mineralogical Society, in 1878 A. Giedraitis carried out geological work in Gardins Governorate, neighbouring Lithuania and Poland territories.

A. Giedraitis prepared the reports of these studies, which were published 1886-1887 (see bibliography). In 1882 after the establishment of the Russian Geological Committee, A. Giedraitis becomes its member and actively engages in its activities.

He conducted geological routes in Kaunas and Suvalkai provinces (Fig. 6), used their geological material for making the fifth sheet of the 10-valve scale geological map (Гедройц, 1884). Later, he conducted new geological surveys of Poliesia, the reports included a geological map compiled by him was also published (Гедройц, 1895).

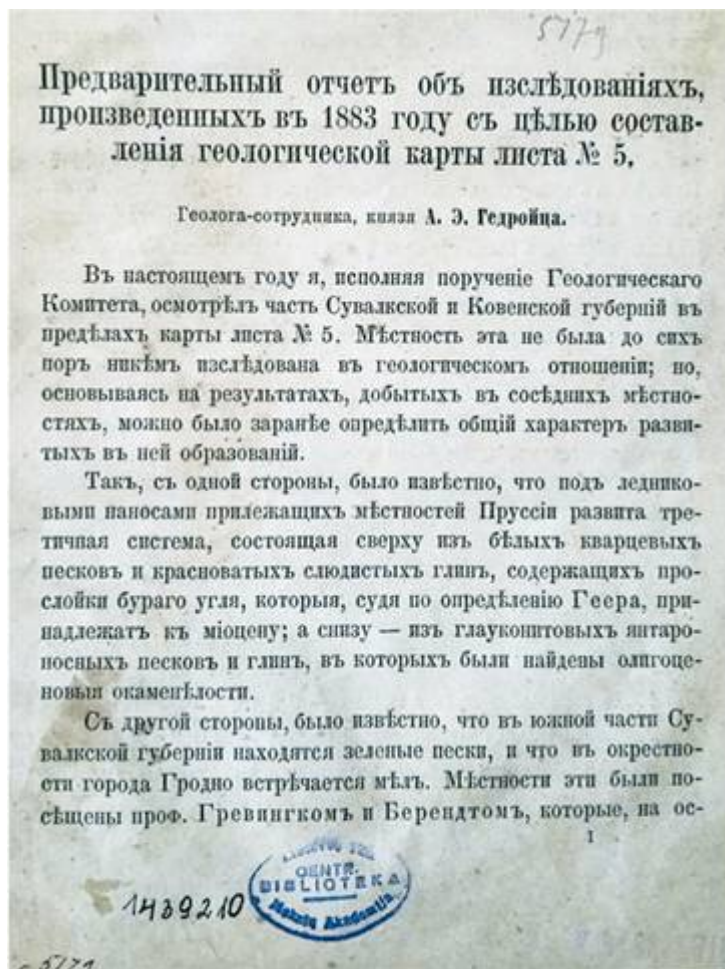


Fig. 6. A fragment of A.K. Giedraitis report on the explorations of Kaunas and Suvalkai provinces in 1883

A. Giedraitis' drawings and descriptions of the observed outcrops' layers, as well as the interpretation of the information suggests that he was very well acquainted with the newly established continental glaciation theory and was proponent of the theory.

The theory of continental glaciation had only recently begun to gain ground in the scientific

world: Swiss pastor Bernar Kuhn (1787), Scotsman James Hutton; the Swiss Jean Pierre Perraudin (Fig. 7) and Ignaz Venetz (1818); Norwegian Jens Esmark (1824); German Prof. Reinhard Bergardis (1832); Louis Agassiz (1837) tried to convince that there was no "global flood" (Fig. 8).



Fig. 7. The house built by Jean-Pierre Perraudin himself is now a museum in the village of Lutjero (Switzerland) (photograph by E. Rudnickaitė)

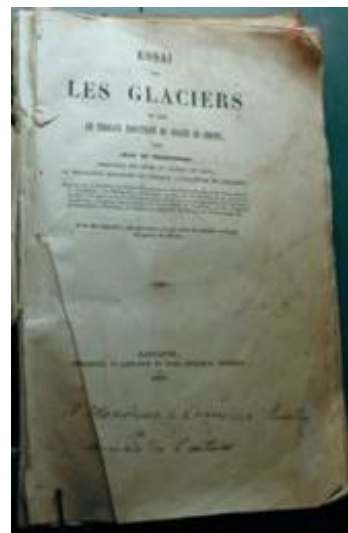


Fig. 8. Agassiz's book *Essai sur les glaciers* published in 1841, title page with inscription of gift autograph to Perraudin (photograph by A. Bitinas)

Finally, in 1880, the scheme of the chronology of the old glaciations was "born".

We don't know if A.K. Giedraitis had read all the works of L. Agassiz (1839, 1840, 1841, 1847, 1866). But it is safe to say that they were known to him.

A.K. Giedraitis discovered that there was more than one glaciation in the areas he studied. Some outcrops had visible sediment from two glaciations at different periods, in others even three.

By supporting the polyglacialism theory he stated that he lacks data to precisely name the number of past icings. In A.K. Giedraitis opinion

the polyglacialism theory is also supported by aging surface relief from north to south.

R. Guobytė (2023) states: «No topographic maps were available at that time; therefore, he could not map the distribution of glacial and post-glacial deposits. He emphasized that the distribution of these deposits depends greatly on the surface features he had so carefully described in his notes. A.K. Giedraitis recognized the most prominent morphological structures: a belt with numerous lakes (present-day marginal Baltija Uplands); a sandy, undulating south-eastern plain grading into dunes; and the lowland of the Nemunas low reaches. He recognized Telšiai-Raseiniai (Samogitian) and Venden (Vidzeme) uplands, nowadays

recognized as insular uplands. He described two depressions stretching southward from the Riga Bay and Peipsi (Čiudas) Lake, which nowadays are recognized as pathways for the Last Glacier flows. A.K. Giedraitis was a follower of the glacial theory and the first scientist to build a realistic, close to modern understanding, geomorphology picture of Lithuania and neighbouring areas. A.K. Giedraitis, by no doubt, is a pioneer of geomorphological mapping».

Pioneer of Quaternary research in Lithuania

Although only one phase of this scientist's life is related to Lithuania, it is definitely possible to claim that A.K. Giedraitis was one of the pio-

neers of Quaternary research in Lithuania (Figs. 9 and 10). He completed several routes along the banks of the Nemunas, Neris, Šventoji, Dubysa, Jura and other rivers, explored the river valleys of the territories of Belarus and Poland.

The presented geological map of A.K. Giedraitis shows that two routes were in the meridian direction (the first - from the headwaters of the Venta River through the Kaunas, Suwalki and Gardinas governorates; the second - from Vilnius along the Poliesé railway to the city of Rovno in the Voluinés governorate). The third route continued through the governorates of Minsk, Gardin, Suwalki, Lomza to Warsaw. More than a third of these routes fall on the territory of Lithuania (Fig. 27).

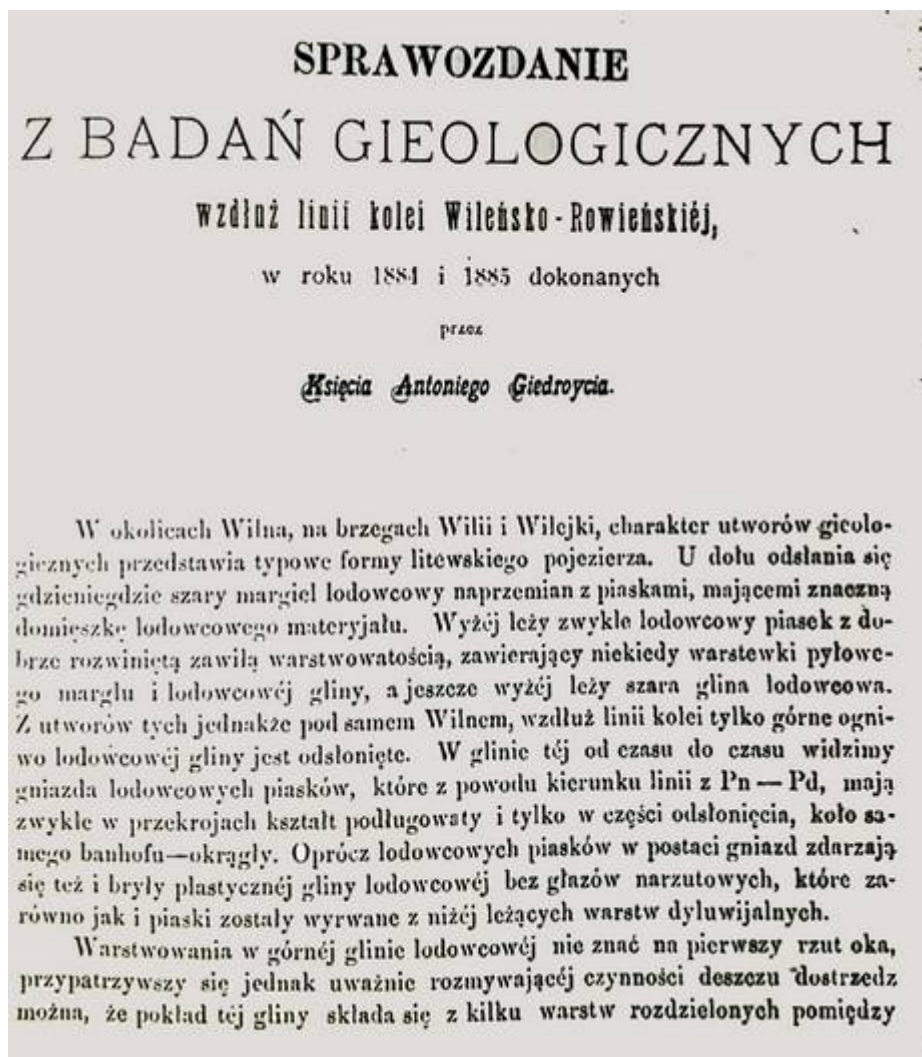


Fig. 9. Fragment of the article about geological research conducted on 1884-1885 along the Vilnius - Rovno railway line

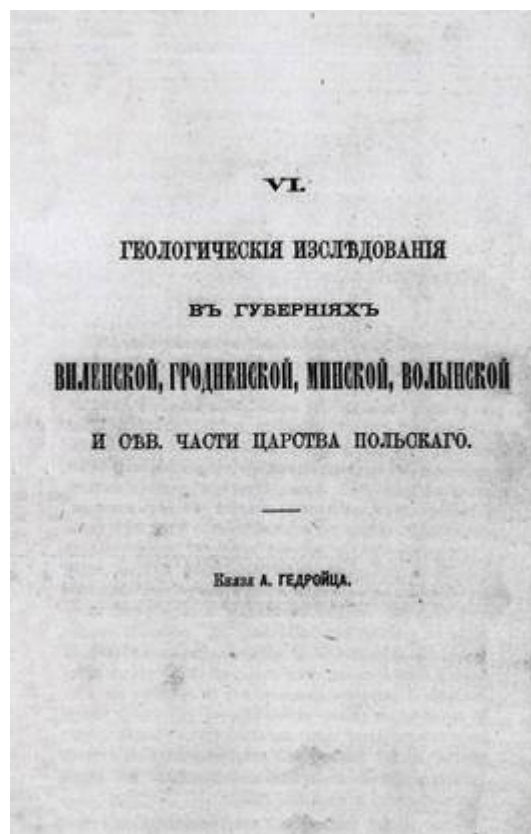
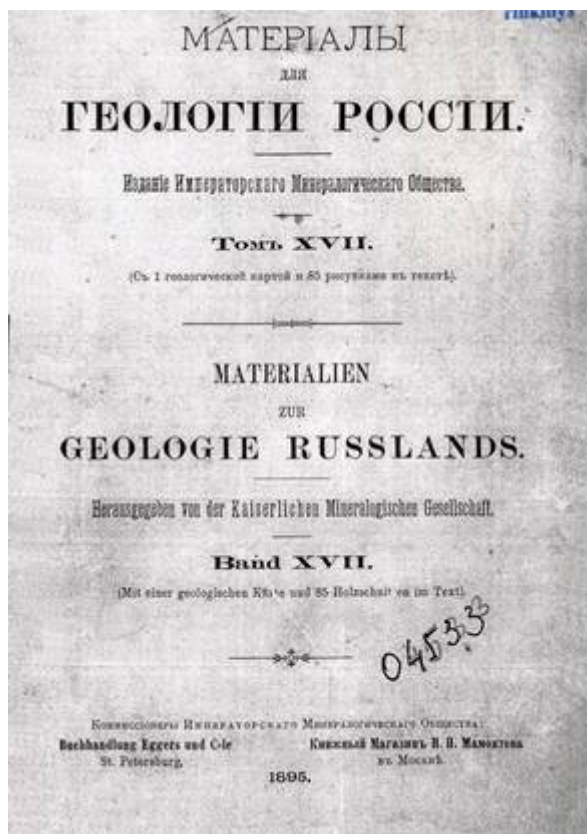


Fig. 10. The cover of A.K. Giedraitis (1895) book and the title of Chapter VI

A.K. Giedraitis was a consistent supporter of polyglacialism, he described and summarized his research data obtained by studying the relief, composition and structure of glacial formations (Figs.11, 12, 13, 14, 15, 16, 21), stratigraphy, soil formation, mineral raw materials. in 1884 in the report, he claimed that in glacial formations it is often possible to find slabs of Tertiary, Cretaceous and Jurassic formations (Figs. 12, 14, 15, 16, 18, 20, 22, 23), for example, Druskininkai, Kaimelis, Gelgaudiškis, etc. areas. Very interesting are the drawings of his outcrops, illustrating the nature of glacial accumulation and the structure of compressed moraines (Dalinkevičius *et al.*, 1969).

When describing clays of glacial origin, A.K. Giedraitis distinguished layered and non-layered clays. According to him, there are layered or banded clays in many areas (in Tauragė, Nemunaitis, near Ukmergė, etc.). He rightly assumed that it was the sediment of preglacial lakes. Unstratified clays are widespread at the margins of stratified clay basins. Peats A. Giedraitis called brown coal and studied them in the vicinity of Gardin, where they sank under red moraine loam.

The scientist concluded that the periods of warm and humid climate that existed during the Ice Age were favourable for the formation of peat (Giedroyc, 1884; 1886; 1887).

After collecting a lot of factual material, the scientist came to the conclusion that two separate morainic horizons (ed. - layers) are spread on the territory of Lithuania (Figs. 16, 18, 20, 21, 23, 26), and even three morainic clay horizons are found in Vilnius (Figs. 16, 19, 22, 24, 25). The author indicates the number of past glaciations very carefully - the morainic loam horizons differ only in colour, while the composition is very similar. The colour of morainic loams depends on the rocks that the glacier scratched as it moved, because it is precisely from them that the ice age formations were formed. By studying the composition of moraine loams and boulders, according to the author, it is possible to trace the composition of the pre-Quaternary rocks of the areas through which the glacier moved. Thus, boulders and slabs of the main layers are indicators of a pre-Quaternary bed (Figs. 18, 20, 22, 23).

A few drawings from A.K. Giedraitis, 1895 (Гедройц, 1895) publication

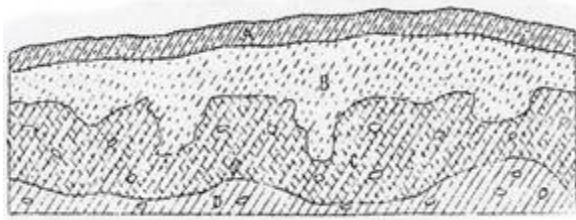


Fig. 11. Periglacial wedges

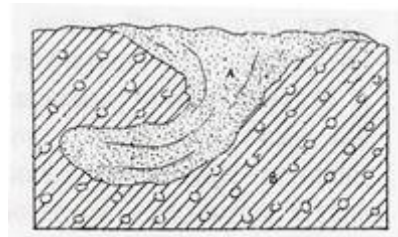


Fig. 12. Inclusion texture

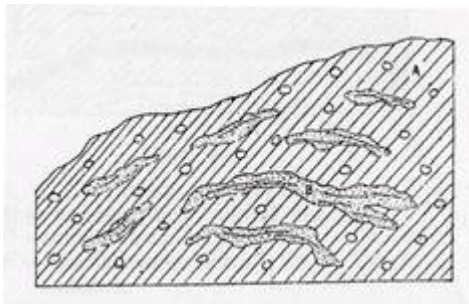


Fig. 13. Sand lenses in loam

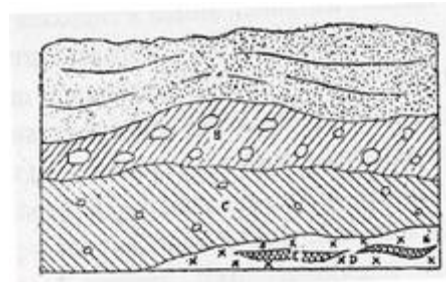


Fig. 14. Plastic clay inclusion texture in loam

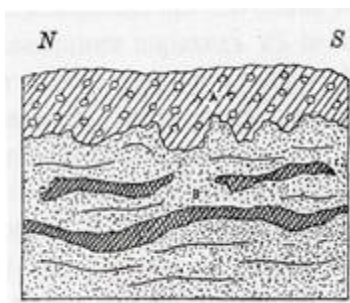


Fig. 15. Layered clay, light and pink sand and loam

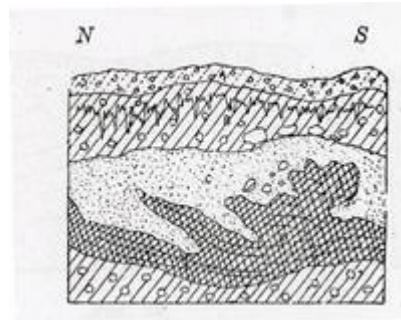


Fig. 16. Inclusive texture between two moraine layers

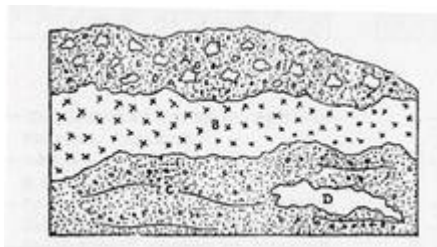


Fig. 17. Black clay layering of gravel yellowish-brown layered clay and boulders

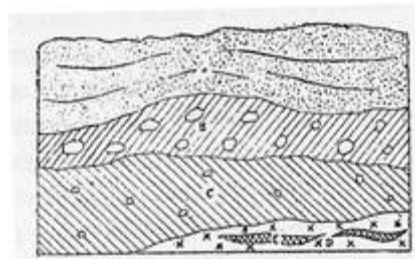


Fig. 18. Layers of glauconitic sand grey plastic morainic loam, red morainic sand and greenish laminated sand

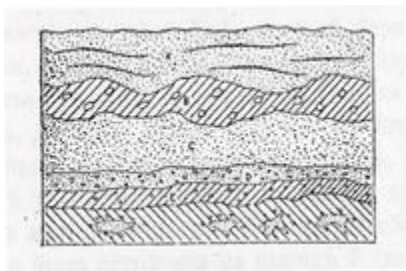


Fig. 19. Outcrop with three layers of different moraines

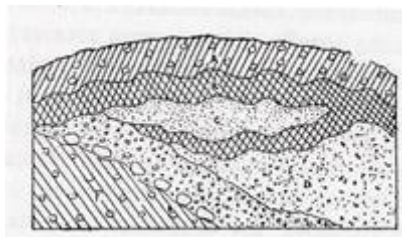


Fig. 20. Between the two moraines layers is the texture of a deformed tertiary clay layer

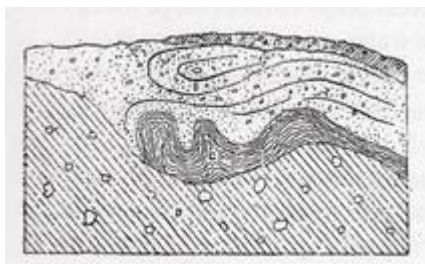


Fig. 21. A push-and-push texture between two moraine layers

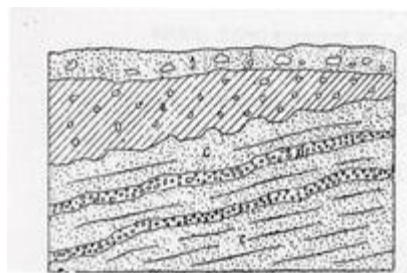


Fig. 22. Sandy clay with boulders, red glacial clay, reddish hardened sand, gravel, grey glacial sand with a predominance of glacial and tertiary material

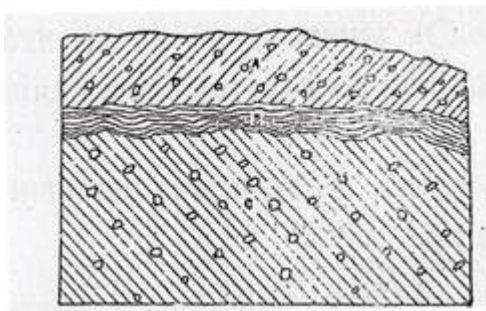


Fig. 23. Red glacial marl, layered shale and clay marl, grey glacial marl with pieces of glauconite sandstone

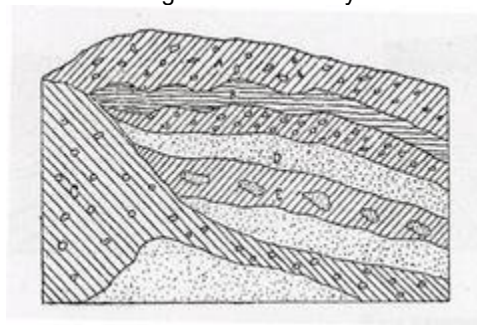


Fig. 24. Glacial sandy clay, greenish layered sandy clay, glacial marl, whitish green sand, glacial grey sandy clay, interspersed with sand, sand, grey glacial marl, greenish grey glacial sand

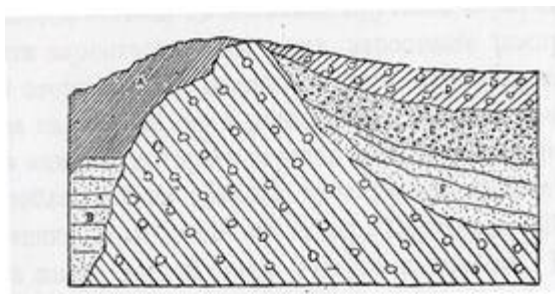


Fig. 25. Scree, glacial guss and partly red glacial clay, glacial gravel, layered sand, grey glacial marl

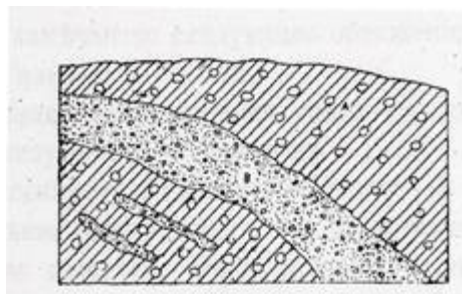


Fig. 26. glacial red clay, glacial sand; glacial red clay containing layers of glacial sand

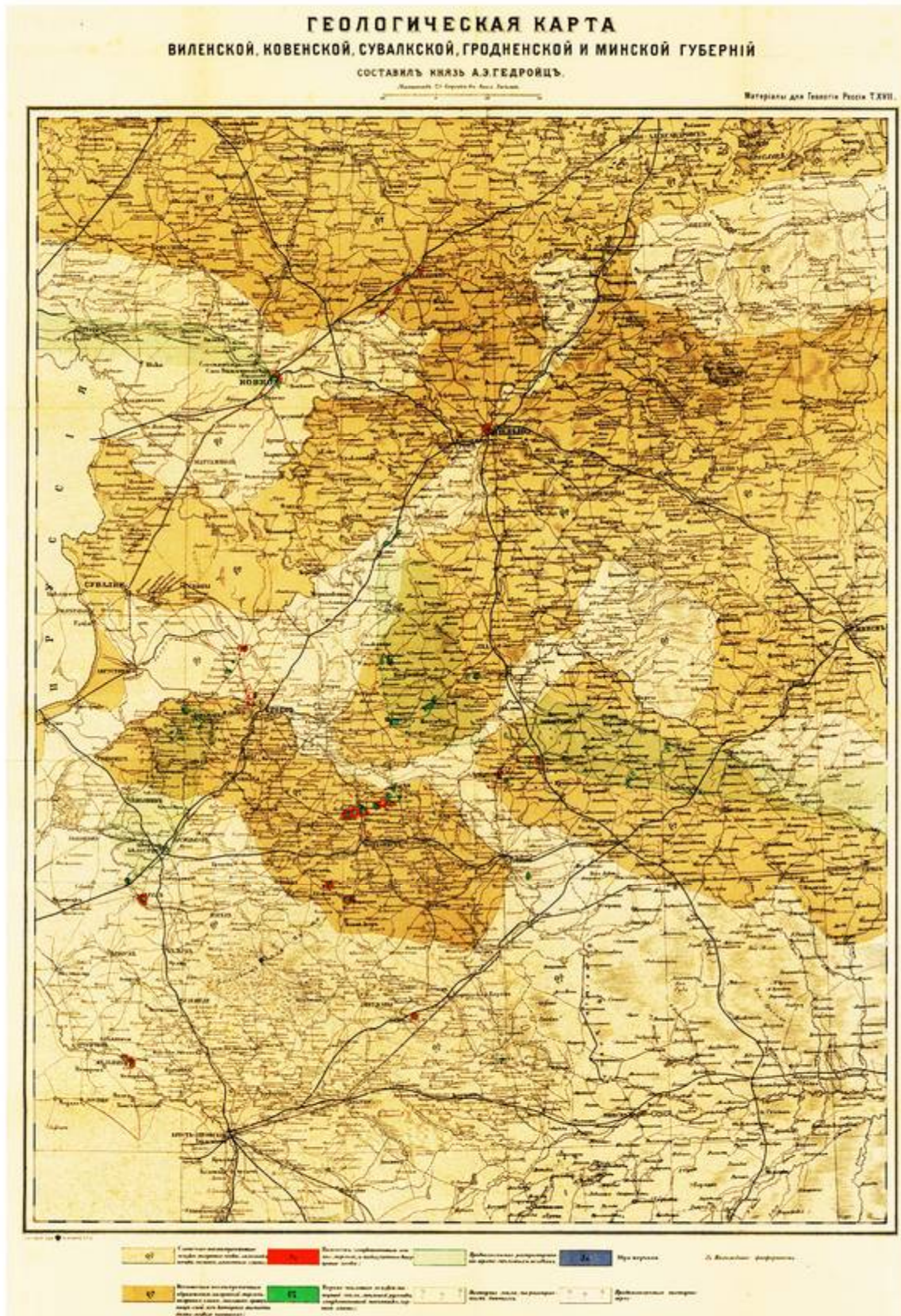


Fig. 27. Geological map. Vilnius, Kaunas, Suwalki, Gardin and Minsk governorates. Created by Duke A.K. Giedraitis. (Гедройцъ, 1895). General view. Digital version from the personal archive of prof. Andrzej J. Wójcik (Polish A Sc)

Instead of an epilogue

175th anniversary of the Duke and geologist A.K. Giedraitis' birth was celebrated in 2023 by the

Lithuanian community of geologists, scientists, Vilnius, Kaunas, etc. and Karvis township citizens.

The conference was organized, the publication dedicated to this occasion was published.

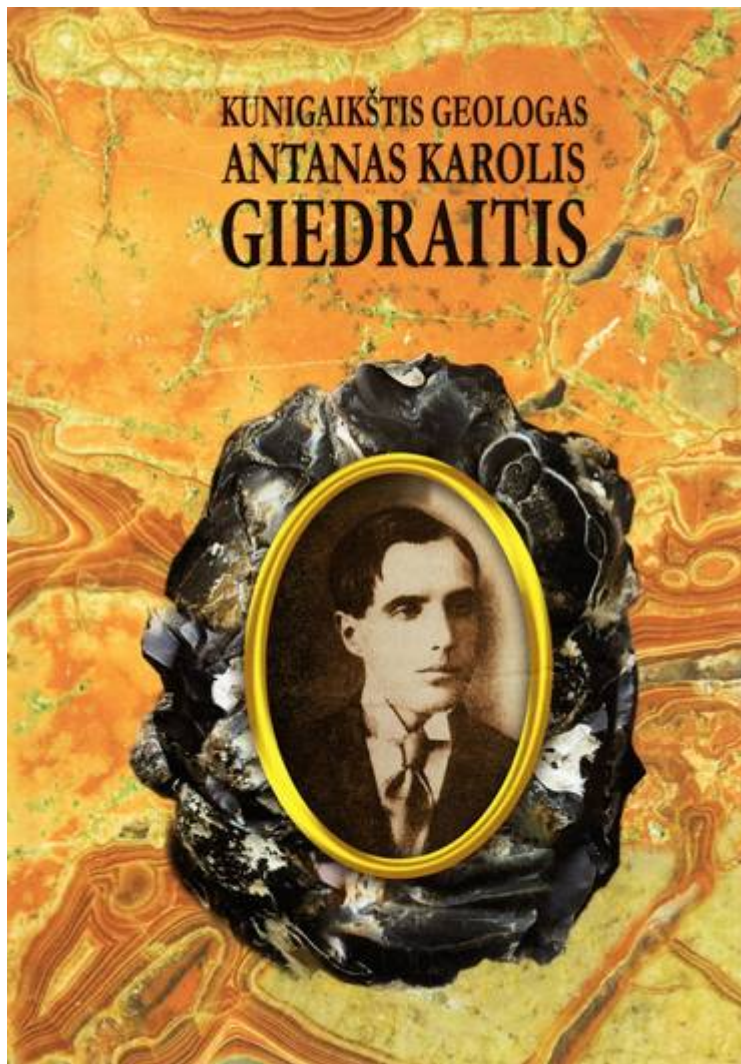


Fig. 28. Cover of the book "The Duke and the Geologist Antanas Karolis Giedraitis"

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Abbé Paramelle: early excursions and observations in the department of Lot (1818-1827)

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Abstract. Abbé Paramelle explored for water on the Causses of the department of Lot beginning in 1818. He was aggrieved by the plight of his parishioners who lived on the limestone plateau and suffered from a severe lack of water for themselves, their farm animals, and their crops. Believing that water could be found nearby, Paramelle began nine years of walking the Causses to find out where the rainwater went. By 1827 he had observed enough terrain to be able to locate water and determine its depth. He submitted a report on his ideas to the government of the department of Lot in 1827, who supported the testing of his theory. Paramelle found water as predicted and his services were soon in high demand. He was released from his parish duties in 1832 and started a career spanning 22 years during which he found water throughout France. His observational method used stratigraphy and geomorphology. He popularized the idea that water was not far below the land surface and that it could be reached without excessive effort. Because he did his early water research on a limestone plateau, he recorded and published important karst observations.

Keywords: Causses – groundwater – karst

1. Introduction

As a young village priest, Jean-Baptiste Paramelle (Fig. 1) was distressed by his parishioners' lack of water. He was sure that water must be available nearby. He had no reference books to tell him how to find it, so he started walking the land surface looking for it. This article focuses on Paramelle's early years in Lot, where with meager resources and no geologic maps, he challenged himself to find groundwater and succeeded in doing so. After nine years of observation, Paramelle submitted his ideas to the Conseil General of the department of Lot in an 1827 memoir, which is the topic of this article (Paramelle, 1827). The handwritten report resides in the Bibliothèque municipale of Cahors (Fig. 2). Luckily for us, Jacques Audoin of the Spéleo-club de Paris transcribed it in 2010 (Paramelle 2010).



Fig.1. Abbé Jean-Baptiste Paramelle (undated photo). Paramelle family collection.

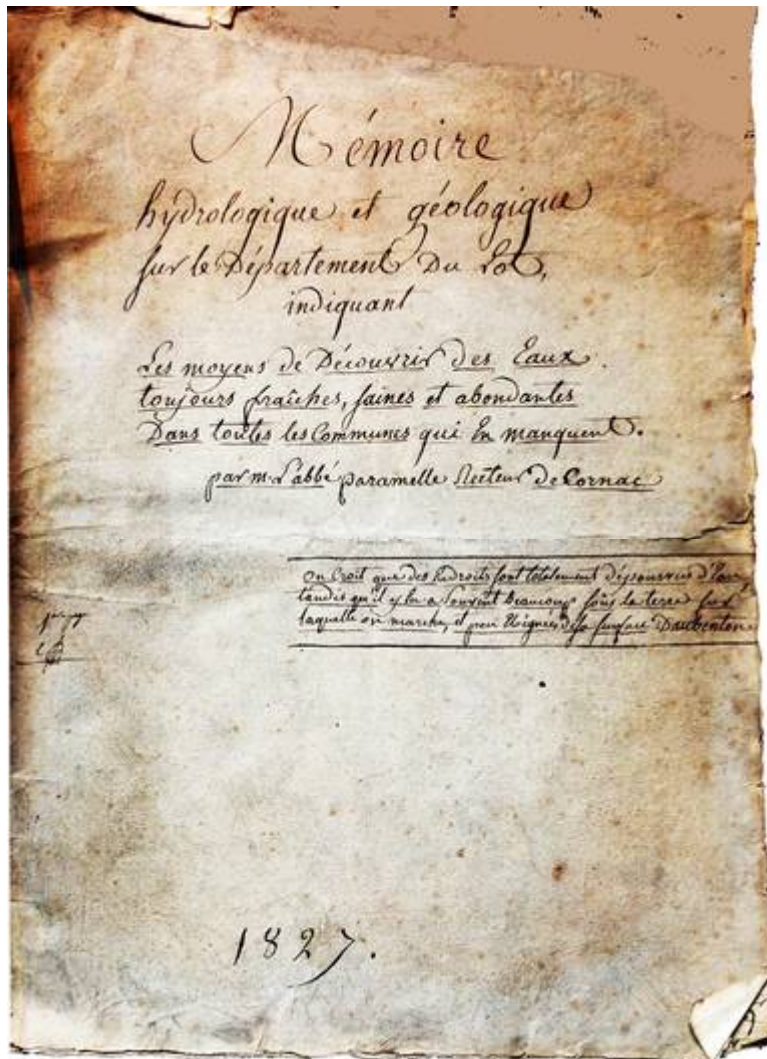


Fig. 2. *Mémoire hydrologique et géologique sur le Département du Lot*, 1827. Page 1. Photo by P. Bobeck

2. Biography

Paramelle was born in 1790 in Felzins, in the department of Lot (Fig. 3). He attended the seminary in Cahors and was ordained there in 1815. He was assigned to Saint-Jean Lespinasse parish in 1818, and became rector in Cornac in the 1820s (Fig. 3). After submitting the 1827 report, receiving a grant to test his ideas, and showing his ideas to be successful, requests for his services multiplied rapidly. The young priest began a career as a hydroscope. In 1832, he was released from parish responsibilities. He then began his water-finding travels throughout France, which continued until 1854 when he could

no longer ride a horse. By his own account, between 1832 and 1854, Paramelle explored 40 of France's departments, evaluated 30,000 sites, and indicated water at 10,275 sites with a 90% success rate. In 1854, Paramelle retired to Saint-Céré and wrote *The Art of Finding Springs*, which was published in 1856. This book, which was based on the 1827 report, included additional observations and methods he developed throughout his later career. The book was a how-to manual for the public; it became a best seller that was reprinted six times. The last edition appeared in 1926. The book was translated into German in 1856 and Spanish in 1863. The English translation appeared in 2019 (Bobeck, 2019). Paramelle died in Saint-Céré in 1875.

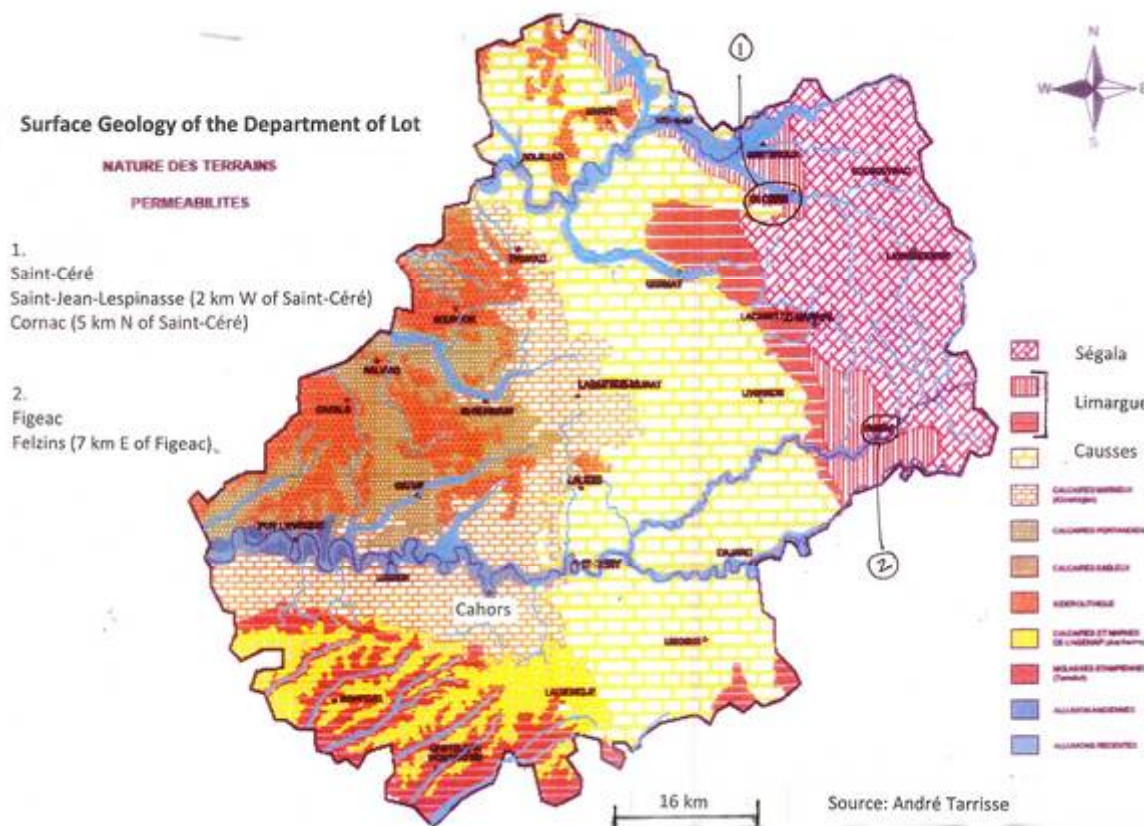


Figure 3. Geologic map of the Department of Lot.

3. Paramelle's observational method

Paramelle's parishes were situated on the Causse, a limestone plateau located in the central part of the department of Lot, where surface water is scarce (Fig. 3). Paramelle had grown up in the eastern part of the department of Lot, where the surface is impermeable clay and schist (Limargue and Ségala). Paramelle had childhood memories of streams and abundant surface water. He also knew that the same amount of rain fell on his childhood home and his parishes. Paramelle observed that streams that cross the Ségala and the Limargue are quick to disappear where they flow westward onto the Causse. In a passage that many geologists can relate to, that is, looking at a feature and not realizing its significance, Paramelle recounts how he walked the Causse for nine years before

recognizing that disseminated dolines on the Causse surface convey water to the subsurface (Fig. 4).

Paramelle sought to increase his geologic knowledge by reading. Throughout his career he amassed a library of 3000 volumes by such authors as Brongniart, d'Orbigny, d'Aubuisson des Voisins, and de La Bèche (in translation). Presumably by the early 1820s farmers had observed water flow into limestone, but this information may not have been published and the concept of karst was not known outside of Eastern Europe.

Some of Paramelle's observations stem from reports of local residents and farmers. Many of Paramelle's observations appear obvious to today's reader. Paramelle was able to link these obvious

facts such as water flowing downward on a hillslope, to that same water flowing into a surface stream, which, in Paramelle's observation, is always underlain by a subsurface stream, and thus groundwater. Given that this superposition of streams was common on the Causses, where streams disappear into

the subsurface and then spring forth downstream into the course of the surface stream, Paramelle took this phenomenon as a universal. This idea may seem quaint to us, but in Paramelle's time, water was thought to flow primarily through natural underground conduits.



Fig. 4. Photograph of doline near Rocamadour. Photo by P. Bobeck.

4. Paramelle's question n°1: where is the water?

Paramelle eventually understood that limestone allows rainfall to penetrate and noted that water does not evaporate underground, allowing for accumulation of large amounts of water in the subsurface. He noted that water forms both surface and subsurface streams as it flows downslope. He claimed that every surface stream, dry or not, is underlain by an underground stream. In the department of Lot, streams such as the L'Ouyse disappear into the subsurface and reappear downgradient as resurgent springs.

Paramelle observed that disseminated dolines on the Causses surface convey water to the subsurface to form underground streams that flow downward, unseen, and often issue as springs at the base of cliffs.

The department of Lot has three large river basins, separated by crests (watershed boundaries): the Dordogne, the Lot, and the Céré. Obviously, rain that falls on slopes flows downgradient into rivers, so Paramelle's sound basic advice is to look for water in valleys. He notes that many people build their houses on a high point and plan to obtain water adjacent to the house, but he points out that water is found in valleys. Paramelle categorized valleys as primary and secondary. A wide valley will collect more water than a narrow one, and the amount of water present can be estimated by considering the size of the valley. He explains where to dig in a wide valley to intercept an underground stream.

Paramelle also noted interrupted vs continuous valleys. Interrupted valleys occur on the Causses; minor barriers can cross dry valleys, thereby hiding a valley trace, and he describes how to find the val-

ley trace within the barrier. The importance of the valley trace is that the dry valley overlies the underground stream, thus, the groundwater.

5. Paramelle's question n°2: how deep is the water?

Having established that water can be found at the base of cliffs, under dry streams, and in wide valleys, Paramelle set out to determine the depth to water. In the 1820s, depth to water was critical, given the lack of power drilling tools. His determination of water depth was simple. For surface water that flows into disseminated dolines on a plateau and issues as a spring at the base of a cliff, the water depth is intermediate between the plateau elevation and the elevation of the base of the cliff. The slope of the hill and its underlying water can be calculated and a person can determine roughly the point where the water is closest to the surface. Paramelle provided a model for making a level to measure slope.

He suggested a method for finding water that flows between an unknown doline and a river. If the water flows on the valley surface before entering the river, a person can determine the amount of flowing water by the angle at which the water approaches the river. Paramelle explained which direction to follow to walk up the slope and describes landmarks to guide the water seeker to the doline. This exercise provides the elevations of the river and doline, and the water seeker can identify the location where the water is likely to be closest to the land surface.

Surface streams (flowing or not) in shallow valleys have underlying underground streams and the water in both streams follows equal slopes. As stated above, Paramelle explains where to dig in a wide valley to encounter groundwater. Paramelle suggests using depths of nearby wells, if available, to determine groundwater depth.

6. Paramelle's Legacy

Paramelle's 1827 report was a major advance in water-finding knowledge. He singlehandedly popularized the idea of groundwater as an inexpensive, easily obtainable resource. He showed the public that water was not far beneath the surface and made it possible for many individuals, farmers, and communities to tap into clean groundwater for themselves and their animals. Paramelle demystified the process of finding water.

Unbeknownst to Paramelle, as he was looking for water on a limestone plateau, he made important contributions to the study of karst. Taisne and Choppy (*Karstologia*, 1987) enumerate Paramelle's ideas that became central to karst as follows: a) lines of dolines are frequent features in dry valleys, b) a surface valley usually overlies a subsurface stream, and c) the sinkhole-resurgence connection is a general phenomenon.

As Paramelle travelled, observed, and made more discoveries between 1832 and 1854, his successes were widely publicized in newspapers. Henry Darcy, the engineer known as the father of quantitative hydrogeology, cites his contemporary Paramelle three times in Darcy's 1856 *The Public Fountains of the City of Dijon*. He praises Paramelle's knowledge and his success in supplying so many communities with clean, abundant, and free water (Darcy, 1856).

Paramelle's 1856 book (Paramelle, 1856), the outgrowth of his 1827 report, was used for finding water in the department of Lot as late as the 1970s, according to Andre Tarrisse, retired hydrogeologist of the department of Lot (Tarrisse, personal communication, 2015). In the 1970s water utilities began using geophysical techniques to find larger quantities of water but prior to that, Paramelle's observational method had been the primary guidance on finding water for more than 100 years.

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First geological investigations in Australia and Antarctica by French scientists, naturalists and surgeon on voyages of discovery, between 1792 and 1840

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Abstract. When Binot Paulmier de Gonneville returned from a long ocean voyage in 1504, claiming to have found the fabled Great South Land, the landmass that is now Australia was still an undefined part of this imaginary southern continent. Two other French navigators set out in the late 18th century to prove the existence this legendary land in the south. They reached Australia but left few records of the nature and the shape of the country they briefly encountered. Between 1792 and 1840 seven French expeditions of discovery visited Australia, five of which as part of voyages around the world. All had embarked on these voyages with different objectives and their contributions to descriptions of the landscape and to the knowledge of Australian geology vary considerably. One of the major tasks of the first two of these expeditions led by Bruni d'Entrecasteaux (1792) and Nicolas Baudin (1801-1803) was the charting of the still incompletely known coasts of Australia. Their work resulted in the publication, in 1811, of the first complete map of the continent. Both expeditions sailed with a large complement of civilian scientists who examined and recorded aspects of the country's natural history, including its geology. The loss of relevant journals and the death of some of scientific personnel and ships' officers has severely diminished our knowledge of their findings. The following five expedition to visit Australia were commanded by Freycinet (1818) Duperrey (1824), Bougainville (1825) and Dumont d'Urville (1826 and 1839-40). On these voyages the ships' surgeons took over the role of naturalists. Most had a considerable knowledge of the natural sciences, which often included mineralogy. They made valuable contributions that provided early insights into the nature of the continent's landscapes and geology. Many thousands of specimens were collected and taken to France for study and display. The last of these expeditions sailed from Tasmania to Antarctica, where its crews were the first to discover solid land beneath the cover of ice and proved the existence of a southern continent.

Keywords: Australia – Tasmania – Antarctica – Freycinet – Duperrey – Bougainville – Dumont d'Urville

Introduction

The sighting of ice-free land in Antarctica in January 1840 by the crew of the French expedition led by Dumont d'Urville provided the world with the first firm evidence of the existence of a southern land, albeit largely hidden below a cover of ice. It was a fitting discovery as it had been another Frenchman, the navigator Binot Paulmier de Gonneville, who in c. 1503, may have been the first to set out in search of the imagined *Terra Australis incognita* (Sankey, 2013). He claimed to have found an idyllic land inhabited by friendly natives, to the east of the Cape of Good Hope.

The theory of the existence of a large landmass that encircled the southern part of the globe, proposed in the writings to Alexandrian astronomer, mathematician, and geographer Claudius Ptolemy (100-170 CE), would influence the perceptions of Europeans for centuries. On the sixteenth century world maps of both Mercator and Ortelius, the Great Southern Land is shown to encircle the southern extent of the globe, to enclose the Indian Ocean and, in one part, to reach north to embrace the present outline of Australia.

When in 1642, Abel Tasman set sail from Batavia for the Southern Ocean, Australia's north,

west, and southwest coasts had already been partly charted by Dutch navigators. Tasman would add Van Diemen's Land (Tasmania) and the east coast of New Zealand to these discoveries. Setting a northerly course on his homeward voyage, in effect circumnavigating in a wide arc, what was then referred to as New Holland, he proved beyond doubt that it was not a part of the elusive southern continent.

Following the attempts of several French navigators to discover the southern continent, it was in 1771/72 when two French expeditions commanded respectively by Marc Joseph Marion Dufresne (1724-1772) and Yves-Joseph de Kerguelen de Trémarec (1734-1797) left Mauritius to renew the search for the southern land. The former, in the *Mascarin* and the *Marquis de Castries*, sailed in forty-degree latitudes and discovered the Prince Edward Islands, to the south of South Africa. He continued his voyage to reach Tasmania and New Zealand, but without sighting the southern continent. Kerguelen in *Fortune*, together with his second-in-command, Louis Aleno de Saint-Aloüarn, captaining the *Gros Ventre*, discovered a group of islands in sub-Antarctic waters. The commander believed that he had found the northern capes of the Great South Land. Becoming separated from his companion ship, he returned to France to announce the erroneous news of his discovery. Saint-Aloüarn followed his instructions and proceeded to the next rendezvous point on the southwestern coast of Australia. With no sign of the *Fortune*, he charted part of its western coastline on his way north to Batavia. In August 1771 he claimed the western coast of Australia for France, some eighteen months after the then lieutenant James Cook had claimed its eastern coast for Britain.

First geological observation in Australia

Before the arrival of Alüoarn, Dutch and English navigators had sailed along and had charted part of the western and southwestern coasts of Australia but had made only cursory comments on its landscape and geology; their recording of rock outcrops was mainly related to their significance to navigation. When the Cook expedition reached the east coast of Australia in 1770, its accompanying botanists, Joseph Banks and Daniel Solander, seemed to show no interest in the country's

geology, and collected no specimens. It was Cook himself who gave a first, brief description in his journal of the sandstone formation of the Sydney area.

La Pérouse's expedition arrived at Botany Bay, a few days after the first British convict fleet had anchored there, in 1788. During its brief stay, the Abbé Mongez (1751-1788), considered to be the first person with expertise in mineralogy to visit Australia, discovered a white clay which he believed to be suitable for making good chinaware.

The British authorities responsible for sending the First Fleet carrying more than 1,000 convicts and crew, did not consider it necessary to include a single person with expertise in any of the sciences, other than medical officers. It therefore fell to laypersons to explore the area near their new settlement at Sydney Cove for raw materials such as clay and limestone for building and to make observations on its landscape. Arthur Phillip, the colony's first governor, in referring to the sandstone strata around the first settlement, informed the authorities in London of the outcrops of Freestone, which he compared to the Portland stone in England (Mayer, 2007).

The aims of the seven French expeditions and their personnel

The period between 1792 and 1840, during which the seven French expeditions of discovery discussed in this article visited Australia, coincided with several major regime changes in France. The first voyage, led by Bruni d'Entrecasteaux, which left France in 1791, was approved by the National Assembly and sailed with the support the monarch, Louis XVI, while the second, commanded by Nicolas Baudin, departing in 1800, was authorised by the Republic's First Consul, Napoleon Bonaparte. Louis de Freycinet, who commenced his voyage in 1817, and those that followed, sailed under the flag of the restored monarchy.

The purposes of the various voyages and the instructions given to the expeditions' commanders differed in line with changing circumstances in their home country. The missions of the first two expeditions, which arrived in 1792 and 1801, respectively, included the charting of Australia's still incompletely known coasts and, at their stopovers,

to survey and study aspects of the country's natural history. The five expeditions which visited the country between 1818 and 1840 could now navigate with greater ease along its well-charted coasts. They stopped at fewer locations, and with some exceptions, for briefer periods. They found a country much changed, with larger settlements and an increased population.

The vast accumulation of new knowledge and fresh concepts in newly recognised disciplines of science in the late eighteenth and early nineteenth centuries led to the appointment of personnel on voyages of discovery, who were knowledgeable in a range of scientific fields. The wide background and experience of many of these scholars allowed each to conduct surveys and make collections across several disciplinary areas. They were often assisted in their work by some of the ships' officers and even their commanders, some of whom possessed considerable knowledge of or had an interest in the natural sciences.

The first two expeditions commanded by Bruni d'Entrecasteaux and Nicolas Baudin, sailed with large complements of civilian scientist and naturalists, 9 and 23 respectively. As these savants were not subject to naval discipline, they sometimes disregarded instructions issued by their commanders and overstayed their time onshore, either voluntarily or, even, acting in a reckless manner, becoming lost. This often resulted in great inconvenience to their captains and led to heated arguments and disharmony on board. Louis de Freycinet, who had been a lieutenant on the Baudin expedition and had experienced such disputes at first hand, decided against employing civilian scientists on his own voyage in 1817-19, and instead relied on his naval surgeons to also take on the roles of naturalists. All the captains of subsequent French expeditions followed his example.

The expeditions' medical doctors had a broad knowledge of the natural sciences. They may have lacked a deeper understanding of respective scientific disciplines, but nevertheless made important observations and collected specimens during their mostly brief stays ashore.

It is a great loss to the history of the natural sciences, including to geology, and to the history of exploration that many of the scientific personnel of

the two early voyages, as well as their commanders, did not survive to prepare accounts of their work and travels. Various circumstances, including wars in Europe, involving frequently changing alliances between nations and, very probably, simple negligence on the part of individuals and authorities, led to the unfortunate loss of both journals and collections. This affected particularly the records of the expeditions' geological work.

D'Entrecasteaux's expedition and the first scientific study of Australian geology

In 1791, the French National Assembly authorised an expedition to the South Seas with the aim of searching for the missing La Pérouse and his crew, who had not been heard of since his ships had anchored at Botany Bay in 1788. At the urging by members of the *Société d'Histoire naturelle*, the expedition was given the additional task of charting the continent's unknown coasts and to study its natural history. Bruni d'Entrecasteaux (Fig. 1), was appointed commander of the voyage and sailed from Brest with the frigates *Recherche* and *Espérance*. He was a native of Aix-en-Provence and the son of a member of the *Parlement de Provence*. After joining the Navy at the age of 17 he saw service in the Far East, and in 1785 was appointed as Governor of Isle de France and Isle de Bourbon.



Fig. 1. Bruni d'Entrecasteaux (1737-1793)

Expectations for the success of the voyage were high. Several individuals, foremost among them Dolomieu, had written memoirs providing instructions and advice to aid the assigned mineralogist in his geological investigations. It was hoped that the expeditions findings would contribute towards advances of the theory of the Earth and perhaps result in the discovery of new mineral deposits (Richards, p. 62).

The expedition left Brest in September 1791 and after reaching Cape Town, D'Entrecasteaux decided to sail directly to Van Diemens Land (Tasmania). Following a stay there of just over a month he resumed his voyage to the Pacific Islands in what proved to be an unsuccessful search for La Pérouse. Following visits to islands to the north of Australia he returned to Cape Leeuwin, the continents southwestern point, to commence the charting of its southern coast and to provide opportunities for his naturalists to engage in their respective studies.

Among the nine scientists on board, who had been carefully selected by the *Société d'Histoire naturelle* in Paris, was the mineralogist Jean Blavier (1764-1828), the first time a member of this discipline had been chosen for such a voyage. Blavier had only recently graduated from the *École des Mines* (Richard, 1986, pp. 62, 66), and would have brought invaluable expert knowledge to the expedition's investigations had not illness, and, perhaps, dissatisfaction with the conduct of the voyage, led him to withdraw at Cape Town. He returned to France to a successful career, mainly as an administrator of mines.

The responsibilities for the expedition's geological investigations fell to Claude Riche (1762-1797) a medical doctor knowledgeable in both botany and geology. His enormous workload also included responsibility for the study of birds and vertebrates and measuring the temperature of the sea at different depth. Riche had studied at the university of Montpellier and, in 1787, was awarded the doctorate in medicine "*avec la plus grande distinction*" (Richard, p. 66). In 1788 we find him in Paris where he met Cuvier among other leading scientists and where he carried out research and published reports on a wide range of subjects in the physical and life sciences. He was elected a member of the *Société d'Histoire naturelle* in 179. Sketchy references in the literature

refer to him engaging in geological fieldwork in the Languedoc region in southern France, probably at the time when he was studying at Montpellier. He does not appear to have published any of the results of his investigations there. The variety of rock types exposed in the Languedoc, their wide ranges in age and their different settings, would have provided him with a good introduction to geology. His seeming familiarity with current knowledge and ideas regarding the then current state of the geological sciences, and an extensive onboard library containing relevant works on the discipline, provided him with a good background to contemporary thinking.

As we now know, the effective end of the expedition in Batavia on its return voyage and the confiscation of Riche's journals and collections by the Dutch, then at war with France, ended these hopes. Riche did return to Java a year later trying to retrieve his belonging, but without success. He died from consumption in France in 1797.

The first view of the landscape that offered itself to the observers as the ships progressed in an easterly direction along the continents south coast, were of a discouraging monotony and uninspiring. Beyond high coastal dunes and often cliff-lined shores, they noted a vast expanse of low-lying terrain, of a mostly sterile nature, but with patches that had the appearance of being fertile. The great rivers the naturalists had expected to flow into the ocean did not exist and sources of fresh water were very scant. It was the lack of reserves of drinking water which forced d'Entrecasteaux to end the charting and surveying of the continents arid southern coast and set a course for Van Diemen's Land. This denied the expedition the credit for mapping the still unknown parts of the coastline and closing the last gap on the map of Australia (Fig. 2) (Duyker & Duyker, 2001, p. 107-135).

The first documented geological comments on this region are those of the commander himself who, referring to large coastal dunes, wrote in his journal (:): "*It is to be presumed that the kinds of sand mountains are formed by storms, which must be very violent on these coasts, to judge by the ways they are battered by the waves.*" (Duyker & Duyker, 2001, p. 113) And (:): "*Every bit of coast we sighted on the east and west presented the same appearance: that of a steep calcareous rock*

[Eocene to Miocene] of equal height in its whole
 expanse, the layers of which were completely

horizontal, as well as the plateau on the summit.”
 (Fig. 3) (Duker & Duyker, 2001, p. 131).



Fig. 2. Map of Nouvelle Hollande (Australia), showing the yet uncharted southern coastline of the continent and parts of Tasmania when d'Entrecasteaux's commenced his surveys in 1792



Fig. 3. Horizontal strata of Tertiary calcareous rocks exposed in cliffs along the coast of South Australia, described by d'Entrecasteaux

It seems rather ironic that the longest uninterrupted period Riche spent on land on the continent's southern coast was the time when he became lost. During a stopover at Esperance Bay, he had gone ashore with a surveying party but became separated from them. During the more than

two days of his ordeal he remained calm; he even made notes of his discoveries and collected samples. It is to this episode that we owe one of his few surviving written observations on the continent's geology from an entry in his commander's journal. Standing on dunes with a view of both the beach and towards the interior, Riche was astonished to note that (:): *“Looking towards the north, the interior was very visible far inland; the country was very fertile, and columns of smoke were rising a few leagues away. The mountains at the horizon very far in the distance were not very high. It is remarkable that granite, bristling with feldspar, which forms the core of all the high primitive mountains of the globe, is here at the foundation of an immense region, very smooth and nearly at sea-level in its entire expanse.”* (Fig.4) (Duyker & Duyker, 2001, p. 122).

His views were most likely based on his reading of Pallas (1771-1776), who identified the granites forming part of the core of the Ural Mountains

as the oldest (Primitive) and successive sequences of overlying sedimentary rocks as younger (Secondary and Tertiary) That author's work was readily available in France and would have been part of the comprehensive onboard library. Future visiting naturalists would also have their knowledge of geology, acquired in Europe, challenged by observations in Australia.

Among the dunes he also noted large numbers of petrified tree trunks and roots in their growth position and concluded that this [...] "*destroyed forest*" [...] had once grown in a fertile valley located further from the sea (Duyker & Duyker, 2001, p. 119). Naturalists of later French expeditions would record the finding of many such petrification, particularly along Australia's western coast.

Jacque-Julien Houtou de Labillardière (1755-1834), the expedition's botanist, whose journals and collections were in time returned to him, displayed his versatility as a scientist when he discovered a coal seam at South Coast Bluff in Tasmania (Duyker, 2003, p. 145). The seam, now known to be of Triassic age and interbedded with sandstone was only a few centimetres thick (Fig. 5). Based on his apparent knowledge of European coal measure sequences, in many of which coal is associated with sandstone layers, he predicted that more substantial seams of coal would be discovered in this area. Coal was indeed mined in this region some decades later. Labillardière also speculated on the occurrence of iron ore in the area based on his noting of rust-coloured water in a stream.



Fig. 4. Outcrops of Archaean granite on the southern coast of Western Australia, like that seen by Claude Riche in 1792



Fig. 5. Triassic sandstone with coal seams, first recorded by the botanist Labillardière in 1792

The Baudin expedition 1801-1803 and the first tertiary qualified geologists to visit Australia

In October 1800 the expedition authorised by Napoleon Bonaparte and commanded by Nicolas Baudin (1754-1803) (Fig. 6) left Le Havre in the corvettes *Géographe* and *Naturaliste*, on its voyage to Australia. Its commander, born at St Martin on the Île de Ré joined the merchant navy at the age of 15. His widely varied career included service in the American revolutionary war and as captain of several botanical collecting voyages (Horner, 1987, pp. 24-35, 2006, pp. 43-55; Rivas, 2006, pp. 73-112; Jangoux, 2010, pp. 41-50). Although ten of the twenty-three scientific personnel selected for the voyage left the expedition at the Ile de France, the still large number of the scientific staff, together with a supply of modern equipment, up-to-date charts, a wide range of books and an experienced leadership, made this the most successful of the seven voyages in terms of the charting of the continent's coastline, the range of its scientific discoveries and the size and variety of its natural history collections. Baudin was to lose four more savants to disease in Australia and another two, who had long been ill, on the return voyage. The latter included the mineralogist Louis Depuch, who died on the Ile de France in 1803. Baudin himself succumbed to illness on the same island (Mayer, 2005, 2009).

The flowering of interest in the Earth, both among scientists and the public, and the significant advances made in geology in the latter half of the eighteenth century, had prompted the *Institut de France* to appoint four mineralogists to the expedition. Two of these, Denys Montfort (1766-1820), better known for his work on molluscs, and Antoine Busche (1776-?), withdrew before the ships sailed.

Louis Depuch (1774-1803) and Joseph Charles Bailly (1777-1840) were appointed as senior and junior mineralogists, respectively. The former was born in the small village of Caumont in the southwest of France and graduated from the *École des Mines* in 1798. His teachers had included Déodat de Dolomieu and René-Just Haüy. As Depuch generally added the title 'Mining Engineer' after his signature on documents, it can be assumed that he had worked in the mining indu-

stry before embarking on this voyage. The loss of his journals after his untimely death limits our knowledge of the surveys he carried out and his interpretation of the country's geology. Before he became ill, he did however send regular reports of his work to his captain, which have been preserved. Bailly, born in Nancy, studied geology at the *École Polytechnique*. He does not seem to have kept a journal but produced a catalogue of the geological specimens he collected and wrote reports of his geological investigations (Péron & Freycinet, 1816, pp. 92, 142-146).



Fig. 6; Nicolas Baudin (1754-1803)

The two mineralogists received unexpected help from the multi-talented François Péron (1775-1810) who, although appointed as the expedition's zoologist, took a great interest in geology. When Depuch became incapacitated, Péron took over much of his work. His descriptions and interpretations of the country's landscape and geology along its margins introduced European readers to a range of the continent's natural features (Péron, 1807; Péron & Freycinet, 1816).

At the expedition's first stopover in western Australia's Geographe Bay (Fig. 7), Depuch recognised extensive outcrops of 'granite' [Precambrian granite gneiss] composed of feldspar, quartz and brilliant black mica occurring in bands. The paral

lelism of these mineral bands in alignment with well-defined and regularly spaced joint planes in the rock led him to conclude that the granite was bedded (Fig. 8). He saw his discovery as confirmation of the claim by de Saussure (1779, pp. 99-100) that granites in the European Alps were stratified. Observing these outcrops prompted him to write (:) "It is impossible not to be convinced here

of the fact, which M. de Saussure was the first to recognise and which several naturalists still contest, that granites are apt to stratify" (Baudin, 2004, p. 167). His views agreed with the those of Dolomieu, his former teacher, who in his four-fold classification considered crystalline rocks to be derived from a precipitate in the oceans and the first to form in any region (Cordier, 1796).

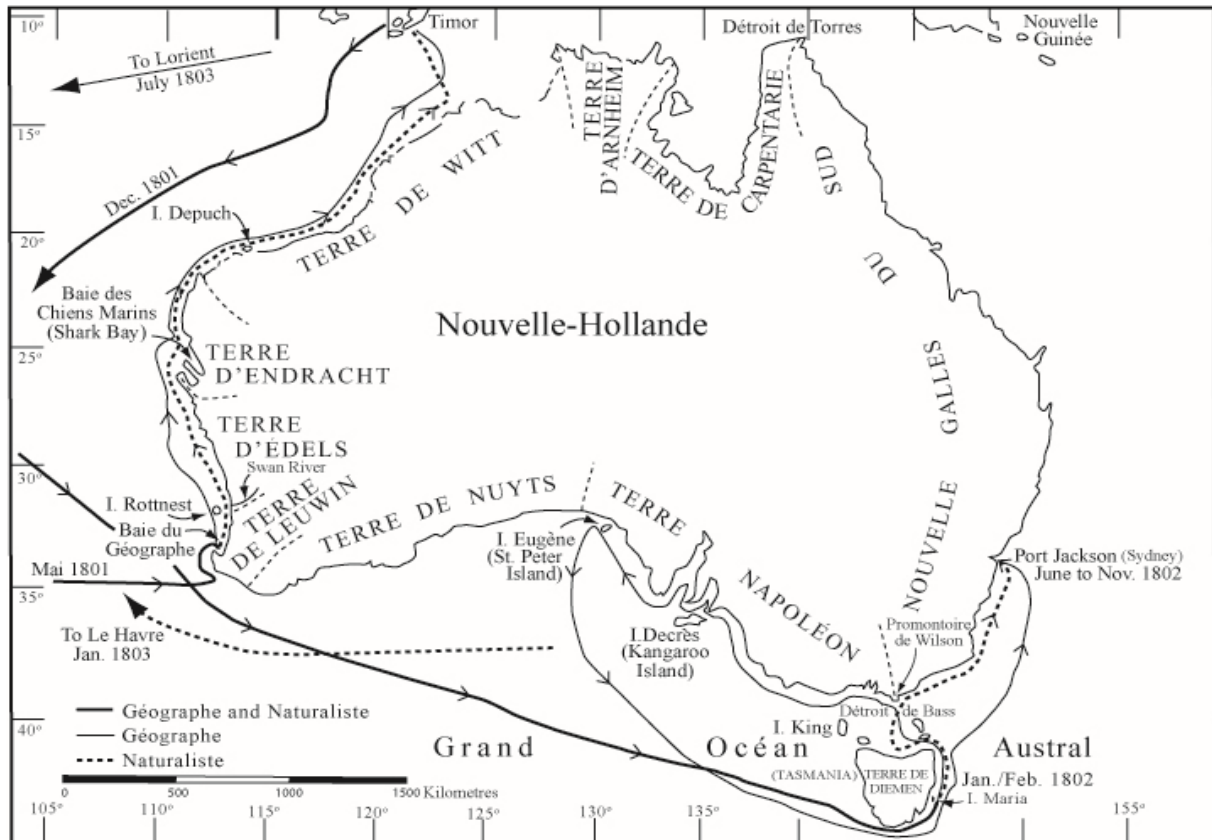


Fig. 7- Route map of the Baudin expedition 1801-1803



Fig. 8. Outcrop of Precambrian granite gneiss at Geographe Bay in Western Australia. Depuch considered these rocks to show stratification

At to the foothills of the Blue Mountains, a short distance inland from Sydney, Depuch and Bailley noted pebbles of granitic rocks in a riverbed which had been carried down from the higher ground, while the banks of the river were formed of horizontal layers of sandstone. This provided them with a good example in support of their idea that granite formed the core of mountain ranges and was the first-formed of rocks, classed as the Primitive, while the stratified sedimentary rocks were part of the Secondary and were assumed to overly the granitic core of the range. It may be thought curious that, unlike Riche some ten years earlier, Depuch seems to have accepted without question finding granites at sea level on the continent's western coast, which he himself had described as "*low-lying, or at least, not very high*" land (Péron and Freycinet, 1816, p. 60).

At the same location the two mineralogists also "*found large deposits of bituminous schist which burns with a bright flame*" (Péron & Freycinet, 1816, pp. 339-347), the first recorded finding to oil shale in Australia. Layers of the shale crop out higher in the range and it can be assumed that the 'deposits' they referred to were accumulations of pebbles in the riverbed.

Baudin's observation from out at sea of "*a chain of extremely high mountains*" (Baudin, 2004, p. 427), to the south of Sydney, and information gained from inhabitants that they extended northwards, led the visitors to the conclusion that the Blue Mountains formed only a small part of an extensive range along the eastern margin of Australia [the Great Dividing Range]. Péron went so far as state that "*these mountains of New Holland are remarkably similar to the Andes in South America in situation.*" (Péron and Freycinet, 1816, pp. 307-308).

The firsthand knowledge the two geologists had gained of the sedimentary sequences in the Sydney area and being made aware of coal outcrops on the region's coast, both to the north and south of the town, led them to suspect that the coal seams extended below the inhabited land. This prompted Bailly to write (:): "*To judge by analogy and from numerous indications presented by the composition of the terrain, one could state positively that there is a great quantity of coal beneath the very soil of Paramatta*" [then a small settlement

close to Sydney] (Péron & Freycinet, 1816, p. 340). Their interpretation suggested the existence of a basin structure, now known as the Sydney Basin.

On their separate excursions to survey the geology along the coast of Western Australia, the mineralogists and Péron recognised a sequence of calcareous sedimentary rocks composed of an aeolian sequence containing petrified tree trunks and root and of marine interbeds with various species of molluscs. The shells in these strata were like those found "*living on the beaches in front of the stratified cliffs.*" He assigned the strata to the Secondary and agreed that they were of a geologically young age and had in recent times emerged from the sea (Fig. 9) (Péron & Freycinet, 1816, pp. 92, 142-146). The two geologists and Péron also concluded the rock sequence found along the Swan River and on Rottnest Island in the southwest of the state were the same as those they examined in Shark Bay, more than 700 km to the north (Fig. 7). We recognise this formation today as the Tamala Limestone of Pleistocene to Early Holocene age (Mayer, 2008; Playford, 2006; Kendrick 1991).



Fig. 9. Horizontal strata of the Pleistocene Tamala Limestone

Péron also noted the presence of corals in strata now well above sea level and deduced from this discovery that an ancient ocean must once have covered the entire Earth but has since retreated to expose the land. He pondered the question of the fate of the vanishing waters but reached no satisfactory conclusion (Péron, 1804, p. 467). Péron seems to have been unaware of then recent developments in the geological sciences. It is clear from his writings that he accepted Dolomieu's classification of rock types and probably absorbed much of the latter's teaching in conversation with his friend Depuch.

Péron's finding of living specimens of the mollusc *Trigonia* on the Australian coast (Bonnemains *et al.*, 2001, p. 267) caught the attention of both Lamarck (Lamarck, 1804) and von Buch (von Buch, 1814). The former saw this as a confirmation of his theory that animals did not become extinct but merely underwent small changes over time. To the latter this provided grounds to question the view held by Werner (Werner, 1786) that sediments had been deposited uniformly in a universal ocean.

Freycinet's expedition and his surgeon/naturalists

In 1818, some 15 years after Baudin's departure from Australian shores, one of his former lieutenants, Louis de Saulces de Freycinet (1779-1841) (Fig. 10), returned in the *Uranie* in command of his own expedition. He was the first in a succession of officers who had participated in earlier voyages to Australia and who would later return leading their own expeditions. Born in Montélimar in southeastern France, he joined the French Navy at the age of 14 and took part in several engagements against the British before his appointment to the Baudin expedition. On his first voyage Freycinet had played a major part in charting the remaining unknown part of the continent's southern coast and, in 1811, had published the first complete map of the Australian coastline. The primary aim of his new mission was to conduct research into the shape of the globe [*la figure du globe*] and the elements of terrestrial magnetism. When time allowed during stopovers, he was also to carry out studies into the three kingdoms of nature and to facilitate the collection of specimens (Freycinet, 1826, pp. XIII-XIV).



Fig. 10. Louis de Freycinet (1779-1841)

Freycinet asked his two surgeon Jean René Constant Quoy (1790-1869), and Joseph Paul Gaimard (1793-1858) to also take on the roles of naturalists. Quoy was a graduate of the School of Naval Medicine in his native town of Rochefort. He took part in several exploring expeditions, followed by a distinguished career as professor of medicine and culminating in his appointment as inspector general of the naval bureau of medicine and surgery. In addition to his work in zoology and anatomy, he also had an interest in mineralogy. His fellow surgeon Joseph Paul Gaimard, born at Saint Zacharie in south-eastern France, graduated from the naval medical school in Toulon. He is best known for his Arctic voyages and his accounts of Iceland and Greenland (Gaimard, 1850). Freycinet made only two stopovers in Australia – at Shark Bay on the West Australian coast and in Sydney. Fortunately for his naturalists, Freycinet's stays at these locations were lengthy ones, giving them the opportunity to make some detailed nature studies.

Quoy, ably assisted by lieutenant Duperrey, expanded the work started by Depuch and Péron who, on their visit to Shark Bay in 1801, had been the first to describe the cliff exposures limestone in this area (Fig. 9). He gave a detailed description of the stratified sequences he examined and identified the rocks as composed of quartz grains held together by a calcareous cement and containing large quantities of bivalve shells. Like Depuch before him, Quoy noted the presence of calcareous

nodules with concentric layers in their interior and irregularly disturbed through the sedimentary layers (Fig. 11). While the former had believed that these concretionary bodies had formed prior to being included into the sediment, to which he referred as a breccia, Quoy concluded that they had formed in situ and stated that, “*those who believe that these globules have been transported deceive themselves; I attribute their formation to a kind of crystallisation*” (Freycinet, 1826, pp. 472-476).



Fig. 11. Concentric layers in calcareous concretions

The extensive sand dunes at the base of cliffs in Shark Bay contained abundant tubular structures, up to 15 cm long and about 3 cm in diameter. Quoy noted that they were composed of sand grains held together by a paste of calcite. And formerly held vegetable matter that had since decayed. Duperrey discovered “*an infinity of petrified trunks on a small plain surrounded by dunes.*” He informed Quoy that they were up to a meter high and had a diameter of up to 30 cm (Freycinet, 1826, pp. 472-476).

During the expedition’s six weeks sojourn at Sydney in 1819, the naturalists had ample time to explore the region. It had only been five years earlier that the surveyor George Evans had made the first crossing of the Blue Mountains and descended to the western plains. Both Quoy and Gaimard made the journey from Sydney across the mountains to the interior. It is to Quoy we owe the first account of the landscape and geology of the region inland from Sydney, then known as the County of Cumberland.

He divides the land into two natural divisions: the plains and the mountains (Fig. 12). The former is an undulating terrain in the midst of which rise some small, isolated hills, extending from the seashore to the foothills of the Blue Mountains. The rocks he identified were quartz sandstones, which in coastal cliffs can be seen to form immense horizontal beds “*a wall of rocks*” and grey, horizontally layered shales [the Triassic Hawkesbury Sandstone and the overlying shales of the Wianamatta Group, respectively, forming part of the Sydney Basin sequence]. He also noted a small hill [Prospect Hill] protruding from the plain composed of an almost black igneous rock, which he referred to as ‘ophite’ [a dolerite laccolith of Early Jurassic age].



Fig. 12. Map du Comté de Cumberland

When crossing the Blue Mountains, he traced the extent of the sandstone sequence to the higher points of the divide where they were interbedded in cliffs with shales and criss-crossed by cracks [joints]. He noted that the high walls of rock rising from the valley floor were often “*hollowed out at their base, and overhanging at the top*” (Fig. 13).



Fig. 13. Blue Mountains.
The cliffs walls in valleys have a concave shape

It reminded him of the similar appearance of sea cliffs where wave erosion had given them a concave shape at their base. It led him to conclude that only the action waves could have shaped these cliffs. He was not alone in reaching this conclusion. When some 17 years later Charles Darwin visited the Blue Mountains, he became convinced that the valleys had been carved out by an ancient inland sea.

When descending the mountains on their inland side, Quoy noticed a sudden major change in the geology from sandstone to red granites,

containing large crystals of pink feldspar. He and his companions had crossed the western extent of the Sydney Basin and were now travelling over the much older underlying rocks of the Lachlan Fold Belt of Ordovician/Silurian age. It was apparent to Quoy that the changes in geology had also brought about a change to the landscape. At this point, he stated that, “we entered into a second part of the Blue Mountains” (Fig. 14). He noted that his path had led him from a terrain of insurmountable valley walls to a country of rounded hills with gentler slopes that made walking much easier.

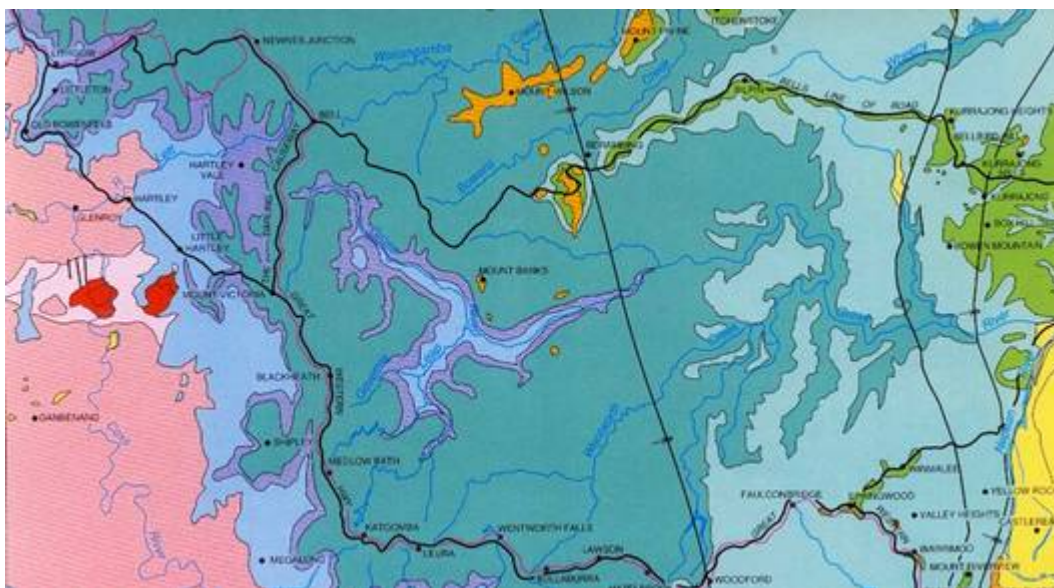


Fig. 14. Geological map of part of the Blue Mountains. The Triassic sedimentary rocks shown in shades of green form both the major and the higher parts of the range. The areas in blue indicate outcrops of Permian sedimentary rocks at the base of the Sydney Basin sequence and mark its western margin. Areas in pink and red represent granitic rocks, part of the Ordovician/Silurian Lachlan Fold Belt. From Pickett, W. and Adler, J. D. (1997). *Layers of time: The Blue Mountains and their geology*

The surgeon was also given the opportunity to travel to the southern end of the Sydney Basin where he again encountered the older rocks underlying it, in this case slates containing mica, but mainly a rock with the appearance of "*grauwacke*". He noted that the layers followed a southwest-northeast trend and were vertical, cut by numerous quartz veins of different dimensions, but did not equate the structural change in these rocks with deformation. (Freycinet, 1826, pp. 672-685).

Duperrey's expedition accompanied by the naturalist Lesson

Louis-Isidore Duperrey (1786-1865) was born in Paris and joined the French Navy in 1802. He gained valuable experience as a lieutenant on the expedition to Australia led by Freycinet and distinguished himself by carrying out work on marine hydrology. He also took an interest in the natural sciences and contributed to the collection of specimens.

In 1822 he was appointed to lead a round-the-world voyage in the corvette *La Coquille* with the main mission to explore the Pacific Ocean and its islands (Duperrey, 1839). He arrived in Sydney in 1824 for a stopover of almost three months. His surgeon René-Primevère Lesson (1794-1849) served as the expedition's naturalist. Like Quoy before him, he was a graduate of the Naval Medical School at Rochefort. Lesson's main interest lay in zoology, particularly the study of birds, but he also described the geology of the regions he visited. He was joined in this work by the expedition's second-in-command, lieutenant Dumont d'Urville, whose main interest was in botany, but who also took an interest in geology and collected geological specimens.

Together, the two made the now customary journey across the Blue Mountains, following in the footsteps of Quoy and Gaimard, but making more detailed observations of the land's natural features. Lesson, in his account of the journey (Lesson, pp. 1- 26), expresses his surprise that no detailed studies have been made of "*the natural wealth of a virgin region still almost unknown in its interior*" (Lesson, 1825, p. 1). His account of the colony's natural history includes descriptions of its geology, zoology and botany, based on his own observations and on information received from the settlers. He modestly refers to his comprehensive

summary as « *une simple généralisation de quelques aperçus* » (Duperrey, 1839, p. 240).

Lesson was the first to state that the sandstones cropping out in the coastal cliffs around Sydney extended across the intervening plain to the Blue Mountains and that they were part of the same formation. He described them as stratified and composed of lightly cemented quartz grains colored by iron oxide. Like Quoy before him, he visited Prospect Hill (Fig. 12) on his way to the mountains and identified its rocks as "*composed entirely of dolerite.*"

High in the mountains, Lesson observed horizontal layers of sandstone forming vertical walls rising from deep valley floors. When descending into the valleys on the western side of the range he found "*a rich deposit of bituminous carbonized wood with matt-black conchoidal fracture and which burns with a lively flame*", and a clay containing fossilized impressions of the leaves. Lesson had reached the base of the stratigraphic sequence at the western margin of the Sydney Basin: shales and coal seams of the Permian age underlying Triassic sandstones. Here the outcrops of sedimentary rocks start to give way to granites containing "*large grains of pink felspar crystals, grey quartz and glittering mica*". He correctly marked this transition as the boundary between two mountain chains of differing geological composition (Fig. 14).

His examination of the outcrops he passed on his journey satisfied him that the granites were part of an older "*primitive terrain*" and were overlain by a younger sequence of sedimentary rocks. He appears to have accepted an aqueous origin of granite and like Quoy, concluded that the overlying rocks were marine deposits. It was only in later years that the Sydney Basin rocks were identified as fluvial in origin.

Hyacinthe de Bougainville

It was only a little over a year after Duperrey had left Sydney when Hyacinthe de Bougainville (1781-1846) arrived. He was born in Brest, the son of the famous navigator Louis-Antoine de Bougainville, who but for the obstacle presented by the Great Barrier Reef would have discovered the eastern coast of Australia before Cook. The younger Bougainville started his own career in the

French Navy as a midshipman with the Baudin expedition, some 23 years earlier. After taking part in various naval campaigns, he rose rapidly to higher ranks. In 1824 he was given command of the forty-four-gun frigate the *Thetis* to undertake a voyage around the world. Its main mission was to show the flag and to further French commercial interests. The expedition's almost three-months stopover at Sydney contributed little that was new to the knowledge of the country's natural history. Bougainville's most noted legacy to Sydney was his commissioning of a monument to the missing La Pérouse at Botany Bay, near the southern Sydney suburb that now bears his name. The tragic end of La Pérouse and of its crew at the island of Vanikoro would not become known for another two years.

Dumont d'Urville in good company with Quoy and Gaimard

Dumont d'Urville (1790-1842) (Fig. 15) was born at Condé-sur-Noireau in Lower Normandy. After studying at the Lycée Impérial in Caen he joined the French Navy at the age of seventeen and graduated from the Naval Academy in Brest. Dumont d'Urville saw service in the Mediterranean and took part in hydrographic surveys. Not long after his return to France with the Duperrey expedition he was given command of another voyage around the world, which departed Toulon in 1826. The refitted *Coquille*, now renamed *Astrolabe*, in honor of one of La Pérouse's ships, was again pressed into service. The commander was fortunate when the two veterans of the Freycinet expedition, the surgeon/naturalists Quoy and Gaimard, decided to sign up for another voyage. Dumont d'Urville himself was an accomplished botanist, who had carried out fieldwork and studied the vegetation of the Provence region. The trio were already familiar with many aspects of Australia's natural history and would add to its knowledge during their stopovers in the country (Dumont d'Urville, 1830). The few, relatively brief stopovers by the *Astrolabe* along Australia's coast, including at Sydney, did not give the naturalists the opportunity to carry out detailed geological studies. However, the search for the site where La Pérouse perished, first attempted more than 25 years before by d'Entrecasteaux, met with success, when Dumont

d'Urville positively identified the location at the island of Vanikoro.



Fig. 15. Jules Dumont d'Urville (1790-1842)

The expedition's first stop in Australia at King George Sound at the southern tip of Western Australia, gave an opportunity to Quoy and Gaimard to examine a report of the occurrence of corals at the top of one of its headlands. In 1791, the English navigator George Vancouver in company of his naturalist Archibald Menzies, had climbed what is now known as Bald Head and discovered what they believed to be fields of coral, some 200 m above sea level (Vancouver, 1798). Quoy noted outcrops of coarse grained granite containing large crystals of pink feldspar at the base of the hill but found that Bald Head itself was composed of limestone. At its summit, he and Gaimard soon discovered that Vancouver's branched corals were petrified tree roots, similar to those they had seen at Shark Bay on their earlier visit with the Freycinet expedition (Fig. 16) (Dumont d'Urville, 1830, pp. 92, 113, 200-201).

Quoy also discovered Tertiary basaltic lava along the shores of Western Port in Victoria and obtained plant fossils from shales in the Sydney region. He was delighted when, like Péron at an earlier visit, he found a living species of *Trigonia* off the New South Wales coast. (Dumont d'Urville, pp. 137, 207-208, 210).



Fig. 16. Fossilised tree roots on Bald Head, Western Australia

Dumont d'Urville bound for Antarctica 1837-1840

In 1837, Dumont d'Urville embarked on his third round-the-world voyage in the corvettes *L'As-trolabe* and *La Zélée*. Australia would again be on his itinerary, but his more important aim was to discover land in Antarctica and to determine the location of the south magnetic pole.

His surgeon/naturalists on this voyage were Jacques Bernard Hombron (1798-1852) and Élie-Jean François Le Guillou (1806-1860). Both were graduates of the *École de médecine navale* at Rochefort. Hombron was also a noted botanist and had a keen interest in geology and mineralogy. During a brief reconnaissance of parts of Australia's northern coast and during their stopover at Hobart, both naturalists collected rock and mineral specimens, but the shortness of time in the field did not allow more detailed geological studies. Le Guillou on a short excursion up the Derwent River from Hobart merely speculated that "*the geologist will find great riches*" in the steep mountains that rise from its banks (Le Guillou, 1845, p. 178).

When the expedition's two corvettes arrived at Hobart, to prepare for the voyage to Antarctica, many of their crews were seriously ill. One of the ships' surgeons needed to stay in town to care for them in a make-shift hospital that had been erected onshore. Hombron, "*who did not enjoy a*

robust health" (Dumont d'Urville, 1841-1853, v. 8, p. 186) was to remain behind to care for the sick, while Le Guillou sailed south with the *Zélée*.

In early January in 1840, Dumont d'Urville left Hobart on the perilous voyage to the frozen wastes of Antarctica in the fervent hope of discovering solid land under the cover of ice and to prove beyond doubt the existence of the long-sought southern continent, the *Great South Land* of earlier times. Before sailing he allowed the captain of the *Zélée*, Charles Hector Jacquinot (1796-1879), the choice of either joining him on the dangerous voyage or to stay behind. Jacquinot, who regarded the voyage to the icy regions as the expedition's high point and the "*most glorious if also the most dangerous part of the mission*", insisted on sailing with his commander (Dumont d'Urville, 1841-1853, v. 8, p. 98).

After a swift voyage south, the corvettes were becalmed in latitudes close to the Antarctic circle (66°.33' S). In fine weather they were surrounded by islands of ice taller than the masts of their ships. In his account Dumont d'Urville describes the magnificent display they witnessed when the sun briefly set behind the icebergs and marvelled at the greatness of the spectacle as the setting sun ushered in the brief polar night, a view to which he thought *no painting could do justice*. (Dumont d'Urville, 1841-1853, v. 8, pp. 138-139).

The eyes of everyone on deck now scanned the vast white horizon for any dark patches that might indicate the presence of land. After several possible sightings, members of the *Zélée*'s crew were the first to positively identify the presence of ice-free land, later recognised as one of a series of eight to ten islets. As a faint breeze did not allow the ships to move closer to the firm ground, open boats were despatched from each ship to explore one of the islets. That of the *Astrolabe* reached the land in 2 ½ hours and arrived shortly after that despatched from the *Zélée*. There they raised the French flag on land "*which no human had either seen or set foot on before us*" (Fig. 17) (Dumont d'Urville, 1841-1853, v. 8, pp. 150-154). The arrivals used their hammers to collect samples of the islet's rock, a task which due to its hardness

yielded no more than small flakes. Fortunately, they soon found large, loose pieces of the stone and loaded them into their boats, enough, according to one officer, "*to supply specimens to all the museums in France*". The general views among the naturalists and officer, including those of Le Guillou and Hombron, were that the Antarctic rocks were a type of coarse-grained granite or gneiss. With the benefit of present-day analysis, they have been described as paragneiss (Fig. 18) and amphibolite (Fig.19) (Godard *et al.* 2017). These specimens would represent undisputed proof to the world of the discovery of a southern land. The officers on board the two ships also succeeded in establishing the coordinates for the site of the south magnetic pole, but as it lay deep in the southern continent, they were unable to reach it.



Fig. 17. First landing in Antarctica and raising the French flag on Rocher du Débarquement

The commander named the newly discovered land *Terre Adélie*, to perpetuate the memory of his wife. The most prominent islet on which the sailors landed and collected the rock samples, he named *Rocher du Débarquement*, and to a close by cape he gave the name *Pointe Géologie* (Dumont d'Urville, 1841-1853, v.8, p. 154).

There could have been little doubt among the population of Hobart of the truth that land had been discovered in Antarctica as, according to Le Guillou, the day after the return of the ships, "*the fireplaces in many homes were decorated with pieces of granite from Terre Adélie*" (Le Guillou, 1843, p. 219).



Fig. 18. Proterozoic paragneiss collected on Rocher du Débarquement



Fig. 19. Proterozoic amphibolite collected on Rocher du Débarquement

In the introduction to his account of the voyage, Dumont d'Urville acknowledged at great length the difficulty faced by naturalists in exploring the lands they visited, given their often-limited time spent ashore and recognised that this applied particularly to geological investigations. He was aware that, *“geological observations require a much greater precision than are needed for other sciences. In zoology and botany an individual specimen can have great importance, but a rock specimen on its own has no value if you do not know the precise point from where it has been collected, the rocks on which it rests, the layer it has been taken from and those which overlie it. The making of geological observations must always proceed by the exact and precise knowledge of places and the descriptive anatomy of formations. It is only after this study that general considerations of the origin and the age of regions can be raised”* (Dumont d'Urville, 1841-1853, v. 1, pp. VII-XV).

Conclusion

The geological investigations by scientists and naturalists on early French voyages of discovery to Australia and Antarctica were mostly confined

to observation along the shores of the two continents. Only the opening of a route across the Blue Mountains offered them the opportunity to travel a short distance inland. The publications of descriptions and interpretations of the geological features they examined provided both scientists and the public in Europe with a first impression of the landscape and geology of these lands. They also challenged some views about geological processes, then widely held by scholars in Europe.

The above chronicle of the geological explorations carried out by the scientists, naturalists, and ships' officers of the seven expeditions' is not exhaustive but rather provides an overview of many of their significant findings. The accounts of the various expeditions were widely read in France and, in translation, in other European countries, but remained little known in Australia. It was not until the end of the nineteenth century that the geological work of the Baudin expedition was brought to the attention of Australian scientists (Tate, 1893). One of the legacies left Australia by the commanders and officers of the first two expeditions, was the bestowal of more than 600 French names on localities along the country's shores, more than half of which are still in use today.

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Scientific relations of Alexander P. Karpinsky (1847-1936) with France

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Abstract. The paper is devoted to some aspects of international cooperation in geosciences related with activities of the outstanding Russian geoscientist A. P. Karpinsky with a focus on his links with France. General questions concerning his role in the organization and development of geology in Russia are discussed. The position of Karpinsky as a member of an international geological society is underlined. An obvious recognition of the merits of Karpinsky in France was the awarding of his Cuvier Prize in 1921.

Key words: A. P. Karpinsky – history of geosciences – international scientific relations – France – Prix Cuvier.

Introduction

The Karpinsky family is the oldest and most famous mining and geological dynasty in Russia. Its ten generations gave Russia many famous names in the organization of mining, prospecting and exploration of minerals and geosciences since the beginning of the 18th century. The most famous representative of the dynasty is Alexander Petrovich Karpinsky (1847-1936). His name is associated with the organization and development of the main Russian scientific institutions and various fields of geological researches.

Karpinsky was a gifted geoscientist, teacher, one of the founders of the geological survey in Russia (Geological Committee of Russia), and the first elected President of the Russian Academy of Sciences¹ (1917-1936).

Called the "father of Russian geology" Karpinsky was well-known abroad. His career was associated with three Russian scientific institutions: the Mining Institute in Saint-Petersburg, the

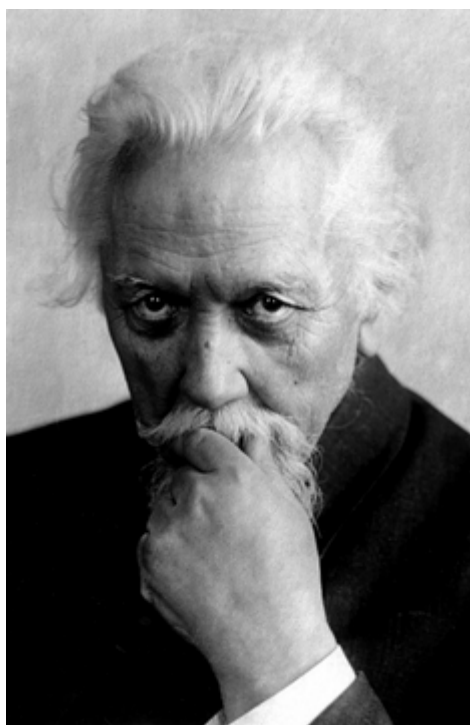


Fig. 1. Alexander Petrovich Karpinsky, 1920.
https://www.flickr.com/photos/hi_geo/sets/72157661829858712

¹ Academy of Science and Arts in Saint-Petersburg (1724), Imperial Academy of Science and Arts in Saint-Petersburg (1747), Imperial Academy of Science (1803), Imperial Academy of Science in Saint-Petersburg (1836), Russian Academy of Sciences (1917), Academy of Sciences of the USSR (1925), Russian Academy of Sciences (1991).

Geological Committee of Russia, and the Academy of Sciences.

After graduation from the Mining Institute in Saint-Petersburg in 1866 Karpinsky was closely related with his 'alma mater' as a teacher. For about 30 years (1867-1896) of teaching in the Mining Institute he has educated dozens of students who ensured the development of geosciences in Russia in the 20th century. The most part of prominent Russian geoscientists were his disciples.

Two Russian institutions were the places of the organizational activities of Karpinsky – the Geological Committee of Russia and the Academy of Sciences.

Karpinsky was one of 8 first staff members of the Russian geological survey – the Geological Committee of Russia founded in 1882. Elected its director in 1885 he kept this position until 1903.

In 1886, Karpinsky joined the Imperial Academy of Sciences in Saint-Petersburg as an adjunct. He became a full member in 1896 and was the first elected President of the Russian Academy of Sciences (May, 1917). Karpinsky headed the Academy of Sciences until the end of his life in 1936.

Karpinsky as a geoscientist

Karpinsky was the leader in all positions he had. Both scientific schools, and fields of geological researches have been started and developed under his leadership. Outstanding researches of Karpinsky in geological mapping, petrography, stratigraphy, paleontology, regional geology, tectonics, and mineral deposits are well known.

Since its of foundation (1882) the Geological Committee of Russia has started to compile the map of the European Russia to be a part of the International Geological Map of Europe (scale 1:1 500 000). Karpinsky headed this work as the Editor-in-Chief of the Russian map and was elected a representative from Russia in the Commission of the International Geological Map of Europe of the International Geological Congress (IGC).

He developed a general map legend and compiled map sheets in the Urals himself.

Ten years later the compilation of the Geological Map of the European Russia was finished (Karpinsky et al., 1893). Three sheets for the International Geological Map of Europe were prepared sometime later.

Progress in paleogeography in Russia in the second part of the 19th century has widened perspectives for tectonics. And Karpinsky has brilliantly demonstrated it. Using facial researches and compiling paleogeographic maps Karpinsky has reconstructed the tectonic development of the European Russia (Karpinsky, 1887).

Karpinsky is considered a pioneer in tectonics in Russia. His article "On the regularity in outline, distribution, and structure of continents" (Karpinsky, 1888) is recognized as a classic paper, which is why it was published in English with comments in *Episodes* (Romanovsky, Zoubarev, 2003). The article on the movements within the European Russia (Karpinsky, 1894) was published in French in *Annales de Géographie* two years later.

Karpinsky's publications in paleontology and stratigraphy were well known abroad and much discussed in Europe. He was one of the first who draw attention to the stratigraphic significance of the study of cephalopods. The phylogenetic series of the Upper Permian (Artinskian) ammonoids distinguished by him was a real discovery and caused most heated discussions among specialists.

Helicoprion and its close relatives were one of the favorite subjects of Karpinsky's studies. It is not needed here to report all the data, which had already published on the helicoprionids. One can be re-addressed to the large list of publications, focused on morphology and systematic position of this fish group (see these works for further references: Obruchev, 1953; Lebedev, 2009; Itano, Lucas, 2018). Many of the helicoprionid fossils are originated from the Lower Permian deposits, and the most representative collections of the helicoprionid remains in the Urals area came from the Artinskian deposits outcropped in the close vicinity of the City of Krasnoufimsk, Sverdlovsk region (Naugolnykh, 2016, 2018).

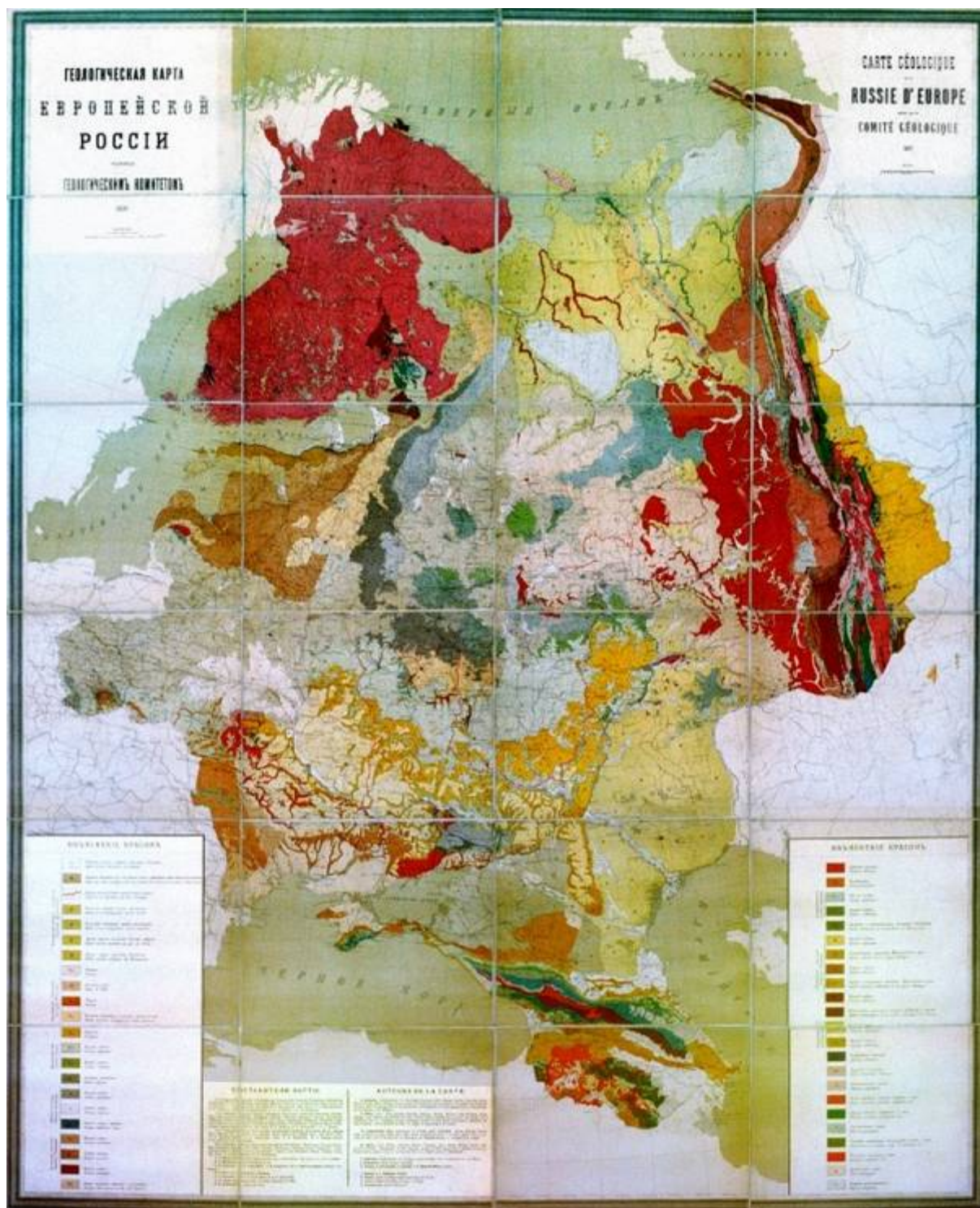


Fig. 2. Geological Map of European Russia, published by the Geological Committee in 1893. Scale 1:2,520,000 (60 versts per inch) (Karpinsky et al., 1893)

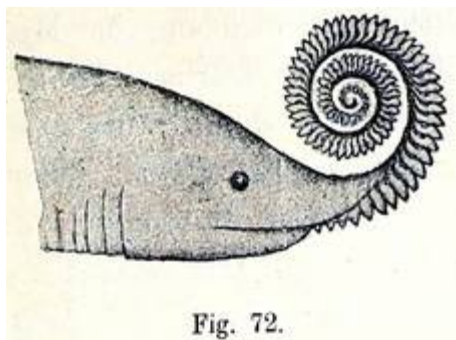


Fig. 3. The first reconstruction of the *Helicoprion* dental spiral position (Karpinsky, 1899)

In 1903, Karpinsky described one quite particular chondrichthyan tooth of durophagous morphology attributed to the genus *Campodus* de Koninck, 1844. The tooth was found together with a fragment of the teeth whorl of *Helicoprion* sp. and cephalopods *Popanoceras krasnopolskyi* Karpinsky, *Medlicottia artiensis* (Grünwald), etc. (Karpinsky, 1903).

The material collected up to the present moment from a number of localities disposed in the Urals area by several scientific teams, mostly representing local or regional museums, such as the Krasnoufimsk regional museum, allows adding some new facts worth being taken in account for a further discussion of the helicoprionid paleoecology and morphology. Now we can suggest that the Artinskian deposits in transection from the City of Krasnoufimsk on west and to the City of Arti on east represent more or less gradual changes in paleoenvironments from the algal-bryozoan reefs with inter-reefs sea basin to the near-coastal basin with fast adding of clastic material from the Paleo-Urals on east. Further studies of the Artinskian sections of the western Urals started more than one hundred years ago by Academician A.P. Karpinsky will be continued and will lead to a multidisciplinary reconstruction of the Early Permian landscape, biota, and paleoclimate of this region in future studies.

Karpinsky as a member of the international geological society

These scientific and organization activities made Karpinsky well known abroad. He was an active member of the international geological society. His activities in the work of International

Geological Congress have been noticeable for 55 years.

In 1881, the work of Karpinsky "Essai de l'unification systématique des procédés graphiques en géologie" prepared for the 2nd IGC Session in Bologna received one of the prizes (Karpinsky, 1882). He was a member or the head of Russian delegations at the next IGC Sessions: Zurich (1894), the President of the 7th IGC in Saint-Petersburg (1897), Paris (1900), et al. The last IGC Session for Karpinsky was the Congress in Madrid (1926) but he intended to take part in the 17th IGC Session in Moscow (1937). During the IGC Sessions and commissions meetings Karpinsky had opportunity to meet with foreign colleagues.

The works of Karpinsky were published in the foreign press. Paleontological and stratigraphic conclusions were more discussed than the tectonic ones.

The discussion concerning the nature and interpretative morphology of the spiral teeth whorls of *Helicoprion bessonowi* Karpinsky, a discovery of which made the name of Karpinsky familiar not only to professional geologists, paleontologists and stratigraphers, but also to a wide public as well (brief discussion see above).



Fig. 4. Holotype (right) of *Helicoprion bessonowi* Karpinsky gen. et sp. nov. Academician F.N. Chernyshev Central Geological Research Museum specimens 1670/1 (left) and 1865/1 (right) (Sokolov, 2021)

Among the partners who intensively discussed the problems of helicoprionid and edestid morphology and systematics there are such eminent scientists as O. Jaekel, E. Van der Broeck, A.P. Ivanov, A.S. Woodward, O.P. Hay, C.C. Branson, and many others (Obruchev, 1953).

References to Karpinsky's tectonic papers can be found in the works of Ed. Suess and M. Bertrand.

Scientific relations of Karpinsky with France

Through history Russia has been closely connected with France. A vivid manifestation of this fact in science is the participation of French scientists in the activities of the main scientific institution of Russia – the Academy of Sciences. Since its foundation in 1724 remarkable foreign scientists have been inviting to work in Russia. French scholars worked in Russia and were elected as foreign honorary members or correspondents. There are more than 20 French geoscientists in the list of foreign members, while the total amount is about 125 (Malakhova et al., 2012).

The scientific biography of Karpinsky allows you to trace some Russian-French scientific relations. He visited France several times and also welcomed French colleagues in Russia.

In 1892, Karpinsky visited Switzerland and France to participate in the Meeting on the publication of the Geological Map of Europe and to get acquainted with the Geological Society of France.

At the 6th IGC in Zurich (1894), the Vice-President from Russia Karpinsky has announced the Russian proposal for the next meeting in Saint-Petersburg. In 1897, members of the French delegation could appraise the efforts of Karpinsky as the President of the 7th IGC.

There were 89 delegates from France in the list of the 7th IGC participants, with 41 participating in person – Ch. Barrois (and his son), M. Bertrand, M. Boule, Ch. Depéret, Em. Fallot, A. Gaudry (with wife), P. Jannettaz, P.-Em. Levasseur, Em. Margerie, St. Meunier with his wife and daughter, A. Offret, and many others.

Ch. Barrois, M. Bertrand and A. Gaudry were elected as Bureau members. Ch. Depéret joined the Commission on the Unification of Geological Nomenclature and worked in close contact with Karpinsky and other Russian colleagues (Congrès géologique international..., 1899).

26 French delegates participated in geological excursions: 15 before the Session (the Urals and Finland), and 21 after the Session (the south of the country, from Moscow to the Caucasus and Crimea).

Karpinsky himself led the part of the Ural excursion (the Pre-Urals and the western slope of the Urals, from Urzhum to Yekaterinburg). There were 8 French participants in this group (M. Bertrand, P. Jannettaz, E. Margerie, A. Offret et al). M. Bertrand was very active during excursions and reported impressions and results of his Russian journey « Les excursions du septième Congrès géologique international en Russie » (Bertrand, 1897) at the meeting of the Geological Society of France. Ch. Barrois (Barrois, 1897), M. Boule (Boule, 1897) and A. Gaudry (Gaudry, 1898) did the same their (Kolbantsev, 2019). The spouses Meuniers published their impressions in the form of detailed sketches-reports "VII Session du Congrès Géologique International" (Meunier, St., 1897-1898) and "Voyage d'un Congrès en Russie" (Meunier St., M-me, 1898).

Later Karpinsky visited France several times. In 1899, he participated in the meeting of the International Petrographic Commission in Paris. A year later Karpinsky headed the Russian delegation at the 8th IGC in Paris (1900). He gave a welcoming speech at the Opening Meeting and introduced A. Gaudry, as President of the Session. Karpinsky was a member of the Bureau of the Congress. He made reports on the next topics: the Floating Marine Institute Project, the work on the Geological Map of Europe, the principles of classification and nomenclature of rocks, the teaching of geology in schools (Congrès géologique international..., 1901).

In 1902, Karpinsky attended the 6th Congress of Hydrology, Climatology and Geology in Grenoble, where he was a member of the Bureau of the Geological Section.

Karpinsky participated in the International Congress on Mining, Metallurgy and Applied Geology in Liege (1930), and then in the festivities dedicated to the centennial of the Société Géologique de France (SGF) and the 50th anniversary of the Société Française de Minéralogie et de Cristallographie in Paris. « A.P. Karpinsky and his accompanying daughter E.A. Tolmacheva and paleontologist Academician A.A. Borissyak listened to the inspired speeches of A. Lacroix and P. Termier » (Romanovsky, 1981).

As a member of the Academy of Sciences Karpinsky has nominated and supported the election of French geoscientists as foreign correspondents. Ch. Barrois (1897), M. Bertrand (1899), A. Lacroix, E. Haug (1909), P. Termier (1924), Ch. Depéret (1927), L. Cayeux (1929) were among them (Malakhova et al., 2012).

Karpinsky remembered his French colleagues and published obituaries in Russian scientific periodicals: for example, to the memory of Gabriel

Auguste Daubrée (1814-1896) (Karpinsky, 1896), Marcel Bertrand (1847-1907) (Karpinsky, 1907), Jean Albert Gaudry (1827-1908) (Karpinsky, 1908).

His close scientific ties with French geoscientists are evidenced by extensive correspondence stored in the Archive of the Russian Academy of Sciences in Saint-Petersburg. There are next letters from French scholars – Table 1 (Karpinsky Alexander Petrovich, 1886-1936).

<i>Correspondents</i>	<i>Letters & Postcards</i>
Barrois, Charles Eugène (1851-1939)	13
Bertrand, Marcel Alexandre (1847-1907)	3
Cayeux, Lucien (1864-1944)	2
Depéret, Charles Jean Julien (1854-1929)	4
Daubrée, Gabriel Auguste (1814-1896)	14
Gaudry, Jean Albert (1827-1908)	15
de Grossouvre, Marie Félix Albert Durand (1849-1932)	2
Haug, Gustave Émile (1861-1927)	8
Lacroix, Alfred François Antoine (1863-1948)	11
de Margerie, Emmanuel Pierre Martin Jacquin (1862-1953)	12
Meunier, Étienne Stanislas (1843–1925)	17

Table 1: Some French correspondents of Alexander P. Karpinsky

Letters from France contain comments on scientific publications of Karpinsky and interest in receiving the results of his research in paleogeography, stratigraphy and mining resources exploration. Correspondents showed great interest in Karpinsky's initiatives reported on the 7th IGC Session, and especially in the Geological Map of Russia (Karpinsky, 1897).

The letter of A. Gaudry as of October 10, 1898 is very interesting. He supported the plan of the Floating Institute creation suggested by Karpinsky from the podium of the Congress (Congrès géologique international, 1899) and promised to contribute to its implementation from the French side. Gaudry also informed Karpinsky that the recommendation to introduce teaching of geology

and paleontology in gymnasium suggested at the 7th Congress was approved by the French Ministry.

And more from Gaudry's letter: « *J'ai reçu un jour-ci une lettre m'annonçant que sa Majesté l'Empereur de Russie me confère l'ordre de St Anne de première classe. Je suppose que je vous dois en partie cette distinction à laquelle je ne m'attendais nullement et je vous remercie de tout cœur de me donner en bien de plus avec votre grande nation, si aimé de tous les Français. Nous continuons à préparer le Congrès de 1900 à Paris, mais il nous sera impossible de vous égaler* » (Karpinsky, Alexander Petrovich. 1886-1936. Fund. 265. List 6. File 171, pp. 5-6)

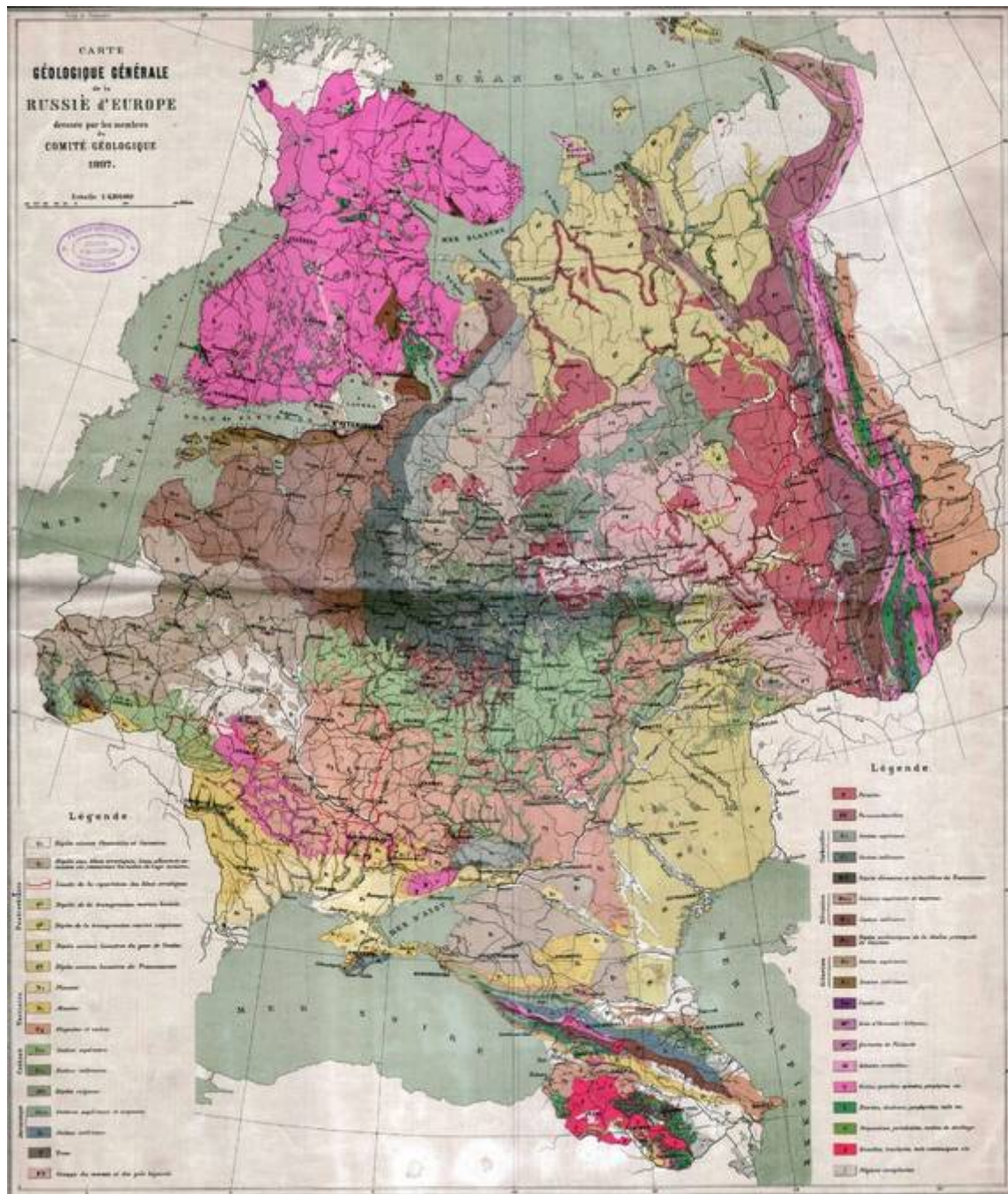


Fig. 5. A general geological map of European Russia, compiled by members of the Geological Committee in 1897. Scale 1:6,300,000 (150 versts per inch). The map was given to the participants of the VII IGC session in Saint Petersburg, 1897

5. The Prix Cuvier

A vivid recognition by the scientific community of France of the Russian geologist's merits was the awarding of the Prix Cuvier.

The award named by Jean Léopold Chrétien Frédéric Dagobert, baron de Cuvier (1769-1832) was established by the French Academy of Sciences in 1850. The French naturalist is known worldwide for his pioneer zoological and geological work. He was a member of the Academy of Sciences in Paris from 1795. The Prix Cuvier should be awarded to well-known scholars for works which « *will be recognized as the most outstanding among all researches on the animal kingdom or geology published after the death of this great naturalist* » (Prix Cuvier, 1850, p. 263).

Such distinguished scholars as Jean Louis Rodolphe Agassiz (1807-1873), Richard Owen (1804-1892), Roderick Impey Murchison (1792-1871), and Arthur Smith Woodward (1864-1944) were honored until 1921, when the first Russian name was listed. At that time A.P. Karpinsky was and still is the most known geoscientist in Russia.

In 1921, the Commission on the Cuvier Prize of the Academy of Sciences (Institut de France), composed of Ch. Barrois, H. Douvillé, F. Walerant, P.-M. Termier, L. de Launay, E. Perrier, A. Lacroix, Ch. Depéret. The decision of the Commission on the Prix Cuvier of the Academy of Sciences in Paris to award Karpinsky was reported at the Session by E. Haug.

The next Karpinsky's official regalia include nomination of the French Academy – Director of the Geological Committee of Russia, President of the 7th Session of the International Geological Congress (IGC) in Saint-Petersburg (1897), and President of the Academy of Sciences in Petrograd. The decision was based on scientific merits of Karpinsky. As his main accomplishment Commission noted: «Tertiary deposits of the Eastern Urals» (1883); «The general nature of the earth's crust movements within European Russia» (1894); many paleontological works of Karpinsky and, first of all, the study of genres *Helicoprion* and *Volborthella*, as well as description of *Trocholisques* (Prix Cuvier, 1921, p. 1244).

As indicated in the introduction letter, one of the main reasons for the Prix Cuvier awarding was the broad study of the spiral teeth whorls of the genus *Helicoprion* Karpinsky, established in 1899 and widely,

« *les recherches paléontologiques de M. Karpinski sur les Ammonoidés des couches d'Ar-tinsk sont depuis longtemps classiques. Elles illustrent d'une manière saisissante le parallélisme qui existe entre les stades du développement individuel et ceux auxquels sont arrivés les genres successifs d'une série phylétique. Elles font, en outre, connaître en détail de nombreux termes de passage entre les faunes carbonifères et les faunes triasiques.*

Les travaux ultérieurs de l'auteur ont trait au genre Helicoprion, curieux élasmobranche, dont les dents étaient disposées en spirales, au genre Volborthella, le plus ancien céphalopode connu, aux trocholisques, singulières algues calcaires des terrains primaires, représentées par leurs oogones, qui les classent au voisinage des characées. Ils témoignent tous de remarquables dons d'observation et d'un sens critique très affiné » (Prix Cuvier, 1921, p. 1244).

In 1922, the Russian scientific journal *Priroda* (*Nature*) congratulated academician A.P. Karpinsky with the remarkable award – the *Prix Cuvier* of the Academy of Sciences (Institute of France) in Paris with reprinted text of the nomination (Prix Cuvier for academician..., 1922).

Conclusions

Science in Russia has been much obliged to foreign scholars and institutions ever since the foundation of the Academy of Sciences in Russia. Geological theories and practice have much followed foreign ones.

The time of Karpinsky was a period of the progress of geosciences in Russia and the effective cooperation of Russian geoscientists on a par with foreign colleagues: change of ideas, discussions and personal contacts. And Karpinsky is the symbol of that time;

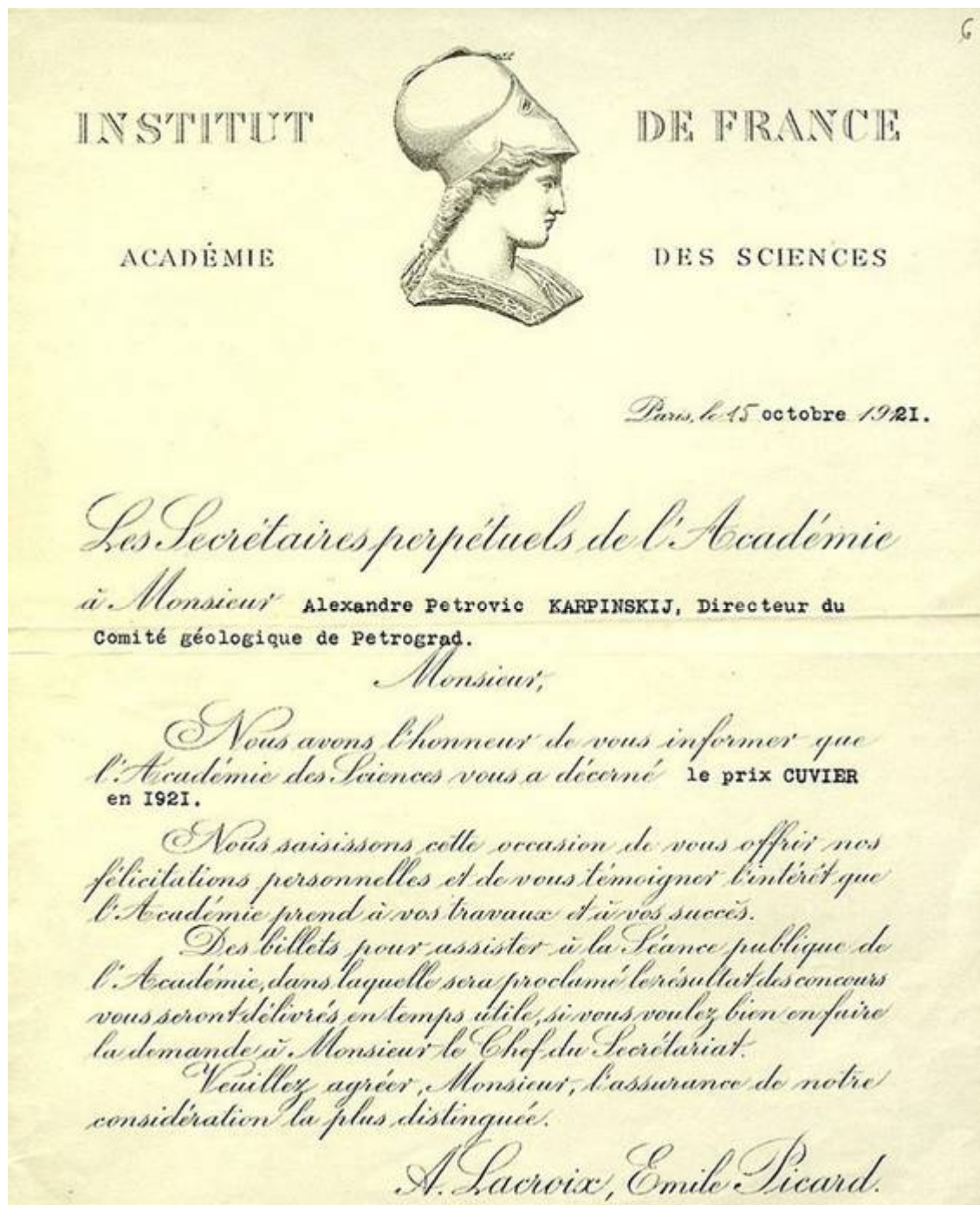


Fig. 6. Diploma of the French Academy of Sciences: Prix Cuvier for A.P. Karpinsky. The Archive of the Russian Academy of Sciences. Saint Petersburg Branch. Fund 265. Inventory 2. File 15. List 6. <http://ranar.spb.ru/rus/vystavki/id/340/>

He led science in Russia and the USSR during the October revolt (1917), the Civil War (1918-1922), the postwar devastation and famine (1917-1922), and during the build-up of fear and the beginning of the Stalinist terror (1931-1936). The Academy's efficiency during this period was his merit in many respects.

New data on the paleontological characteristics of the Artinskian deposits of the stratotype area, as well as new stratigraphical observations allowed adding new considerations on Early Permian paleoecology and even paleo-landscape/paleoenvironmental reconstructions of this region, for further developing of Karpinsky's ideas.

Karpinsky's scientific relations with French colleagues were long-lived and very fruitful for international cooperation in geosciences. The correspondence of Karpinsky testifies to the active exchange of scientific information. The letters from France imbued with deep respect for the Russian geologist. And the Prix Cuvier is a proof of that.

The World War I (1914-1918) destroyed many scientific relations. Russia, Germany and some other countries were under sanctions. So, the act of Karpinsky awarding was so remarkable at that time, and confirms the conclusion of Vladimir I. Vernadsky that science has neither nationalities, nor borders (Vernadsky, 1930).

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Characteristics of earthquakes in the Mediterranean Sea and their effects, in Arab-Islamic heritage

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Abstract. Historical information on earthquakes is important and useful data in the earthquake prediction process and in determining the seismicity of an area. The Arab-Islamic heritage sources constitute a very important reference for such data.

The seismic events which this article refers to, cover a period from November 885 until January 1409. These events are cited in historical sources covering a period from the first half of the 12 Century to the beginning of the 16th century of the Christian era. The geographic, historical and literary sources, constituting the Arab-Islamic heritage that refers to earthquakes, cover a longer period, ranging from the very beginning of the 8th century, until the end of the 18th century.

In this article, we have focused on a variety of scientific heritage sources (books and letters in the natural sciences, travel books, a number of historical sources), which deal with earthquakes in the Mediterranean basin (especially in its eastern part). In addition to the definition and description of the phenomenon, these sources refer to many features of the earthquakes as their causes, types, intensity, strength, extension, material damage and human casualties; their recurrence and duration; As well as the phenomena associated with them, such as natural effects (such as tidal waves or tsunamis) and impacts on the landform.

Finally, it is important to note, contrary to what many historians of science think, that the Arab-Islamic civilization clearly contributed to the development of seismological thought. Arab-Muslim scholars have defined earthquakes and described them appropriately. They also tried to understand the phenomenon and to offer scientific explanations to it, far from the mysterious and mythical interpretations that prevailed in many parts of the world, in early and high medieval period.

Key words: Earthquakes – Islamic Heritage – Mediterranean – Causes – Genetic classification – impacts.

1; Introduction

Seismology relies heavily on trying to predict, so it needs a series of information and historical data that may help to calculate appropriate indicators of areas of weakness in the Earth's crust. Historical sources, yearbooks, books and letters on the subject can be considered as important sources in monitoring earthquake events. It should be noted that seismic events have received special attention in Arabic writings.¹

2; Earthquakes, description, types and causes of their occurrence

2.1 Description of the earthquake

Earthquakes have been described in traditional Arab-Islamic sources in different ways. The most interesting descriptions liken them to an underground vibratory movement that makes the earth undulate or to the trembling of a feverish body or

¹- Geological Encyclopedia. V: 4. p: 85.

to the movement of a sieve or even to the flapping of a bird's wings. Ibn Al-Aadim says about the earthquakes of the year 1138 (Ibn Al-Aadim, p. 113): «*On Thursday 13 Safar, a strong earthquake occurred, then another followed, and the earthquakes continued, so the people fled Aleppo to the outskirts of the country... and the earth was seen to ripple, and the stones on it were shaking like wheat in a sieve.*».

2.2 Causes of earthquakes

In ancient times, people attributed the occurrence of earthquakes to mythical and legendary causes, such as: the movement of the whale carrying the earth above she or the bull moving the earth he carries, from one horn to the other, after he is tired...

This remained widespread among men at least until the early and high Middle Ages.

The ideas of Greek philosophers represent some of the first scientific attempts to explain the seismic phenomenon. We cite mainly those of Aristotle in his "Meteorologies", in which he presented the ideas of his predecessors, specifying his point of view regarding their ideas.

Aristotle believed that there are two kinds of exhalations: a moist one, called vapor, and a dry one called pneuma. Pneuma is a common element in earthquakes and winds. In fact, the Earth produces a large amount of pneuma, either through its internal fire or externally, when it is heated by the Sun. Sometimes, the pneuma comes out completely and gives rise to the winds; sometimes it heads towards the interior of the Earth, where it accumulates and causes earthquakes; sometimes still, it is shared between the surface and the interior and can produce small earth tremors. This theory was taken up by Lucretius, Seneca, Pliny..., as well as all the encyclopedists of the Middle Ages (Isidore of Seville, Bede the Venerable...) (Poirier, 2008, p. 28).

Earthquakes attracted the attention of several Muslim scholars who attempted to explain the phenomenon scientifically, without simply reproducing the ideas of Aristotle and other Greek philosophers.

The Ikhwan Al-Safa (1995, p. 505) state, «Concerning the movements of the Earth, they come in three forms: some are like flashes of lightning, some are like eclipses, and others are like swaying back and forth. As for the cause of earthquakes, it arises from the repressed vapor within the earth, seeking to escape. It shakes certain parts of the earth, causing them to become agitated and tremble, much like a person with a severe fever trembles. When a fever rages within a body, accidental heat ignites, melting and decomposing it, transforming it into smoke and vapor escaping through the body's pores. The entire body or a part of it vibrates and quakes. The body remains in this state until these vapors and smoke escape, calming and settling. Similarly, parts of the earth move during earthquakes. Perhaps the earth's surface will crack open, and all these winds, smokes, and confined vapors will escape at once. The earth and its surroundings will collapse, falling into this abyss, just as the roof of a house collapses and falls into its foundation. ».

Hammudi Adnan (1986, p. 63) believes that the comparison between Aristotle's interpretation of earthquakes and that of Ikhwan Al-Safa, reveals fundamental differences between the two ideas, notably: the origin of wind (or dry vapor); wind accumulation factors inside the earth; As well as the heat source which transforms surface water into dry steam.

"Al-Shifa" encyclopedia is considered one of the most important sources of Arab-Islamic scientific heritage dealing with earthquakes. Indeed Ibn Sina devoted several paragraphs of the book "Minerals and Meteorologies" to discussing the opinions of the scientists and philosophers who preceded him. He also presented the main ideas and opinions that had been formed on earthquakes up to his time.

Ibn Sina Said (1965, pp. 20-21): «Regarding earthquakes, they are the result of a disturbance that exposes a portion of the Earth's surface as a reaction to what lies beneath it. Undoubtedly, the motion below the surface triggers a corresponding motion on the surface. The causes of this earthly agitation can be attributed to various factors: a potent, smoky vapor rushing like the wind; a liquefied body of water; an aerial force; a fiery presence; or

a terrestrial element. The fiery presence doesn't naturally form beneath the surface as fire, but is, without a doubt, a powerful smoke or a burning wind. Similarly, the terrestrial body doesn't undergo motion unless driven by a cause similar to its basic nature, making it the primary instigator of earthquakes. Concerning the windy element, whether it possesses fire or not, it must emanate from beneath the earth's surface, leading to the undulating movements of the earth in most instances. The aerial force, on the other hand, can only exhibit movement when influenced by external factors, such as the strong flow of water. In such cases, the air's blows it forcefully, as seen in collapses resulting from the erosion of pit and cave corners. These collapses fall downward, disrupting the air and the earth connected to it, and they also reach the surface if they land on a solid foundation. In essence, the primary agents of earthquakes are water and earth's movements, often mediated by the influence of the air. These are the various scenarios in which earthquakes can occur, driven by either strong winds or fiery vapors that set the earth in motion, and this is the most important aspect, either waters that flow at once, and this is the opinion of Democritus, or the collapse of certain pillars inside ».

Ibn Sina stated (1965, p. 21), «A compelling piece of evidence suggesting that engorged winds are a primary cause of earthquakes is observed in regions where earthquakes are frequent. In such areas, if numerous wells and canals are excavated to facilitate the release of accumulated winds and gases, the occurrence of earthquakes diminishes. ».

As for Al-Quazouini (2006, p. 145), he explained that earthquakes and subsidences subjected by the Earth are linked to the accumulation of vapors within its interior, «when these vapors are confined without any means of release, the entire earth's structure begins to tremble and become unsettled, much like a person's body in the grip of a severe fever due to the presence of trapped, decaying moisture within. This moisture ignites the body's natural reactions, causing it to melt and break down, transforming into vapor and smoke that escapes through the body's pores. The heat generated in the process causes the body to shake and quiver. This state persists until these substances find an outlet. In the case of earthq

uakes, the movements within the earth's parts are eventually quelled, and the earth's surface may crack open, allowing these confined materials to be released all at once. ».

These ideas can be considered as an interesting contribution to the development of scientific perception of earthquakes and the internal structure of the Earth. And these texts are of great importance in the history of seismology in particular and in the history of geology in general.

The most important of these ideas can be summarized as follows (Hammudi Aadnan, 1986, pp. 66-70):

- the causes of most earthquakes are found underground;
- the bodies that can move and make the Earth move are either gaseous (vapour), liquid, stone or fire. It is an inference that reflects an evolution of geological thinking regarding the Earth, its nature and what might be happening inside;
- these factors are of unequal strength and influence;
- according to Ibn Sina, the wind (one of the most important causes of earthquakes), is an internal, smoky, ardent and flaming wind that rushes with enormous force from the depths of the earth and does not depend on atmospheric factors; whereas the Aristotelian wind results from the dry vapor which bubbles in the depths, and it is a wind which depends on the atmosphere, the climate, the temperature of the sun, day and night, and the nature of the ground.

The engorged winds or the smoke, considered to be the cause of earthquakes, correspond well to the vapors and gases accompanying volcanic eruptions, as can be deduced from the speeches of Ibn Sina and Al-Quazouini. These would be the first texts relating to "seismic energy" residing inside the Earth.

The fall of meteorites from outside the Earth and their collision with the Earth's surface is considered one of the well-known causes of earthquakes, many of which have occurred in many regions of the Muslim world, have been recorded by many historians, such as: the

earthquake of Qums and Nishapur in the year 855 AD (Al-Yaacoubi², 1995, p. 312); And that of Damascus in the year 1505 AD (Al-Aaydarous³, 2001, p. 28).

Some Muslim naturalists; including Jaber bin Hayyan; believed that earthquakes were linked to astronomical phenomena (IBn Hayyan, 2006, p. 299).

This can be seen as an aspect of the influence of Greek thought on early Muslim scholars. But this decreased considerably with the development of seismic thinking among Muslims. Indeed, for Ibn Sina, astronomical phenomena no longer had any role in earthquakes.

It is clear from what it has been mentioned in the writings of scholars of Islamic civilization, such as: IBn Hayyan (721-813), Al-Kindi (805-873), Al-Farabi (874-950), Al-Hamadani (893-947), Ikhwan Al-Safa (10th century), Al-Biruni (973-1048), Ibn Sina (980-1037), Al-Quazouini (1203-1283), Al-Suyuti (1445-1505) and others, that the most important causes of earthquakes are: earth movements resulting from internal body movements; subsidence; And the impact of meteors against Earth's surface.

Basically, we can say that these reasons are the same as those known to seismologists of our time.

2.3 Types of earthquakes

Hammudi Aadnan (1986) believes that the first classification of earthquakes could be attributed to Ibn Sina (Avicenna). It is based on the criterion of genetic factors. Thus, Ibn Sina divided earthquakes into three categories: Collapse earthquakes; Subsidence earthquakes; and Volcanic earthquakes. In addition, Ibn Sina (1965, p. 22) developed a second classification, based on the nature of the tremor that causes the earthquake, according to which he distinguished: Quiver earthquakes in which the effect of the tremor is essentially vertical and rectilinear; Convulsive earthquakes, in which the effect of the tremor is lateral;

And "ladder earthquakes", in which the effect of tremors is both vertical and lateral.

3; Earthquakes' intensity and material damage

Earthquakes vary in strength and intensity. Historians have used several qualifications to point to this variation. Ibn Al-Atheer (1160-1233) described in *Al-Kamil Fi Al-Tarikh* twenty-nine seismic events, with four different descriptions, depending on the strength and intensity of the earthquake, such as: major (great), intense, big (large) and medium earthquakes.

3.1 Physical damage.

In addition to some imprecise qualifiers (enormous, terrible, major, intense, large...), Muslim historians, geographers and travellers, have described the material damage caused by many earthquakes, that can be taken into consideration to distinguish earthquakes according to their strength and their intensity⁴.

Among the many texts that mention seismic events and the importance of the material damage caused by them, we will content ourselves to the following texts:

- Ibn Al-Aadim (1996, p. 113) said about the Aleppo earthquake of the year 1138: «*Many houses collapsed in Aleppo, the fence was broken and the walls of the citadel shook.* »;
- Abu Yaela (1998, p. 206) says about the earthquake of the year 1157: «*The news came from the north, with what was very bad to hear and what his citation terrifies the souls, so that Hama and its castle collapsed and all its houses and homes...; As for Shayzar, its suburb was unhurt, except what was destroyed first; As for its famous fortress, it was demolished... As for Homs, its people had been evacuated to the outside and they were safe, their homes were destroyed and its castle was destroyed. As for Aleppo, some of its houses were destroyed, and its people left. As for its*

² - 9th Century ; Died after 905.

³ - 1570-1628.

⁴- As currently used in earthquake classification scales, such as the M.S.K scale, based on the nature of the physical damage to determine the intensity of an earthquake.

castles and strongholds that were far from it, to Jableh and Byblos, the horrific ruins affected it, and Salamiyah was destroyed, as well as what connected it to the area of Al-Rahba and its surroundings. »;

- Al-Maqrizi (2001a, p. 310) says about the events of the year 1169: «On Monday, the twelfth of Shawwal, after the sunrise, a huge earthquake occurred in Damascus, from which some of the balconies of the Umayyad Mosque collapsed, and the heads of the eastern and western minarets were cracked. And the northern minaret was shaking as the frond shook in the gale-force wind. ».

From the texts that I have been able to consult, it is possible to deduce some characteristics related to the intensity of earthquakes. The most important features that stand out can be summarized as follows:

- a great diversity in the intensity of earthquakes;
- a variation in earthquake intensity according to time:
- a variation in earthquake intensity according to location.

3.2 Human losses (table 1).

In addition to the material damage caused by earthquakes, we found in these sources, a keen interest in mentioning the figures related to the loss of life, caused by many of the mentioned earthquakes. The numbers of victims vary greatly from one earthquake to another, as the numbers ranged from one victim caused by the earthquake of March 4th 1287 in Cairo, to about 80,000 victims left by the Aleppo earthquakes in the year 1169

Author	Source	Time	Location	Number of Victims
Ibn Al-Atheer (1160-1233)	The Complete in History	November. 885	Cairo	1000 in one Day
Ibn Al-Atheer (1160-1233)	The Complete in History	March 25. 1068	Palestine & Egypt	25000 in Ramlah
Abu Yaala (1071-1160)	History of Abou Yaala			About 100 in Banyas And 100 in Al Kods
Ibn Al-Aadim (1192-1262)	Milk butter in the history of Aleppo	October 26. 1138	Al-Athareb	600
Al-Dhahabi (1274-1348)	History of Islam	1169	Aleppo	80000
Ibn Taghri Bardi (1410-1470)	bright luminous stars	1200	Nablus	30000
Al-Suyuti (1445-1505)	History of the Caliphs	March 4. 1287	Cairo	1 (chief judge)
Al-Maqrizi (1364-1442)	The way to know the Kings' countries	Jaunary 1409	Jableh	15

Table 1: Human losses caused by some of seismic events mentioned in historical sources

4; Earthquake intensity, duration and extension

4.1 Seismicity and its intensity for some regions.

Seismic activity varies in different regions and locations, the highest being found at the boundaries of convergent tectonic plates. It is understood from Al-Massaoudi's (896-957) talk about earthquakes (2006, p. 60.), that the Levant and the countries of eastern Anatolia are characterized by

the abundance of earthquakes and their extreme violence. This is consistent with the current reality and with the conclusions of recent seismic studies: Amos (1998), from Stanford University, compared the locations of 47 destroyed ancient cities of the eastern Mediterranean basin, with the epicentres of earthquakes that occurred in the region between 1900 AD and 1980 AD. It was found that almost all of these cities were located in areas that experienced violent earthquakes during the twentieth century (Fig 1).

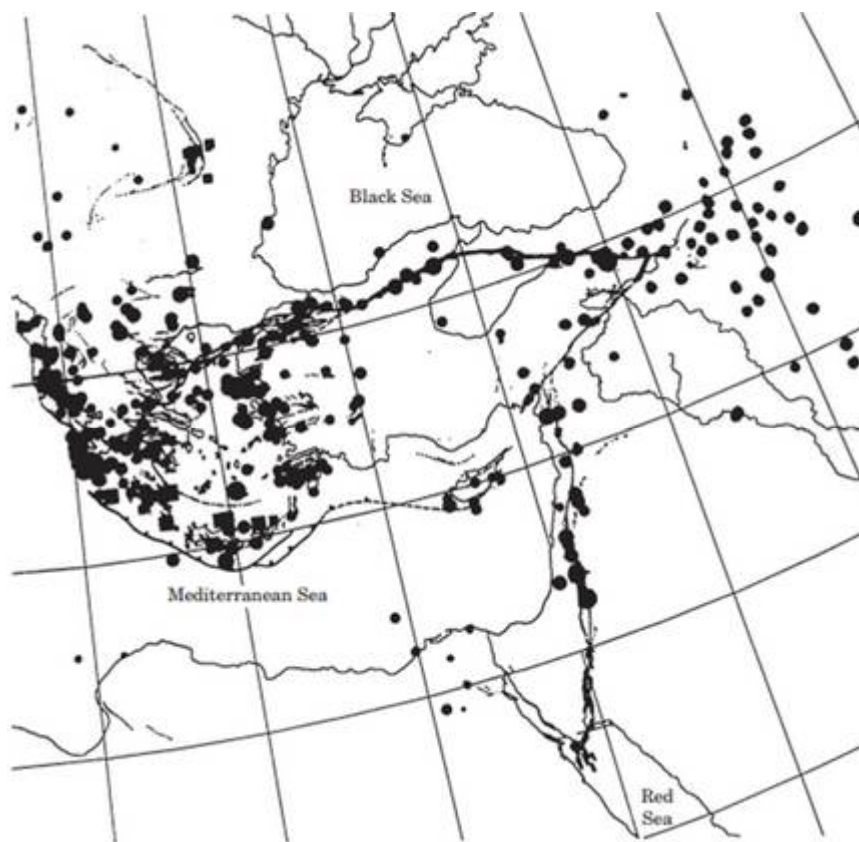


Fig. 1: The Eastern Mediterranean: instrumentally recorded earthquakes of magnitude 6.5 (Intensity VII and larger) in the period c. 1900–1980 (after Armijo, Deschamps & Parter, 1986) (in Amos, 1998).

4.2 Aftershocks and seismic durations.

In addition to documenting the extent of earthquakes, a great interest has been taken to recording information about the number of tremors and the duration of major seismic events and associated aftershocks.

The table 2 summarizes data related to the duration and the number of tremors that characterized a group of earthquakes mentioned in a number of Arab and Islamic heritage sources, and which concerned the Mediterranean basin.

Author	Source	Duration and number of tremors	Location	Time
Abu Yaala (1071-1160)	History of Abou Yaala	80 or 100 times from October 17 to November 05	Damascus	October-November 1138
Ibn Al-Aadim (1192-1262)	Milk butter in the history of Aleppo	80 quakes from October 16 to June	Aleppo	October-June 1138
Ibn Al Jawzi (1160-1201)	The Regular	10 times	Houlwane	December 2. 1149
Al-Maqrizi (1364-1442)	The Honafas' learnings...	From July 05 to August 1st.	Damascus	July-August 1170
Al-Suyuti (1445-1505)	History of the Caliphs	3 hours	Egypt	1247
Al-Suyuti (1445-1505)	History of the Caliphs	An instant	Cairo	March 4. 1287
Al-Dhahabi (1274-1348)	Biographies of the nobles	The time to read the chapter Al-Kahfe	Levant	April-May 1202
Al-Muradi (1760-1791)	Wire of pearls in the notables of 12 th century.	Twice or 3 times a week from October 29 to November 26.	Damascus	October-November. 1759

Table 2: Data on duration and number of tremors for earthquakes cited in Arab-Islamic Heritage sources

4.3 The extent and the superficies of the earthquakes

Among the important information contained in the Arab-Islamic heritage related to seismic events, we find data on the magnitude and on the extent of the earthquakes, so we can cite:

- the events recorded in some cities of the Levant, such as Damascus' earthquakes of the month of March of the year 1157 (Abu Yaela, 1998, p. 202);
- the events which affected most of the cities and regions of the Levant, such as Damascus' earthquake on Monday, the fifth July 1170 (Al-Maqrizi, 2001a, p. 310);
- the events, which were extended from Upper Egypt to the city of Alexandria, covered all the cities of the Egyptian coast and the rest of the Levant, and perhaps even reached Persia, like the earthquake of Monday 04 May 1139 at dawn (Al-Dhahabi, 2003a, p. 4205);

- and those whose extent was much greater, such as the earthquake in 1205, extending from Ceuta on the West Mediterranean coast to Mosul and Iraq. Al-Maqrizi (2018b, p.45) says: «*It was a great earthquake that spread most of the land of Egypt and the Levant, Al jazira, the countries of the Romans, Sicily, Cyprus, Mosul and Iraq, and it reached Ceuta in the countries of the Maghreb.*».

But concerning the area covered by earthquakes, the citations were very rare.

5. Earthquakes: Associated Phenomena and natural impacts

5.1 Phenomena and status associated with earthquakes

Seismic events generate a number of atmospheric and terrestrial phenomena. These phenomena can occur, before the earthquake; during it; or after it ends.

The sources that dated earthquakes did not neglect to talk about this aspect, and the most important of these phenomena and conditions can be summarized as follows:

- the occurrence of thunder and lightning before a great earthquake, which was heard and sensed from half a mile from Aleppo (Al-Maqrizi, 2018b, p.599);
- the eclipse of the sun accompanying a great earthquake that occurred in the land of the Romans (Al-Maqrizi, 2018b, p.1231);
- seeing smoke descending from the sky to the earth between sunset and the night's pray, in Damascus at the land of Qasr Atika, accompanying the earthquake of Karak and Shobak of the year 1212 (Al-Maqrizi, 2018b, p.49);
- a sequence of very loud sounds. The annoying loud thunder sounds that followed the earthquake tremors that took place in Hama in the year 1157, led to a number of deaths (Abu Yaela, 1998, p. 207);
- hot winds (called Samoume) blew with a hurricane. They lasted for three days after the earthquake which occurred in Egypt in the year 1192.

5.2 Effect of earthquakes on landforms

If the devastating earthquakes cause the collapse of many buildings and the death of many people, their effects extend to a range of effects on nature, which can appear quickly and directly (short-term effects) or be delayed for a long period of time (long-term effects). All of this has a clear impact on the outer shape of Earth's surface. We have traced an important number of impacts, mentioned in the sources that dated the most important seismic events, in the Islamic countries in general and in Egypt and the Levant in particular. They are as follows:

- raising/and lowering of areas and formation of hills because of this;
- slidings and horizontal transitions of land;
- cracking of the earth;
- falling rocks and lands' collapse;
- exploding of water springs;

- hiding of rivers and streams and their dispartition inside the earth.

5.3 The tsunamis

The tsunami phenomenon and its linking to earthquakes is very present in the Arab-Islamic heritage, as the texts of Al-Maqrizi (2018b, p. 1101), Al-Suyuti, Ibn Taghri Bardi and others. Al-Maqrizi (2001a, p. 192) says about Egypt's and the Levant's earthquake of the year 1069: «*And in it...the sea in Palestine disappeared from earthquakes, and it moved away from the coast about a day's walk, then returned over many many people who came out to gather from its land.*». Al-Suyuti (1997c, p. 314) also reports that Egypt experienced in August 1303 a great earthquake, «*Its impact in Alexandria was greater than elsewhere, and the sea rose until the half of the country, and the porters and men were taken, and the boats sank.*». It is to point, As Bacha (1997, pp. 60-61) precised, that a re-reading and analysis of these data can be useful in «*Understanding the tectonic state of the Mediterranean region and the potential for coastal areas to be affected by sea seismic waves (tsunami).*».

6. Conclusion

Referring to Western books and articles, which are interested to the history of seismic thought, we generally find an absence of the contribution of Islamic civilization in this field, by jumping centuries from the history of human scientific giving, as is the case with Ben-Menahem (1995) who tried to monitor the most important historical stations of the development of seismic thought until present and with Duncan Carr Agnew (Poirier, 2008, p. 4), who claimed that Muslim scholars during the Middle Ages, were only an echo of the Aristotelian seismic thought.

It must be noted that the Islamic civilization was not absent from this field. By referring to the known current sources, it is confirmed that the imprint of this civilization is very clear, whether it was at the level of theoretical contribution or at the level of historical contribution. El Ghalbi (2018, pp. 48-50) noted that it is possible to summarize the participation of Muslim scholars, like: Al-Hamadhani, Al-Kindi, Ibn Hayyan, Ikhwan Al-Safa and Ibn Sina

and others, in the development of seismic thought, to their contribution to the description and the determination of what earthquakes are, as well as to their contribution to understanding the phenomenon, its interpretation and its scientific explanation.

As for the historical sources and travel stories..., which dated many important seismic events in different regions, they provide many important and varied information and data, concerning the exact date of the seismic event and the hour of its occurrence, the number of its tremors,

the extent of its spread, the number of victims caused by it, its damages, its natural effects, its impact on landforms and the phenomena associated with it. This gives to these sources a great value and importance, as the extrapolation of historical data helps to evaluate the intensity of earthquakes. It also allows -Besides extrapolation of automatic seismic data provided by monitoring devices- the production of the seismic record of a specific region, which purpose is to study the seismic risk in order to reduce it (Fig. 2).



Fig. 2. General plan in seismology and tectonics (from Morabet Azroual, 2005)

In conclusion, it must be emphasized that establishing the origin or the beginning of seismology, allows to stand on the importance of studying heritage sources, in terms of correcting the history

of science and in terms of its role in understanding the nature of natural phenomena, which require accurate and documented facts of its long history (Basha, 1997, p. 61).

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The renaissance of minerals, mining and metallurgy in Tuscany: from Biringuccio's *Pirotechnia* (1540) to Cosimo I de' Medici

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Abstract. The 16th Century Renaissance marks the modern development of mining technology, mineral deposits prospecting and metallurgical practices. New tools and methods were introduced in tunneling and excavations, often paralleled and inspired by the development of siege warfare, as well as in metallurgical methods and ore processing. These are well recognized and documented in German-speaking areas as early as the first half of the 15th Century. Many practices had to be readapted or reinvented, and new metal smelting and refining processes were introduced, also as a systematization of alchemical practices based on the use of fire. The new metallurgical methods of that period are best described in Vannoccio Biringuccio's *Pirotechnia* (1540), while Georgius Agricola's *De Re Metallica* (1556) and *De Natura Fossilium* (1540) are the milestones of both mining/metallurgical technologies and geological/mineralogical studies, respectively.

In Italy, Biringuccio – native of Siena, central Tuscany – proposed a theory of metals formation based on an early concept of “particle structure”, an original synthesis between the Aristotelian doctrine of the elements and atomism. But it was with the weapon of experience that he criticized the opinions of philosophers and alchemists, contributing to the development of a scientific method in the field of geosciences. Biringuccio applies an early knowledge of rocks and minerals to practical problems, starting to shape in a modern way the concept of economic underground resources exploitation (the term “geology” was introduced only later, in 1603 by Ulisse Aldrovandi). He travelled extensively in the mining areas and metallurgical workshops of Tuscany, his homeland, but he also visited Carnia, Friuli, Tyrol, and probably he was twice in Germany.

The mining activity of Tuscany in the Middle Ages was indeed limited to a few mining sites, although some of them were very important; it is worth mentioning that one of the oldest compilations of medieval laws on mining, that guaranteed the freedom of ore prospecting, was written in Massa Marittima already in the 13th Century. The present study frames Biringuccio's activity, travels and studies, also in relation to the development of the mineral resources of Tuscany, linking them to the attempts of Cosimo I de' Medici to revive the mining and metallurgical industry of the Grand Duchy of Tuscany a few decades later. In 1542 Cosimo established a monopoly for the production of iron from Elba and in the 1550's called German miners to reactivate the copper/silver/lead mines of Campiglia Marittima, Pietrasanta and Montecatini.

Keywords: Renaissance mining – Mining history – Biringuccio – Metallurgy history – Cosimo I de' Medici – Tuscany mines.

Biringuccio's life and travels in Italy and Europe

Vannoccio Biringuccio (Siena 1480 - Rome circa 1537) was one of the most influential Italian scholars of the late Middle Ages and early modern age in the field of mining and metallurgy. Literature honors him as an engineer,

metallurgist, mechanic, bell and cannon smelter, armorer, master builder and architect as well as an applied chemist. However, he owes his fame to the posthumous publication of his only book *De la Pirotechnia libri X* (Biringuccio, 1540), one of the earliest mining and metallurgy handbook originally written in Siennese vernacular Italian.

Biringuccio belonged to one of the oldest noble families of the Republic of Siena. Born and

living in times of urban strife, he took an active part in the public affairs of his native city. His father Paolo di Vannoccio Biringuccio was an executive of the public administration and managed some mining activities in Southern Tuscany (Maremma). Very likely, Biringuccio's studies were in continuity with the profession of his father, and oriented to the career of a high-level mining technician. He would later begin his apprenticeship with his father and then in the mining activities of Pandolfo Petrucci. Pandolfo belonged to a rich family of merchants and continued to pursue his trades even when he effectively conquered the maximum political power in Siena, intertwining business and politics.

At that time the Republic of Siena, very sensitive to technological culture, built an impressive network of underground aqueducts for the city, an artificial lake, and stimulated private initiatives to intensify mining and metallurgical activities in order to renew and strengthen the military arsenal. Among the native technicians were Paolo Salvetti, an expert in minerals, and Francesco di Giorgio Martini (1439-1501), author of the *Trattato di architettura civile e militare* (late 15th Century manuscript), which deeply influenced the Italian cultural environment of the years to come. The young Biringuccio may have known Martini both through his collaborator Iacopo Cozzarelli, and for the professional relationships of his father, forging his intellectual profile and personality.

The Biringuccio's family belonged to the managerial class with an active role in the policy of the Republic of Siena. The family's active attendance of the *Camera del Comune* (Chamber of the Municipality, i.e., the administrative office that promoted and coordinated the design and construction of the architectural, hydraulic and military works of the city of Siena), certainly played an important role. Under the guidance of Petrucci, many prominent personalities from various cultural backgrounds had gathered in the *Camera*, forming a sort of technical oligarchy, whose interests ranged from civil and military engineering to architecture, scientific and humanistic studies to land management (Bernardoni, 2008).

In his youth, Biringuccio studied mathematics and natural sciences and learned metallurgy in various workshops as well as in several mines of the Republic of Siena territory. We know that around 1500 Biringuccio was sent to practice in the silver, copper and iron oxides/hydroxides mine of Boccheggiano, near Montieri. Shortly afterwards (1507-08) he was entrusted with the management of a company founded by various noble families for the exploitation of the silver, copper, lead and zinc mines of Monte Avanzo, in the Carnic Alps (Northern Italy, at the time under the control of the Republic of Venice). Biringuccio managed those mines until 1508, when hostilities began between the Republic of Venice and Maximilian I, the Holy Roman Emperor. As a consequence, Biringuccio moved to northern Europe to make at least two educational trips (1508-10) to the mines of Carinthia, Tyrol and probably also in the German areas of Saxony and Bohemia, although these journeys are not fully documented (Mieli, 1914). Visits to *Pleiper* (Bleiberg, Carinthia), *Sbozzo* (very likely Schwaz, Tyrol), *Alla* (Hall, Tyrol) and *Arottinberg* (Rattenberg, Tyrol) are cited in his *Pirotechnia*. It should be noted, however, that he never mentions any knowledge of the technical German language.

Back to Italy, between 1510 and 1512 Biringuccio was in Milan, where he studied the technical systems prepared by Leonardo for the casting of the bronze horse of the never executed colossal statue of Francesco Sforza and finally returned to Siena, with considerable knowledge in the field of bronze casting. In 1513 Petrucci appointed him both director of his iron mine at Boccheggiano, and specialized "workman" of the armory of Siena.

In modern terms, Biringuccio had a relatively short apprenticeship, just over 10 years. However, it seems that his father, Paolo di Vannoccio, owned an ironworks and had been involved by the Pandolfi family in various enterprises aimed at developing the whole technological chain, having also assisted Leonardo da Vinci, with whom in 1503 he was in the service of Cesare Borgia for the reconquest of Romagna. Therefore, by family tradition, by the conversations he heard at home and by personal

experience, Biringuccio had acquired a knowledge of metallurgy (and in particular of that of bronze and iron) superior to that of most of the Italians of his time.

Eventful and problematic times followed: after obtaining an exclusive contract to manage the Sienese mint in 1514, Biringuccio was accused of counterfeiting; he was then banished from Siena and fled to Rome, Naples and Sicily. A few years later he was rehabilitated and, back to Siena, in 1525 he obtained the monopoly for the production of saltpeter throughout the Republic of Siena territory, but this privilege only lasted for a short time. Flying again from the city, he worked as a cannon founder in Florence. Here in 1529, he built, among other things, a large cannon in a single cast, the *Liofante* (the elephant) or *Archibugio di Malatesta* (the arquebus of Malatesta, an Italian prominent family ruling part of the Romagna area at that time). This weapon was a gigantic double culverin, weighing over 6000 kg and almost 7 m long, with the breech decorated with an elephant head. In 1534 Pope Paolo III appointed Biringuccio captain of the artillery, master of foundries and director of the papal ammunitions. The advanced technologies described in the *Pirotechnia* (books 6, 7 and 8) demonstrate his extraordinary skills in the field of bronze casting technology, cannonballs production and explosives manufacturing (black powder).

Biringuccio died suddenly in Rome in August 1537. A more detailed biography based on archival resources is reported in Tucci (1968).

Biringuccio's *De la Pirotechnia* (1540)

The 16th Century Renaissance marks the modern development of mining technology, studies on mineral deposits prospecting and advancements in metallurgical practices. These are well recognized and documented in German-speaking areas as early as the first half of the 15th Century. In 1527, Rühle von Calw published *Ein nützlich Bergbüchlein* ("A useful booklet on mining"). Biringuccio knew Agricola's *Bermannus* (1530), and in his *Pirotechnia* he reports the almost miraculous finds of large blocks of native silver found in Saxony (Macini & Mesini, 2008). On the other hand, Agricola also mentions Biringuccio in his *De Re Metallica*: «Recently,

Vannoccio Biringuccio of Siena, a wise man and experienced in many matters, wrote in vernacular Italian on the subject of smelting, separating and alloying of metals. » (Agricola, 1556).

Bernardoni (2008) wrote that «Apparently, the differences between Agricola and Biringuccio are very marked: if the latter (who had a self-taught training) seems to adopt a purely operational perspective, Agricola instead moves in the most refined circles of scholars and humanists, and publishes his numerous writings and technical handbooks that constantly confronts with the classical tradition. However, while starting from very different cultural contexts and assumptions, Biringuccio and Agricola work in the same direction, that of a re-evaluation of the practical arts, and in particular of those of fire. Both Authors strongly pose the need for a linguistic revision (in open controversy with the obscure language of alchemists) as well as a clear codification of the metallurgical processes, in order to make them reproducible. »

In charge of the mines of the Republic of Siena, Biringuccio was interested in the study of minerals and metals and in investigating the most remote shapes and systems with which they hide in the bowels of the earth; he studied rocks and materials with which they mix, and clearly explained the fastest and cheapest ways to extract and refine them (Barzellotti, 1808).

De la Pirotechnia is considered the first book in the history of technology fully dedicated to metallurgy, characterized by a completely new concept. Published after the death of Biringuccio, the first edition (1540, *editio princeps*, Venice) is written in Sienese vernacular Italian. The work had numerous later editions, more or less modified (Mieli, 1914): we recall the four Italian editions (1550, Venice, which was slightly re-edited in Florentine vernacular; 1558, Venice; 1559, Venice; 1678, Bologna), the three French translations (1556, Paris; 1572, Paris; 1627 Rouen) and also the two Latin translations (1572, Paris; 1658, Köln). Finally, in the last century it was also translated in English (Smith & Gnudi, 1942-1943).

However, the *Pirotechnia* was rarely cited in books of history of metallurgy and mining technology until the end of 19th Century; unlike

his contemporaries who normally reported real or false observation and facts that they collected from ancient sources (Guareschi, 1904), Biringuccio had personally made observations and gathered first-hand experience in the field of metallurgy and mining production; on this basis, he attempted to systematize what he had collected on this subject into a sort of handbook conceived for practical uses. Biringuccio thus introduced a new methodology into the technical literature, as a sort of precursor of the modern experimental and scientific method. Again, unlike other contemporary treatises, the *Pirotechnia* is characterized by its extraordinary practical importance and by the intention of making the results accessible to a wide audience of specialists. A large number of illustration (the book contains 84 woodcuts) complete the descriptions, which are based mainly on Biringuccio's vast practical and experimental experience and are characterized by a clear and concrete representation. However, compared to Agricola's later treatise *De Re Metallica* (Agricola, 1556), Biringuccio refrained from describing some minor technical details, that he thought easily identifiable and understandable by the contemporary expert readers.

De la Pirotechnia collects and systematize most of the techniques related to metal, glass, ceramics, military and civil pyrotechnics, furnaces and castings technology, as well as mining engineering know-how of the time. The book also contains an analysis of distillation and sublimation techniques and theories of the alchemical tradition, analyzed and discussed in the light of a unitary theory of matter (Bernardoni, 2011; Bernardoni, 2014).

Biringuccio dissociates himself from the pure speculative approach of scholastic philosophers, and believes that knowledge of nature progresses towards an ever-deeper understanding of the mechanisms of natural phenomena through the continuous acquisition of new facts. In his view, the alchemists' failures confirmed the limits of artificial production and the superiority of natural products, but the technological progress resulting from alchemy seemed to bridge the gap between natural and artificial entities, leading to a deeper understanding of nature. In this regard,

Biringuccio expresses serious doubts about the regeneration of the alleged "inexhaustible" iron mines of the Elba Island, and does not trust the sulfur-mercury theory for the generation of metal deposits (on this subject, see also Halleux, 1974).

Mineral production in Biringuccio's homeland

The so-called "Metalliferous Hills" of Tuscany is an area strongly characterized by significant mining and metallurgical activities dating back to (at least) Etruscan times. In the past, iron, lead, zinc, tin, copper, and silver ore, together with sulfur, alum and coal, were mined and transformed here. Mining excavations and metal production sites still mark the territory, with hundreds of archaeological records and historical testimonies of great interest, sometimes impressive as for size and number. These activities date back from ancient times to the last decade of the 20th Century, albeit with many ups and downs in production, with a surprising continuity of mining and metallurgical activities that probably has no equal in Europe, maybe except for salt mining in Central Europe.

Evidences of mining and iron workings of the Etruscan and Roman period are documented since the 18th Century, and goes hand to hand with the modern archaeological sciences. In fact, there are many reports of discoveries of ceramic materials and mining tools in landfills containing mining wastes, located near the mining shafts and inside the ancient tunnels and excavations (Targioni Tozzetti, 1770; Lotti, 1893; Badii, 1931). Archaeological remains of iron metallurgy based on ores extracted from Elba Island can be found still today in many localities surrounding the Gulf of Follonica (continental Tuscany, in front of Elba Island), in the form of large piles of slag, sometimes associated with ceramic materials typical of the time (Benvenuti *et al.*, 2000).

In the Middle Ages the small town of today's Massa Marittima, the most important mining center of the Metalliferous Hills, drew great economic benefit from mining and metallurgical activities, witnessed by a remarkable urban and monumental development, which brought it on a par with the largest Tuscan cities. In that period there was a strong flow of immigration of

specialized workers from the German speaking area, expert in mining and metallurgical technologies, and in particular from Saxony and Bohemia.

Among the first to take advantage of the great mineral wealth of the Metalliferous Hills were the bishops of the diocese of Massa and Populonia, and then the people of the Republic of Massa (*Repubblica di Massa di Maremma*), hereinafter renamed as *Massa Metallorum*. Hundreds of mine shafts and tunnels were excavated around the town, and huge quantities of metals were extracted, such as copper and silver, then much more precious than today. The importance of mining activity in the town's economy was such that the oldest and most complete legal regulation of the mining matter existing today can be found in the ancient laws and statutes of the Republic of Massa, a document commonly known as the mining code of Massa Marittima (*Ordinamenta super arte fossarum rameriae et argenteriae civitatis Massae*), a collection of texts dating back to the 13th Century, updated and completed until to *circa* 1325. The extant manuscript is a true milestone in the field of European mining law, that guaranteed the freedom of ore prospecting. Undoubtedly one of the most significant mining documents left to us by medieval Italy, it can be regarded as the first European mining constitution that deals with the overall regulation of an entire mining district, both in terms of the discipline of mining and metalworking (Baldinacci & Fabretti, 1989).

The fortunes of the mining area of Massa (based on copper and silver), and more in general of Tuscany and Italy, decreased towards the second half of the 14th Century due, among others, to the plague of 1348, to famine, to the wars with the Republic of Siena and to a sharp drop in metal prices following the fast development of German and central European mines (Saxony, Bohemia, etc.). Other issues contributed to slow down the mineral production in Tuscany, and in particular the fast depletion of the most superficial parts of the very old mines (the rich gossan present in many mineral deposits), and the increasing difficulty in both deepening the excavation, and draining the underground structures (tunnels, shafts, etc.). Finally, many mining sites were more and more difficult to exploit due to the hardness of the host

rocks, which made the mining activities extremely difficult and poorly profitable.

However, the mining activities were never completely abandoned: in particular, a strategic iron production continued, and in 1377 Tollo Albizzeschi (uncle of St. Bernardino of Siena) obtained from the municipality of Massa the authorization to build an *edificio da foco* ("fire building", *i.e.*, a blacksmith forge) to work the *vena del ferro* (iron ore) (Municipal Archive of Massa Marittima, *Riformagioni* 1376-1382). This is the framework in which developed Biringuccio's activity, *i.e.*, on one side the economic and strategic interest in maintaining the mineral production for the development of the Republic of Siena and on the other the ability to cope with old technologies that were no more adequate for the difficult geologic structures of the Tuscany mines.

Biringuccio's and the Tuscan mines in *De La Pirotechnia*

Undoubtedly, Biringuccio's *Pirotechnia* marks the modern development of mining technology, mineral deposits prospecting and metallurgical practices. New tools and methods were introduced in tunneling and excavations, often paralleled and inspired by the development of siege warfare, as well as new procedures in metallurgical methods and ore processing. Many practices had to be readapted or reinvented, and new metal smelting and refining processes were introduced, also as a systematization of alchemical practices based on the use of fire (Bernardoni, 2011). Biringuccio applies his knowledge of rocks and minerals to practical problems, starting to shape the modern concept of economic underground resources exploitation (it is worth mentioning that the term "geology" was introduced only later, in 1603 by Ulisse Aldrovandi in Bologna).

The first two books of *Pirotechnia* deals with metals and mineral ores. Biringuccio classifies the traditional six solid metals (gold, silver, copper, lead, tin, iron), the making of steel and brass, and many "semi-minerals" (sulfur, mercury, antimony, vitriol, alum, arsenic, orpiment, salt, calamine, manganese, ochre, bole, emery, borax, rock-crystal, gems, glass, etc.). For each mineral he describes the

properties, the principal mining sites, the rocks in which the mineral is contained, the clues to recognize the presence and the technology to produce useful metals or refined mineral products.

Unfortunately, the only solid metal largely produced in Tuscany and explicitly mentioned in De la Pirotechnia is iron. In the first book of *Pirotechnia* he does not report the existence of specific Tuscan mines of copper, silver, lead (although existing, and with a long mining tradition), but highlights the presence of iron only. Biringuccio says that Tuscany is very rich in iron, above all in the Elba Island, where it is so abundant that for its large quantity it spreads also in the surrounding territories on the mainland. But for its quality, abundance, ease of extraction, security of investment and supply in large quantity, one does not care to extract it into the mainland, despite the signs of presence and abundance. He notes that the amount of iron ore excavated in so many centuries is astonishing, and that it is still extracted even today, with a better quality compared to the past and with higher yields. Moreover, the iron ore of Elba is easy to work and melt, and easily provides a very soft and workable iron that make it suitable to any work of the blacksmith: according to Biringuccio, all the above demonstrates its purity. He observes that this does not happen in other mines such as in the ones of Val Camonica (near Brescia, northern Italy) where iron is "wild", and it needs great fires to tame its wildness, resulting from the bad mixtures with other metals (of which it is so full) that it is purified with difficulty. Biringuccio wrote: « I saw this problem in Siena while I was still a young man, in the valley of Boccheggiano where many factories for making iron were constructed by the magnificent Pandolfo Petrucci. Since I was in charge of them, I took some of the iron ores which were found near there as well as that of Elba Island, and I came to be experienced in both » (Authors' translation, from 1540 edition, p. 16 *verso*).

The second book of *Pirotechnia* deals with the semi-minerals; according to Biringuccio, they are produced by nature neither as completely composed of stone, nor completely composed of metal. So, they are minerals in their "initial" stage of development, and thus they do not yield

metals or, if they do, these are only imperfect ones, such as mercury, which is liquid.

Among the semi-minerals contained and produced in Tuscany mines, Biringuccio mentions sulfur, antimony, vitriol, alum, salt, calamine and manganese. He states that sulfur is found in massive aggregates with earthy appearance in areas of hot water springs and volcanoes, such as at Bagni San Filippo in the territory of the Republic of Siena. On antimony, Biringuccio wrote: « There are several mines of this antimony ore in the region of Siena, among which one is near the city of Massa in the Maremma and another large mine near another city called Sovana. Practiced experimenters claim that the latter is the best they know. It is also found in the region of Santa Fiora, near a zone called Selvena » (Authors' translation, from 1540 edition, p. 28 *recto*).

Then, on the vitriol ore: « It is mined at Massa, powerful and beautiful as the *Ciprio* one, Travale and Monterotondo, at San Filippo, at Sovana and in many other places in the Sienese territory. It could also be mined in the region of Volterra; and in mount Amiata in the Santa Fiora region » (Authors' translation, from 1540 edition, p. 30 *verso*).

As for alum Biringuccio reports that in Italy its mines are located in Ischia and Pozzuoli near Naples, and in Tolfa near Civitavecchia; in this latter location, alunite was discovered during the papacy of Pius II in 1462. He wrote: « Alum ore is also found in the Republic of Siena at Massa and Monterotondo and in many other places in the same territory. Furthermore, it is found near Piombino at Montioni and in the territory of Volterra at Campiglia » (Authors' translation, from 1540 edition, p. 31 *recto*).

Biringuccio also describes salt production from sea water or salt springs by evaporation and crystallization, but also its extraction from underground mines in the form of stone. He describes the operation of coastal salterns (salt evaporation ponds), and the production of salt from salt-rich natural brines by means of large boilers, as in Halle (Tyrol). Then he writes: « The same procedure is used in Tuscany in Volterra, with a salt water extracted from some wells, which is evaporated by boiling in lead boilers

similar to those of vitriol. A very white salt is produced, like snow, and in such large quantity that not only the city of Volterra uses it, but also that of Florence and its neighboring territories » (Authors' translation, from 1540 edition, p.35 verso). Among the many other places where salts can be obtained from salt springs, he mentions also San Quirico d'Orcia.

Concerning brass, Biringuccio remind us that calamine, a mixture of zinc minerals useful for brass production, is located in Fosini (Montieri), in the territory of Siena, but he (wrongly) claims that calamine can be found associated with almost all types of mineral ores. About the semi-mineral manganese, he reports that: « It is found in Tuscany in the mountains of Viterbo », indeed a geographic mistake, since then (and still now) this area did not belong to Tuscany, but to present-time Lazio region, since long before under the dominion of the Papal States.

Finally, according to *Pirotechnia*, in 1540 the Tuscan mines in activity were very few, apart from those of iron. The lead-silver mine of Montieri had not yet been discovered; no copper mine was fully active, and Biringuccio observes that Italy was very rich in copper and silver, but it was not extracted for the laziness and fear of risk of the Italian entrepreneurs. Curiously, the cinnabar-mercury mines of Monte Amiata area are apparently unknown to Biringuccio. This area has always been characterized by research and extraction of cinnabar for the production of mercury. The characteristic purple-red color of cinnabar has attracted man since prehistoric times, when small surface excavations were made to extract small quantities of red powder used as a dye for clothes, for cosmetic uses and for its alleged medicinal properties. The first written document that clearly deals with cinnabar mines in the Amiata area is the deed of ownership sharing between the town of Sovana and Santa Fiora (1217), in which it was established that "the excavation of quicksilver" of Selvena will remain undivided and common property.

Cosimo I de' Medici and the Renaissance of mining in Tuscany

It is probable that the reading of Biringuccio's *Pirotechnia* was a stimulus for Grand Duke

Cosimo I de' Medici (1519-1574). He and his son, the second Grand Duke Francesco I (1541-1587), personally supervised the reviving of mining in Tuscany, with the interest of businessmen and the tenacity of investigators, stimulating researches in areas already exploited in the previous centuries (the Metalliferous Hills, Campiglia Marittima, Pietrasanta, etc.), as well as in new areas. He affirmed that «the intention to testing many places, to find and bring to light what is hidden underground, and by finding a good seam, one will pay for the expense, and whoever does not search does not find » (Fabretti & Guidarelli, 1980). In this regard, it is worth mentioning that probably Cosimo I proposed, or indirectly supported, the translation of Agricola's *De Re Metallica* into the Tuscan language. Even if this is not yet fully documented, the Italian translation of Agricola's masterpiece was printed in 1563, and was prepared and edited by the Florentine refugee Michelangelo Florio (Agricola, 1563). Moreover, already in 1547 Bolfo di Augusta, a scribe and secretary who came to Pietrasanta together with Christopher Degler (see below), translated numerous Germanic mining statutes on behalf of Cosimo. This is testified by numerous documents of the Historical Archives of Florence, mining section (Fabretti & Guidarelli, 1980).

The 19th Century mining engineer Theodor Haupt, in charge of re-evaluating the mineral resources of the Grand Duchy of Tuscany (see below), reports that in 1442 several iron mines were active in the territory of Pietrasanta (Apuan Alps, northern Tuscany), and in Montecatini Val di Cecina, near Volterra, many positive attempts to produce copper were carried out from 1469 to 1494. In 1584-1585 the silver mine of Montieri, in the territory of Massa Marittima, was reactivated (Haupt, 1847).

With full Renaissance spirit, the Medici government launched a policy of redevelopment of mining and industrial activities in the area of the Apuan Alps (territory of Pietrasanta, near Lucca), and Cosimo I reactivated the ancient "Argentiere" (silver mine) of Gallena and Farnocchia. The period of activity of the mines began in 1539 and ended in 1595. In the Gallena Silver Mine (today's Bottino mine) the mining activity was resumed with the help of German and Tyrolean mining and metallurgical experts,

given the absolute lack of specific knowledge on the part of local workers. In that period, 40 to 70 workers were employed on average, obtaining a moderate production of lead and silver. However, it was clear that smelting operations were critical due to the antimony and arsenic contents in that specific lead ore, which decreased the efficiency of metal separation resulting in economic losses (Fabretti & Guidarelli, 1980). As a reason for the crisis of this mining activity, we recall again that the end of the 15th Century coincides with the beginning of the arrival of large quantities of silver from the Americas, a fact which in general caused a crisis in all European mining activity, including the one of German mines.

The Medici's mining activities were headed by a technical manager, the *maestro generale* (master general), a position initially held by Christopher Degler, a mining expert hired from Nuremberg, and later by Johans (Hans) Gleggl, an experienced metallurgist from Schwaz (Tyrol, Austria), one of the most important silver and copper mining centers of Europe in the Middle Ages. The importation of skilled labor from northern Europe was possible thanks to the excellent business relationships existing between the Medici family and that of the Fuggers, the famous German bankers: Gleggl himself was one of the Fuggers' mines Director. As mentioned above, Cosimo I was also the promoter of a new mining enterprise in Campiglia Marittima, an area already known for lead/silver, copper and iron ores. This activity took place between 1548 and 1559, and it is well known and described in its specific phases through letters, documents, inventories and accounting records of the time. In the early stage of exploration some German miners, who were already working in the mines of the Apuan Alps, moved to Campiglia (1550-1555), and two hydraulic workshops were built to provide energy for ore processing. This activity was followed by the development of an autonomous mining company (1556-1559) with strong financial and workforce investments to increase production. Unfortunately, considerable difficulties arose in ore smelting, and very low yields were obtained, if compared to the metal content determined with laboratory essays on small samples. To overcome these difficulties, Cosimo I sent Johans Gleggl who brought with him 30 other specialized workers, but the master general and his metallurgists once again failed to

obtain satisfactory results from the smelting and refining of the ore. New smelting methods based on trial and error were widely attempted, but again without consistent results (Fabretti & Guidarelli, 1980). The insignificant production of good quality metals, the scarce water and energy availability, and the strong presence of malaria in this area led to the abandonment of the Campiglia mine (Farinelli, 2017).

Cosimo, still as Duke of Florence (the pope appointed him Grand Duke of Tuscany in 1569), in 1542 established the *Magona del ferro*, a central institution for the administration of the monopoly of the production and processing of iron, functional to the expansionist and reunifying policy of Tuscany. In order to obtain sufficient raw material, he signed an agreement with Iacopo V Appiano, Lord of Piombino (1480-1545), for the general contract of the iron ore of the Elba Island and the lease of their ironworks of Follonica. Cosimo I also reactivated numerous workshops (e.g., the ones of Forni di Accesa and Valpiana, near Massa Marittima) for the production of iron obtained from the processing of Elba Island iron ores (hematite, mixed with oxides and hydroxides of iron) and from the poorer and sporadic iron ore deposits of the Metalliferous Hills. With this domestic production, Cosimo I was able to develop his military industry, which led him to victory in the war with which he conquered Siena in 1555 and unified Tuscany.

Grand Duke Francesco I, son of Cosimo I, continued the intensification of the extraction of alunite at Monte Leo (near Montioni) for the production of alum. Moreover, he promoted exploration activities for copper production in Montecatini Val di Cecina (Volterra area, at present province of Pisa) and in 1585 he began the extraction of copper at the mine of Montecastelli Pisano, an activity that was abandoned after his death in 1587 (Delkeskamp, 1907). In the same period, the silver mine of Montieri was fully active, and it is documented that in 1584 a shaft was dug up to 45 meters, an outstanding depth for the time in this area, and in 1585 an old drainage tunnel reopened to serve the underground mining operations (Haupt 1847). In the light of the above, it is clear that, apart from alum, the only real success of the mining industry promoted by the Medici's in the second half of the 15th Century was in the production of iron,

while for copper and silver only poor and unsatisfactory results were obtained.

In the 17th and early 18th Century the Tuscan mines were neglected and mostly abandoned, as documented in Giovanni Targioni Tozzetti's letter to Richecourt "Short report of observations on mines in the municipal territories of Pisa, Volterra, Siena and Massa Marittima in the fall of 1742" (Targioni Tozzetti, 1743). In the same year he wrote a second letter "On the benefits that can be expected from the mines of Tuscany" attempting, with limited success, to stimulate the interest of the grand ducal administration in developing the mining business (Sammuri, 2021).

As a matter of fact, the Grand Duchy mostly favored the mining industry in the sector of non-metallic ores, and pushed for the search of coal to meet the increasing demand for energy in Tuscany; this is testified by studies carried out, among others, by Giovanni Fabbroni (1790) and Francesco Henrion (1792). After the Congress of Vienna (1815) the Grand Duchy was granted the sovereignty over the Principality of Piombino and thus incorporated in its territory the wealthy iron mines of the island of Elba and the alunite deposits of Montioni for the production of alum. However, the real rebirth of the mining activity in Tuscany will take place only at the end of the Napoleonic period, especially during the reign of Grand Duke Leopold II of Lorraine (1824-1859). In 1830 he invited Paolo Savi, naturalist and professor of the University of Pisa, to join him as an expert during a trip to Germany to study the coal districts of Saxony and Bohemia, during which they visited many mines and discussed with German geologists and mining engineers about the exploration and exploitation of mineral resources.

In the following years, numerous private mining companies tried to reactivate the old mines of the Grand Duchy of Tuscany, but with little financial resources and therefore using equipment and technologies of a typically pre-industrial period. However, Leopold II called from Saxony the aforementioned mining engineer Theodor Haupt and in 1844 appointed him as Royal Consultor for the affairs of the mines. In the following years, Haupt worked together with Belgian and Saxon mining experts to develop the

mining production, including the more and more strategic production of coal.

Conclusions

The mining activity of Tuscany in the Middle Ages encompassed a large number of small mining sites; some of them were very important, at least for the continuity of mining knowledge, sometimes dating back to Etruscan or even prehistorical times. This study frames Biringuccio's contribution in the field of mining and metallurgical developments that took place in Europe in the 15th and 16th Century, also in relation to the development of the mineral resources of Tuscany, linking them to the later efforts of Cosimo I de' Medici to revive the mining and metallurgical industry of the Grand Duchy of Tuscany. Biringuccio, in addition to a good knowledge of the literature of his time, also had direct experience of many mining and metallurgical procedures and practical methods adopted in numerous production sites that he visited and supervised both in Italy and in northern Europe. His descriptions of the single minerals, their aggregation, the typology of rocks in which they can be found, the methods of recognizing the metals and the metallurgical treatments to produce and refine them were a valuable guide for both mine managers and for the foundation of a scientific approach that drove the later development of modern mining and metallurgical engineering.

Probably, the grand ducal master generals who coordinated the activities of the Medici mining company knew Biringuccio's and the other almost-contemporary technical treatises on mining and metallurgy, and in particular the ones of Agricola. In fact, after *De la Pirotechnia* (1540), Agricola's *De Re Metallica* was published in 1556, and translated a few years later into the Tuscan language by Michelangelo Florio *De l'Arte de' Metallii* (Agricola, 1563).

In the second half of the 16th Century the Grand Duke of Tuscany Cosimo I and his son Francesco I, in addition to producing and using the very abundant iron ore of the Elba Island, reactivated several small mines and workshops for the production of iron from the poor and sporadic deposits of the Metalliferous Hills. It was a matter of a direct entrepreneurship of the

Grand Dukes, financed by the Grand Ducal Treasury, fostered by friendship and cooperation with the Fugger bankers who procured the expert German miners and mine managers necessary to this task.

The exploitation of alunite was also developed for the production of alum, a raw material very valuable and strategic at the time. Despite the many attempts and the investments, backed by the strong mining policy of the Grand Duchy, unfortunately there were no significant results in the attempt to increase the production of valuable metals for coins, such as silver and copper. Indeed, the mining policy of the Medici was a relatively short attempt, lasting a few decades, to satisfy the needs of the emerging Grand Duchy. Iron was produced for weapons, lead for bullets, silver and copper as precious metals, alum for dyeing fabrics and tanning leather.

Despite the great efforts and the great knowledge contained in Biringuccio and Agricola, apparently even the most qualified mining and

metallurgical experts did not obtain many results in relation to the metallurgical operations, indeed complex, of the Tuscan metal bearing ores. Here, the smelting of the metal was always considered as an adventure and a unique discovery, due to the variability of the composition of the minerals, and so the standard procedures reported in the contemporary literature have almost never worked properly.

At the end of the 15th Century, most of the Tuscan mines were once more abandoned, and remained substantially poorly exploited until the first half of the 19th Century, when an intense mining activity resumed in the area of the Metalliferous Hills, especially after the unification of Italy, also as a consequence of the need of both new materials, metals and energy for the newborn State. The mineral production in this area boomed during the first half of the 20th Century, mainly for the production of lignite, mercury and pyrite, this latter used as raw material for the production of sulfuric acid for the chemical industry.

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Murchison's assessment of the Donetz coal basin

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Abstract. In 1840 and 1841, Roderick Murchison, together with Edouard de Verneuil and Alexander von Keyserling, undertook two field campaigns to examine the geology of Russia in Europe and the Ural Mountains. The 1840 campaign followed a route that took them as far north as Archangel before returning through Moscow to Saint Petersburg. After the successful 1840 campaign, the Russian government sanctioned a second campaign in 1841 that took the team as far east as the Ural Mountains during which they examined the stratigraphy en route as well as copper, gold, platinum and diamond mines. The team visited the Donetz coal basin during their return journey, having been requested by the Russian government to assess the quality and quantity of the coal deposits in that region. At that time, the Czar and his ministers were debating whether to industrialize Russia, including the construction of railroads, and assessing the coal resources in the Donetz region was an important element in that debate. Murchison and his team spent several weeks in the Donetz region examining the stratigraphy and visiting coal mines. The results of their investigation appear in Chapter 6 of *The Geology of Russia* (Murchison *et al.*, 1845, pp. 89–123) accompanied by cross-sections in Plate 1 and a geologic map in Plate 6. Further records of their fieldwork are found in his field notebooks, journal account, and letters written to his wife Charlotte. The team found that the active surface and shallow mines in the Donetz coal basin would soon be exhausted, but that there was promise for finding additional economic coal buried at depth beneath younger deposits, particularly if steam engines were introduced to assist with exploratory borings and mine dewatering. Murchison's recommendations were supported by his up-to-date knowledge of Paleozoic stratigraphy and coal mining technology. Those recommendations contributed to the development of an important source of coal which had ramifications for the development of Russian industry in the nineteenth century. The energy resources reported on by Murchison continue to play a role in international conflict as evidenced by the war in Ukraine that is currently under way.

Keywords: Roderick Murchison – Donetz coal basin – *The Geology of Russia* (1845) – Ukraine

Introduction

In the late summer of 1841, Roderick Murchison spent several weeks investigating the coal fields of the Donetz region in what was then southern Russia. He had been commissioned by Czar Nicholas and by the Czar's finance minister, Count Georg von Cancrine, to investigate the extent and quality of the coal deposits in the Donetz coal basin (Collie and Diemer, 2004). He was also asked to suggest improvements in coal mining practices that could be applied in order to increase the production of coal. The Russian government at the time was exploring the bene-

fits of expanding the railway system as well as establishing steam-powered manufacturing facilities so that coal was a necessary source of energy to enable those transitions (Riasanovsky, 1984). At that time the Donetz coal basin was the most productive source of coal in Russia and was therefore of strategic importance.

Why did the Czar choose Murchison to undertake this task? First, Murchison was widely perceived as an authority on geological matters, including coal-bearing rocks (Geikie, 1875; Collie and Diemer, 2004). Second, he was known to Baron Brunow, the Russian Ambassador to Brit-

ain, who recommended Murchison to high-ranking ministers of the Czar including Sergey Uvarof, Minister of Education, and Count Georg Cancrine, Minister for Finance (Collie and Diemer, 2004; Benton and Sennikov, 2021). Murchison's growing reputation as an authority on geological matters was widely known; he had joined the Geological Society of London in 1825 at the age of 32 (Geikie, 1875). He quickly rose in prominence and was first elected President in 1831 (Herries Davies, 2007). It was during his second term as President, from 1841 to 1843, that Murchison visited the Donetz coal basin.

Murchison's research method

Murchison's impressive scientific output was possible given his abundant energy, ambition and networking skills (Bailey, 1952; Rudwick, 1985; Secord, 1986; Stafford, 1989; Oldroyd, 1990; Diemer, 2008;). Murchison was also a master at logistics and synthesis, and he developed a fieldwork methodology that enabled him to make rapid progress when mapping large areas (Diemer, 2022). This paper provides an example of his fieldwork methodology as he applied it in Russia. That methodology first of all relied on detailed preparations. He typically assembled as much information as he could about a region he planned to visit. This included gathering together publications and maps and corresponding in advance with scientists who were familiar with the region (Bailey, 1952).

Once on the ground, Murchison invariably sought out local experts to ask their advice (Collie and Diemer, 1995; Diemer, 2017, 2018). He made a habit of visiting local museums to inspect the fossil collections and, where possible, acquired any geologic maps that covered those areas. Another practice Murchison engaged in was to travel with at least one other geologist. This permitted the exchange of ideas in the field and the verification of observations by another expert. In undertaking fieldwork in Russia, Murchison relied heavily on Edouard de Verneuil, an

accomplished paleontologist, to identify the Paleozoic fossil material while in the field. Later, upon returning to Paris, De Verneuil was largely responsible for describing and illustrating the fossil evidence that was published in Volume 2 of *The Geology of Russia* (1845). Murchison also relied on his younger colleague, the naturalist Alexander von Keyserling, to undertake independent surveys of remote locations such as the Petchora River basin on the west flank of the northernmost Urals, and Mount Bogdo in the Khirgis steppe. In both cases, Keyserling's remit was to retrieve fossil material which could then be examined by specialists in order to determine the age of the strata at those remote sites. Upon return from the field, Murchison promptly announced his findings, both at scientific meetings and in print.

The Russian campaigns, 1840 and 1841

An excellent example of his fieldwork methodology in action was the work he did that resulted in the mammoth book entitled *The Geology of Russia in Europe and the Ural Mountains*. The book is a handsome, well-illustrated, two volume set published in 1845 by John Murray of London and Bertrand of Paris. Murchison wrote Volume 1 on the geology of Russia, and his collaborator, Edouard de Verneuil, prepared Volume 2 on the paleontology of the regions that they visited.

Volume 1 of *The Geology of Russia* is illustrated by a pair of maps, one of which is shown here (Fig. 1), five copper engraved plates with cross-sections, as well as a dozen lithographs, and 83 wood-cuts (Thackray 1978; Diemer and Diemer, 2021). The map shown here, Plate 6 of *The Geology of Russia*, is accompanied by a generalized stratigraphic section on the right margin, and a cross section along the base of the map extending from Saint Petersburg on the north to the Sea of Azof on the south.

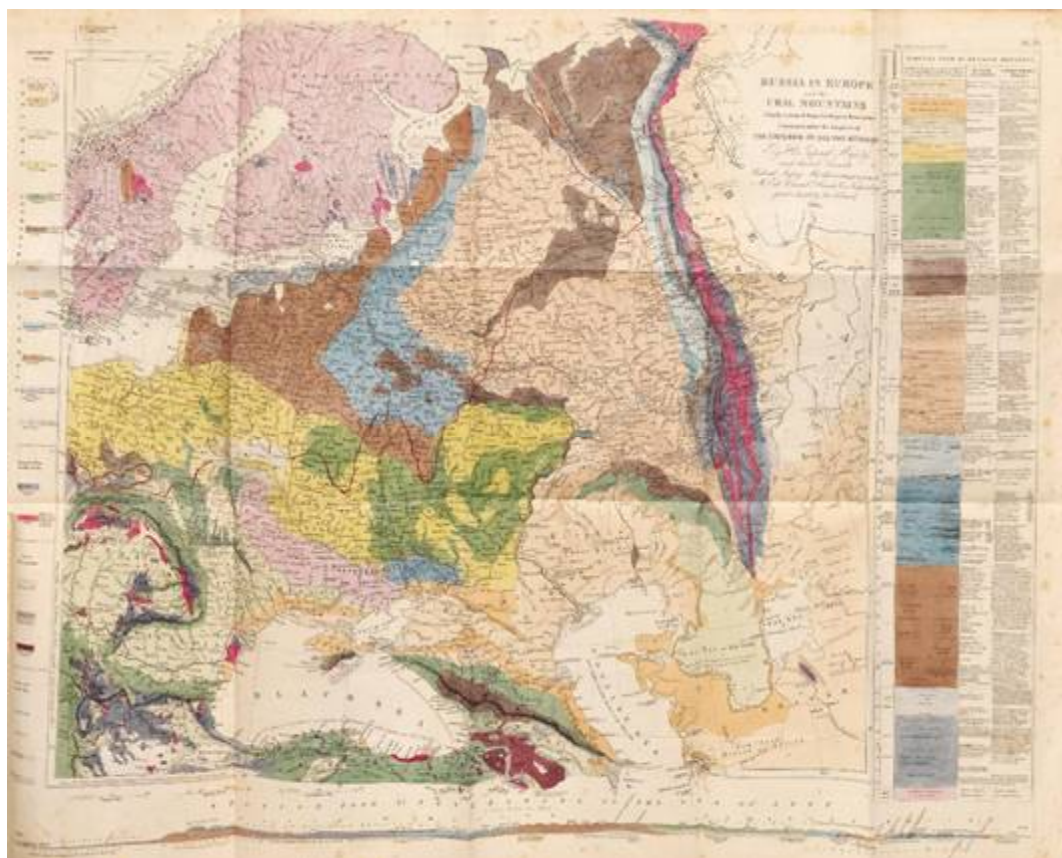


Fig. 1. Plate 6 from The Geology of Russia (1845)



Fig. 2. Travel routes for Murchison and his team in 1840 in northern Russia. Underlying geology modified from Plate 6 of The Geology of Russia (1845)

The maps and sections of Volume 1 were the product of observations made during two extensive field campaigns in Russia. Shown here is the route that Murchison and his team took during the 1840 campaign where they started in Saint Petersburg and traveled north to Archangel before turning southward to Usting and Nishni Novgorod (Fig. 2). Their route then took them to Moscow on their way back to Saint Petersburg. During that expedition they mapped crystalline basement rocks unconformably overlain by the Silurian and Devonian Systems. They also mapped the Carboniferous System overlain by red sedimentary rocks that would later be assigned to the Permian System (Murchison, 1841; Benton *et al.*, 2010; Benton and Sennikov, 2021).

The more southerly route taken in 1841, as well as the route taken in 1840, is shown on Fig. 3. The 1841 route began in Berlin where Murchison conferred with Alexander von Humboldt about the geology of Russia. Murchison and members of his team then traveled to Saint Petersburg and continued through Moscow, Kazan and Perm before criss-crossing the Ural Mountains several times. The team then traveled back through Orenberg, Samara, Sarepta and Novo Tcherkassk before arriving in the Donetz coal basin. Note the modern-day outline of the country of Ukraine and its border with Russia and Belarus. Note also that the Donetz coal basin is in eastern Ukraine and is the location of much fighting today.

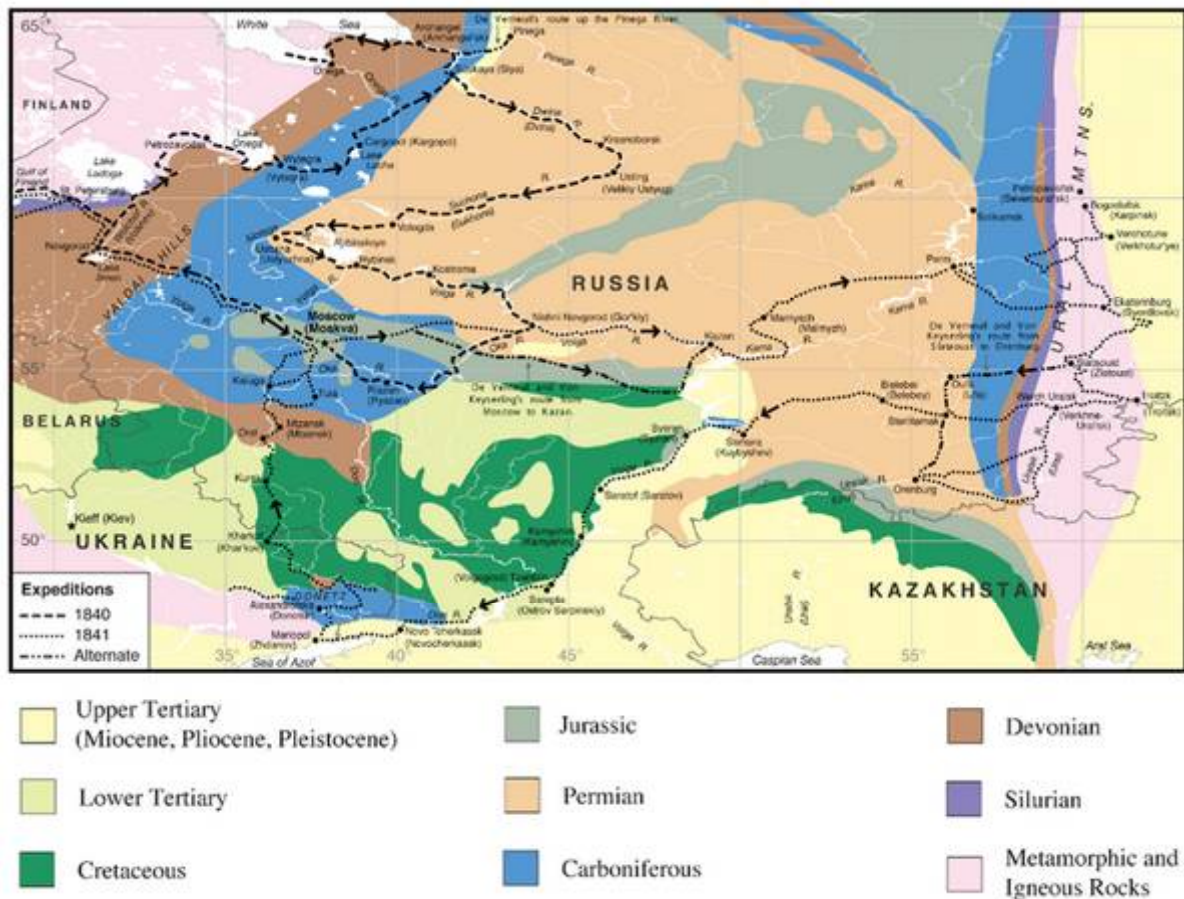


Fig. 3. Travel routes taken by Murchison and his team in Russia in 1840 and 1841. Underlying geology modified from Plate 6 of *The Geology of Russia* (1845).



Fig. 4. Travel routes (dotted lines with direction of travel indicated by arrows) taken by Murchison in the Donetz coal basin in 1841. Underlying geology modified from Plate 6 of *The Geology of Russia* (1845).



Fig. 5. Geologic map of Donetz coal basin, close up from Plate 6 of *The Geology of Russia* (1845). The units shown on the map, and their colors are as follows: a (pink) Azoic gneisses, b (red) younger granites, 3 (blue) Carboniferous, 4 (orange) Permian, 7 (green) Cretaceous, 8 (yellow) Eocene, 9 (pale green) Miocene, 10' (dark tan) Pliocene, and 10' (light tan) Pleistocene.

The Donetz coal basin

A closer view of the Donetz region appears in the next map (Fig. 4). The southeastern corner of this map is labeled as part of Russia. The political boundary can be seen as a gray line situated a short distance to the west and north of Taganrog. The remainder of the map, including the Donetz coal basin, is in Ukraine.

Murchison and his colleagues traveled extensively within the Donetz coal basin, visiting active coal mines, in an effort to assess the quality and extent of the coal deposits. The sites they visited enabled Murchison to map the extent of the Carboniferous system shown in blue in Fig. 4. Upon arriving in the Donetz region, they first traveled northward up the Kalmiuss River valley, and then turned to the east to inspect coal mines that occur in the eastern part of the Donetz coal basin. From there, they traveled westward, as far

as Petropavlosk before returning to Bachmuth, where they then turned northward toward Moscow at the end of their field season. This extensive inspection led to the detailed geology for the Donetz coal basin which was incorporated into Plate 6 as shown in Fig. 5.

This close up view of the Donetz coal basin from Plate 6 of *The Geology of Russia* (1845) shows the locations of various coal mines as black dots, as well as cross-sections as black lines. The cross sections in Plate 1 of *The Geology of Russia* (1845) illustrate the attitude and extent of the coal deposits. Murchison and his team spent several weeks on a close inspection of the Donetz coal basin. Whereas they were not the first to examine the geology of the Donetz coal basin, they were the first to apply the recently developed Paleozoic system nomenclature to those deposits.



Fig. 6. Ivanitski's geologic map of the Donetz coal basin and vicinity. From the British Geological Survey, Keyworth, GSM 1/126 (31).

Previous work in the Donetz coal basin

Shown here is a geologic map of the Donetz region made by Captain Ivanitski (Fig. 6). The shoreline of the Sea of Azof is indicated by a blue band at the base of the map. The blue areas in the central part of the map delineate the occurrence of coal bearing deposits. Murchison was provided with a copy of Ivanitski's map by General Tcheffkine, the Director of Mines and Public Works, when he passed through Saint Petersburg earlier in the summer. This copy of the map is today in the archives of the British Geological Survey and has Murchison's handwritten annotations.

Passages from *The Geology of Russia* reproduced in Fig. 7 identify the sources of information provided by the Russian authorities. It is clear that Murchison benefited from access to that material when he was investigating the Donetz coal basin. He pointed out that the previous workers had said "*that owing to the convolutions of the strata and the want of fixed mineral characters, no regular order could be established.*" He

went on to say "*To geologists, therefore, who like ourselves were thrown into a new field, in which the succession of the beds was perfectly unknown to us, nothing could be more satisfactory than to find, in one of the first sections which we made, a key to the whole order of this country and by which we established the most ancient strata occupy the southern zone of this carboniferous region*" (Murchison *et al.*, 1845, vol. 1, p. 93). Thus, led to the Kalmiuss River section by reference to the maps and sections of Captain Ivanitski and others, Murchison and his team were able to establish that rocks of the Devonian System rested unconformably on crystalline rocks and were dipping and ascending stratigraphically in a northerly direction, as will be shown in subsequent figures. This discovery was an important conceptual breakthrough that permitted the correlation of the coal-bearing rocks of the Donetz region with the Carboniferous System of western Europe. This new overview built on the data-rich observations of Ivanitski to firmly establish the stratigraphic position of the coal-bearing rocks of the region.

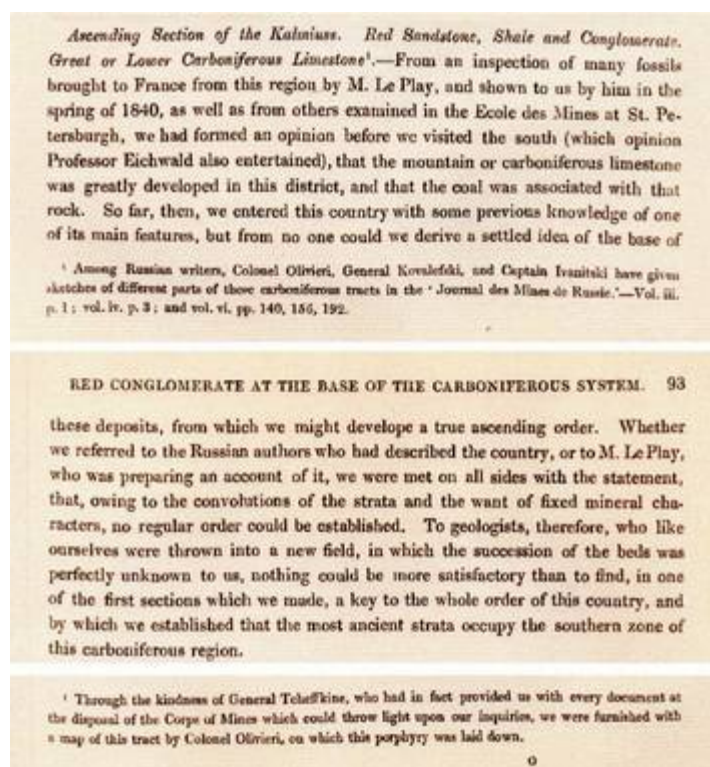


Fig. 7. Sources of information provided by the Russian authorities to Murchison reproduced from *The Geology of Russia*, 1845, pp. 92–93.

Plate 1 of *The Geology of Russia* (1845) documents the attitude and stratigraphic positions of the coal seams at 9 locations throughout the Donetz coal basin (Fig. 8). 'Figure 1' in the upper right portion of Plate 1 is the key Kalmiuss River cross section (Fig. 9) with granites and porphyries at the base which are overlain by a red conglomeratic sandstone which Murchison assigned to the Old Red Sandstone. Recognition of the Old Red Sandstone enabled Murchison to assign the base of the Carboniferous to the southern end of

the Kalmiuss River cross-section. The section includes crystalline igneous rocks (pink and red) at the base which are unconformably overlain by northward dipping stratified sedimentary rocks (brown, blue and gray). The brown strata, labeled as Old Red Sandstone are overlain by tilted and folded Carboniferous strata (gray and blue). The coal seams within the Carboniferous strata are shown as black lines on the section (Fig. 9) and the locations of coal mines are represented by black dots on the map (Fig. 5).

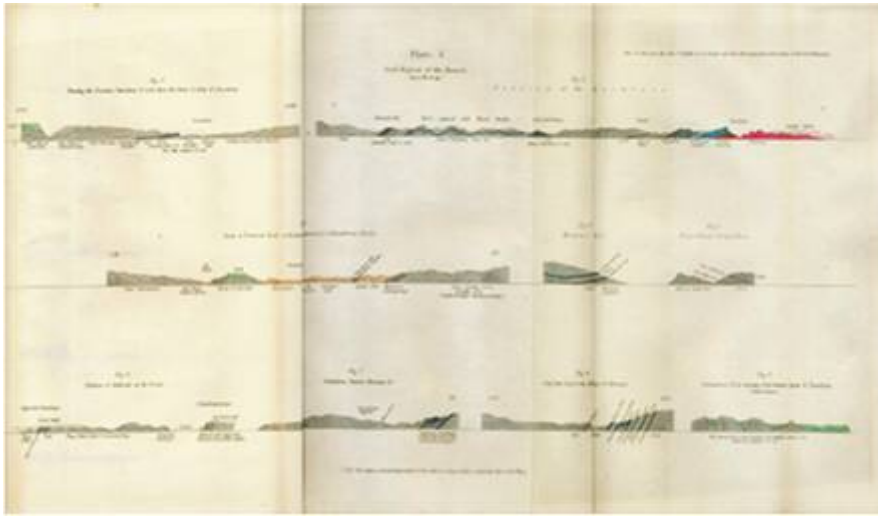


Fig. 8. Plate 1 of *The Geology of Russia* (1845) comprising 9 cross-sections of coal-bearing localities ('Figures 1–9') in the Donetz coal basin.



Fig. 9. Expanded view of Plate 1, 'Figure 1', "Section of the Kalmiuss", from *The Geology of Russia* (1845).

Key localities in the Donetz coal basin

A close-up of the southern end of the Kalmiuss River section is shown in Fig. 10. The sandstones (in brown) overlying the porphyry (in red) are labeled as Old Red Sandstone. The steeply dipping blue layers are fossiliferous limestones interbedded with the sandstones and shales (shown in gray) of the Carboniferous. The black layer is a coal seam within the grits of the Carboniferous.

Fig. 11 portrays the southern part of the Kalmiuss River section by Ivanitski. Compare this section with the one by Murchison (Figure 10) for the same stretch of the river valley. Note that the unconformity between the vertical porphyry and the northward-dipping sandstones and limestones at Karakuba is indicated on both sections. Being able to refer to Ivanitski's section no doubt assisted Murchison to quickly recognize the Paleozoic systems comprising the stratigraphy in the Kalmiuss River valley section.

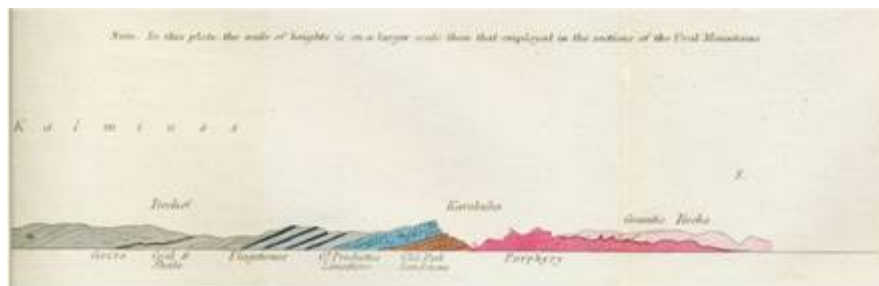


Fig. 10. Close-up view of the southern end of Plate 1, 'Figure 1', from *The Geology of Russia* (1845).



Fig. 11. Ivanitski's section from the southern part of the Kalmius River. Compare to the section by Murchison in Fig. 10. Ivanitski's section is from the British Geological Survey archives, GSM 1/126 (62).

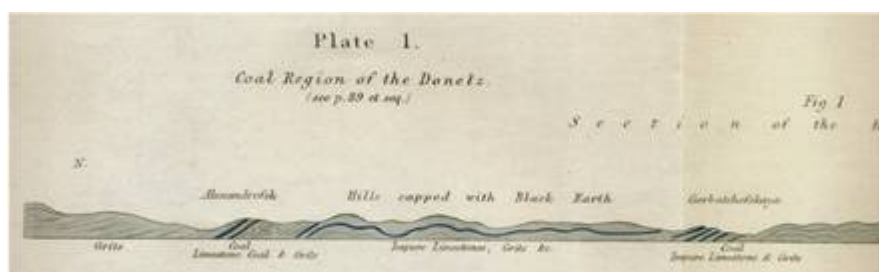


Fig. 12. Northern end of the Kalmius River section, Plate 1, 'Figure 1' from *The Geology of Russia* (1845).

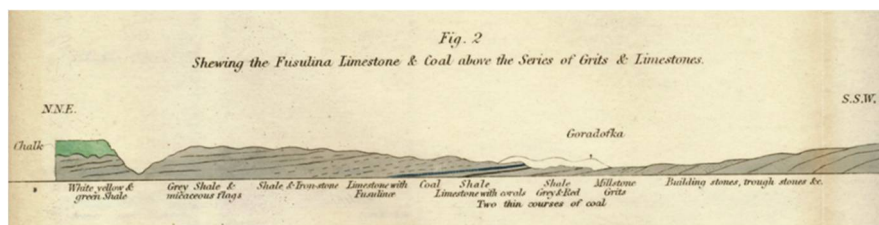


Fig. 13. Cross-section in the vicinity of Goradofka, from Plate 1, 'Figure 2', *The Geology of Russia* (1845).

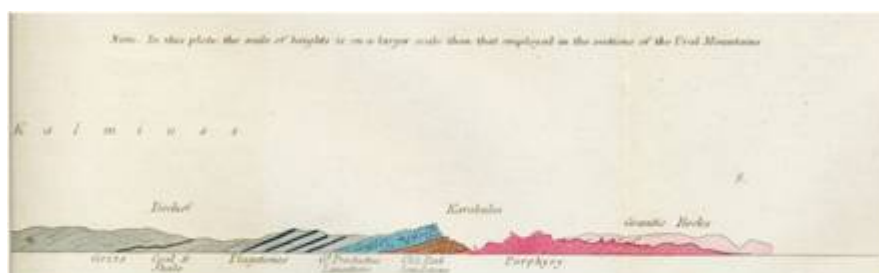


Fig. 14. Cross-section in the vicinity of Bachmuth from Plate 1, 'Figure 3', *The Geology of Russia* (1845).



Fig. 15. Ivanitski's section in the vicinity of Bachmuth. Compare to Murchison's section in the same area (Fig. 14). From the British Geological Survey archives, GSM 1/126 (62).

Fig. 12 portrays the northern end of the Kalmiuss River section in 'Figure 1' of Plate 1. Note that the Carboniferous rocks are folded in this part of the section. Murchison described the 7 feet thick coal seam at Alexandrofsk as thinly bedded, bituminous, and containing pyrite. The coal was mined by the government in shallow shafts located not more than 100 feet above the Kalmiuss River. The depths of the shafts were limited by the influx of groundwater. Steam engines were not in use to pump the groundwater. The coal at Alexandrofsk is overlain by a limestone containing *Productus*, *Spirifer*, and large *Lithodendron*. Murchison thought that the limestone was similar to the 'mountain limestone' in England and Ireland.

Fig. 13 reproduces 'Fig. 2' from Plate 1 of *The Geology of Russia* (1845). It portrays the northward dipping Goradofka section near the stratigraphic top of the Donetz coal basin. The Carboniferous strata comprise flagstones, grits, shales, limestones and coal seams. The grits were quarried and used locally for door-posts and troughs. The limestones contained fusulinids and trilobites and the coals were bituminous. Note that the north end of the section has Cretaceous chinks unconformably overlying the Carboniferous strata. Presumably, the Carboniferous strata continued at depth to the north, and if they contained coal seams, Murchison suggested that those seams might remain within reach of vertical mine shafts for some distance.

Fig. 14 is a line of section oriented SW-NE that passes through Bachmuth (see Figure 5). The section is noteworthy because it exhibits a synclinal structure with Permian beds occupying the center of the fold at Bachmuth. The section also shows Cretaceous chalk unconformably overlying the Carboniferous to the southwest of Bachmuth.

The Bachmuth section prepared by Captain Ivanitski (Fig 15) bears a strong resemblance to 'Figure 3' in Plate 1, prepared by Murchison (see Fig. 14). Once again, Murchison likely benefited from data gathered by Captain Ivanitski as they both depicted a syncline centered on Bachmuth. Murchison assigned the core of the syncline to

the Permian, a system he was in the process of defining in 1841 (Murchison, 1841; Benton *et al.*, 2010; Benton and Sennikov, 2021). By comparison, Ivanitski assigned the red sandstones and shales in the vicinity of Bachmuth to the Triassic. Thus, Murchison was the first to apply the newly developed Paleozoic system nomenclature to these rocks.

The section at Krasnoi Kut on land owned and occupied by General Papkoff is shown in 'Figure 4' from Plate 1 of *The Geology of Russia* (1845) (see Fig. 16). The section depicts

- Two anthracite coals that were mined in adits in the hillside and were in beds about 3 feet thick. According to Murchison, they were 'excellent' seams of anthracite being indistinguishable from iridescent British varieties.
- Murchison noted that the coals at this site were far enough to the east to be anthracite as compared to bituminous coals that occurred to the west. He thought that this may be due to heating from below by emplacement of igneous rocks that "*may have converted the superjacent ordinary coal into anthracite, and have indurated the associated grits, sandstones and schists*" (Murchison *et al.*, 1845, v. 1, p. 101).
- Murchison wrote that the line of transition from bituminous coal in the west to anthracite coal in the east, and the chemical make up of the coals, were being studied by Captain Ivanitski and M. Le Play.
- Murchison also noted that the coal mined at this locality was used in steam engines in a nearby manufactory established by General Papkoff.

Fig. 17 portrays another anthracite coal-bearing section, this one at Popofka. This is 'Figure 5' of Plate 1 from *The Geology of Russia* (1845). Murchison noted that the

- Coals at Popofka, in the eastern part of the Donetz Coal Basin, are high quality anthracite seams about 3 feet thick and were "... chiefly worked by galleries, in which the poor

Cossack miners have followed it to short distances from its natural outcrop on the sides of the brooks" (Murchison *et al.*, 1845, v. 1, p. 102). Murchison also noted that if steam engine water pumps were to be introduced, the seams potentially could be followed to greater depths and below the groundwater table.

- Mining of this anthracite coal was encouraged by Count M. Woronzow, the Governor of the district. The Governor wanted the popul-

ation to move away from scarce wood as a source of fuel. The coal being mined at Popofka was transported by light carts to Novo Tcherkask and to the iron forges of Lugan.

- Mines at Popofka were described by Captain Ivanitski in the 6th volume of the *Journal of the Imperial Mines*. Ivanitski was also conducting experiments on the heat produced by the coal, at the behest of General Tcheffkine.

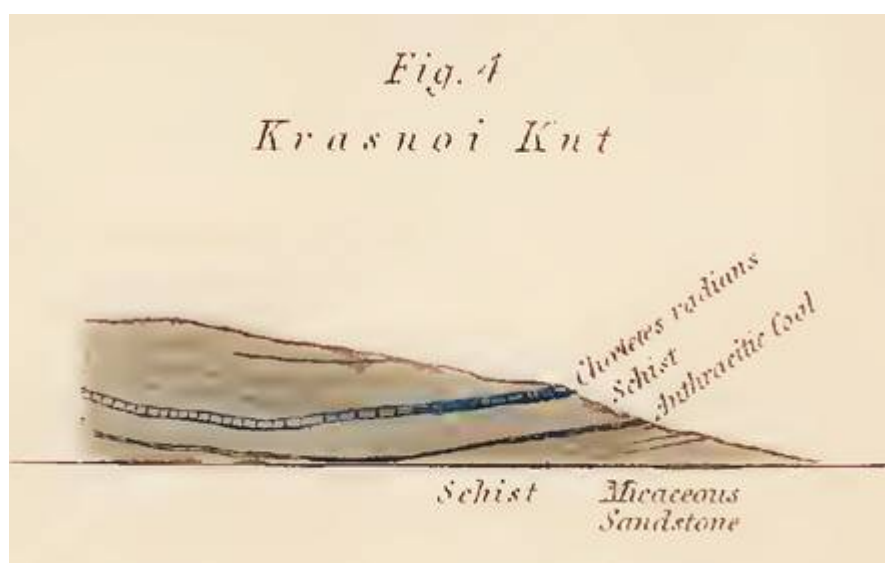


Fig. 16. Section at Krasnoi Kut, the residence of General Papkoff, from Plate 1, 'Figure 4', of *The Geology of Russia*, (1845).



Fig. 17. Section at Popofka, from Plate 1, 'Figure 5', *The Geology of Russia* (1845).

Fig. 18 contains a shaft section of the productive Lissitchia-Balka coal mines. The section was prepared by Captain Ivanitski and it recorded multiple bituminous coal seams in black, interbedded with limestones, shales, sandstones, grits and 'schist'. Note that these bituminous coals occurred in the western part of the Donetz coal basin.

Murchison used Ivanitski's hand drawn shaft section in Fig. 18 to produce the detailed section

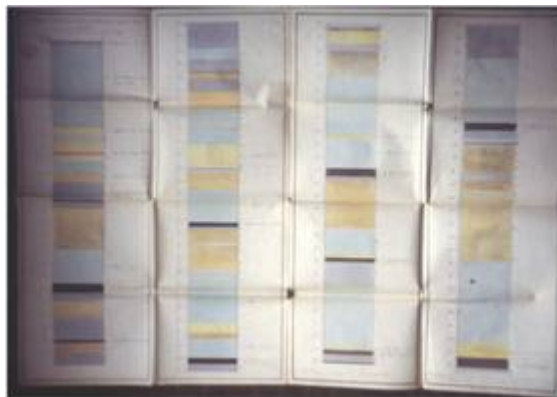


Fig 18. Shaft section at Lissitchia-Balka prepared by Captain Ivanitski. From the British Geological Survey archives, GSM 1/126 (77).

on page 111 of Volume 1 of *The Geology of Russia* (Fig. 19). As with Ivanitski's original section, Murchison's published section comprises interbedded sandstones, shales, limestones and coals. There are 12 labeled coals and the section appears to record multiple cycles of deposition. Murchison interpreted the coals to be 'submarine' in origin, but from a modern perspective, the section more likely comprises multiple transgressive and regressive sequences which deposited cyclothem with terrestrial coals.

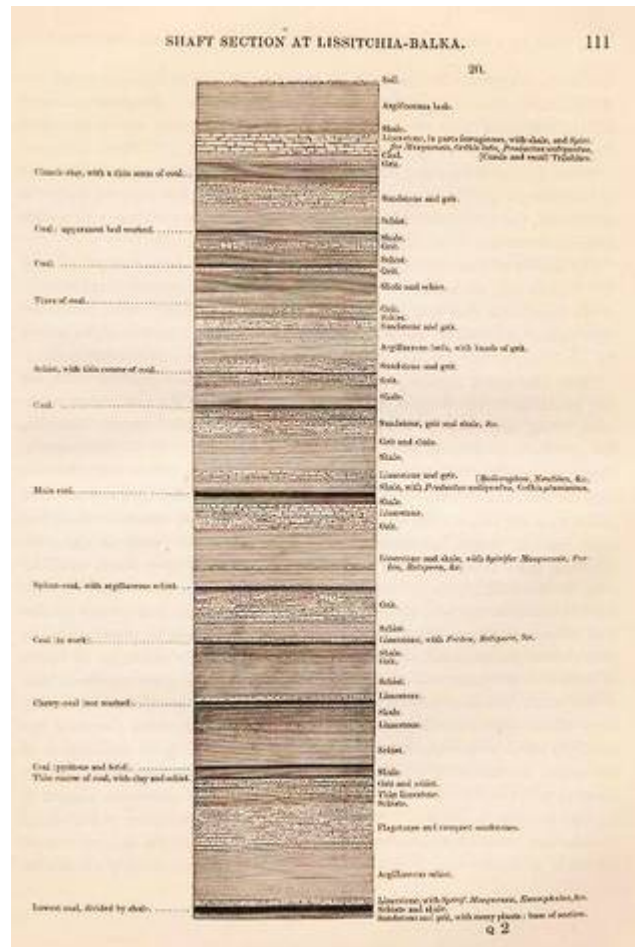


Fig. 19. Shaft section at Lissitchia-Balka by Murchison, from *The Geology of Russia* (1845), p. 111.

Synthesis of observations in the Donetz coal basin

Fig. 20 reproduces a portion of the stratigraphic column on the right-hand margin of Plate 6 of *The Geology of Russia*. It provides a summary of many of the observations and interpreta-

tions made by Murchison concerning the Carboniferous System in Russia. The Carboniferous System is divided into a Lower (dark blue) and Upper Carboniferous (light blue). The Carboniferous is also divided into a 'North Region' without coal on the left and a 'South Region' with coal on the right.

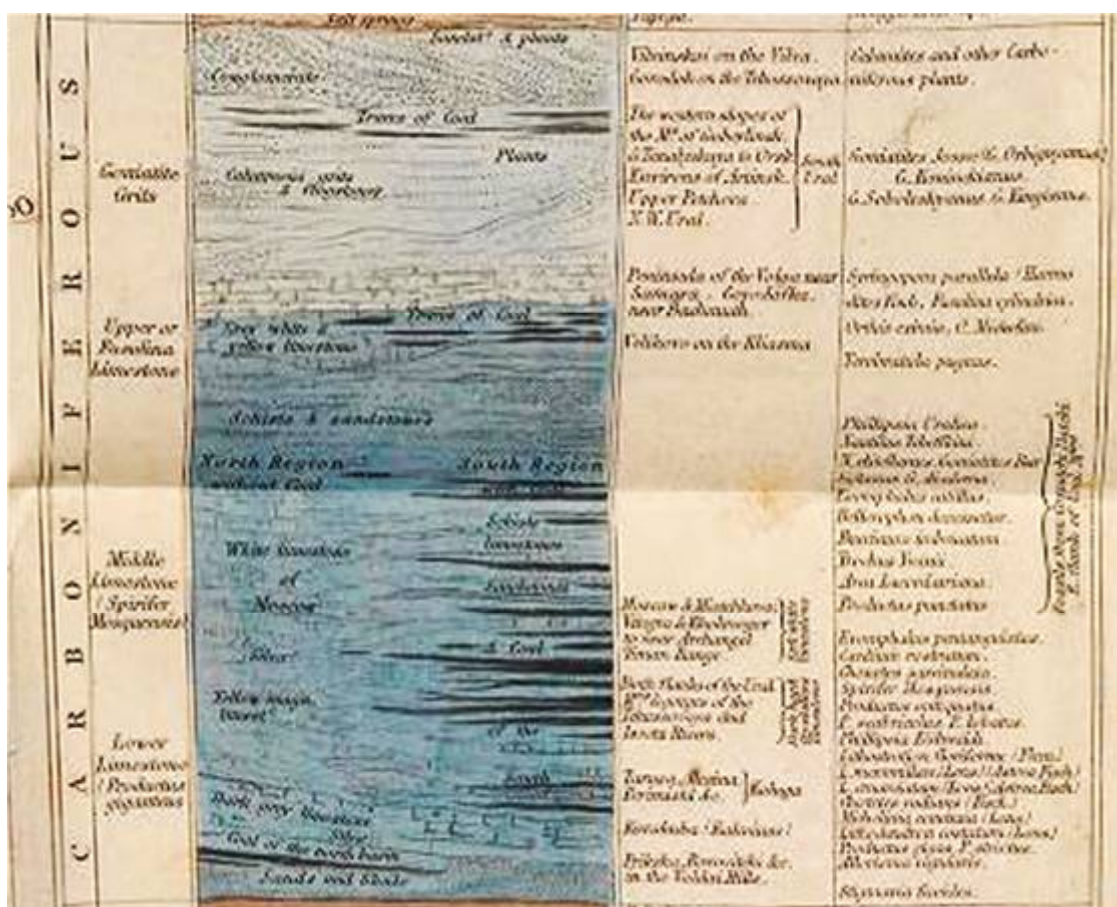


Fig. 20. Regional stratigraphy of the Carboniferous System, from Plate 6 of *The Geology of Russia* (1845).

The right-hand side of the column portrays the stratigraphy of the Carboniferous System in the Donetz coal basin. The base of the Donetz section occurs at Karakuba on the Kalmiuss River. The top of the Donetz section occurs at Gorodofka near Bachmuth. Note the multiple coal seams interbedded with sandstones, limestones and 'schists', similar to the detailed stratigraphy of the shaft section at Lissitchia-Balka shown in Fig. 19.

Conclusions

This paper documents Murchison activities in the Donetz coal basin and provides a good example of his collaborative fieldwork methodology in action.

- First, he researched in advance by reading

available publications and consulting with knowledgeable geologists such as Alexander von Humboldt.

- Second, he assembled relevant maps and publications to assist in his campaign; in this case he made extensive use of Captain Ivanski's geologic map and cross sections.
- Third, he interviewed local experts and visited their collections. Of most use was the Donetz basin fossil collection of M. Le Play of Paris.
- Fourth, he traveled with other scientists to verify his observations. In 1841 he was accompanied by Edouard de Verneuil and Alexander von Keyserling while investigating the Donetz coal basin.
- Fifth, he announced his findings both at meetings and in print, most notably in Chapter 6 of *The Geology of Russia*.

In addition, this paper discusses Murchison's contributions to understanding the geology of the Donetz coal basin. Some of his major findings include the following:

- First, Murchison and his team provided careful documentation of the occurrence and extent of coals throughout the Donetz coal basin, both on the geologic map and in the associated cross-sections.
- Second, they established that the coal fields in the Donetz basin were in rocks of the Carboniferous System that dipped in a generally northward direction.
- Third, the base of the Carboniferous System was recognized by its contact with the underlying Devonian System and older crystalline rocks.
- Fourth, the top of the Carboniferous System was overlain by the Permian System.
- Fifth, Murchison recognized that the depths of mines were limited by groundwater, and

that the introduction of steam driven pumps would greatly increase the production from many of those mines.

- Sixth, Murchison recognized a regional change from bituminous coals in the west of the Donetz coal basin to anthracite coals in the east, and attributed that gradation to heat emanating from the emplacement of granitic rocks at depth.
- Seventh, Murchison recognized that the Carboniferous stratigraphy of the Donetz coal basin was distinct from the Carboniferous rocks in the vicinity of Moscow.

As a final note, the coal deposits of the Donetz coal basin remain of strategic value. They have likely played an important role in Russia's invasion of Ukraine. The Donetz coal basin was occupied in 2014 at the same time as the Crimean Peninsula, indicating that the coal deposits continue to be prized highly by Russia.

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Correspondence between Eduard Suess and Vladimir A. Obruchev: with emphasis on “*The Face of the Earth*”

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Abstract. Eduard Suess was a well-known Austrian geologist, who shaped generations of geologists with his concepts, such as the supercontinent Gondwana and the Tethys Ocean. His correspondence with numerous scientists of his time and the establishment of “*The Face of the Earth*” made a foundation for modern geology. One of the scientists with whom E. Suess exchanged letters was Vladimir A. Obruchev, a Russian geologist and “the father of Siberian Geology”, who studied areas around Lake Baikal, Altai Mountains, and Central Asia. In this study the authors analysed the correspondence between V. A. Obruchev and E. Suess, which give insights not only in their scientific exchange but also in development of their personal friendship. Furthermore, their exchange of scientific data, ideas and knowledge influenced the work of “*The Face of the Earth*”, in particular chapters dealing with Lake Baikal, Altai Mountains and Central Asia. The main aim of this study was to analyse historical documents in form of letters, sketches, and maps from V. A. Obruchev from the Geological Archive in Vienna.

Keywords: Obruchev – Suess – *The Face of the Earth* – Tian-Shan – Nan-Shan – Lake Baikal – Central Asia

Introduction

Europe in the 19th century, both united and extremely divided. It was a time period of revolutions, political and social transformations, rise of the nationalism, rapid industrialization, and dissemination of science across the continent. During this period, geology was ironically a young science, with many ground-breaking inventions and theories yet to be made. The 19th century from geological perspective was dominated by the work of Charles Lyell “*Principles of Geology*”. His work made a foundation for methodology in modern geology, which requires the study of modern processes and collecting precise, quantitative data, which would be used to interpret past geological processes and environments. Interpretation of collected evidence was however dominated by major works of Leopold von Buch, who considered volcanism as a main driving factor of orogenesis. Ano-

ther major work was by Élie de Beaumont, who sought geometric symmetry in the origin of mountain ranges (Obruchev & Zotina, 2009). In this rapidly changing World, two geologists, with considerably different backgrounds contributed a remarkable amount of knowledge in order to unravel the geological *Face of the Earth*: Eduard Suess and Vladimir Afanasyevich Obruchev. In this study, we analysed Obruchev’s letters, maps, and sketches from the correspondence with E. Suess, which gives us interesting insights of not only on how they worked and were thinking but also on how their friendship developed over time.

Eduard Suess (1831-1914)

Eduard Carl Adolph Suess was a well-known and one of the most influential geologists of his time. He was born in London in 1831 in a wealthy

Austrian merchant family. Suess's biography is well known and his concepts of Supercontinent Gondwana or Tethys Ocean are deeply embedded in scientific community and every geology related schoolbook. Eduard Suess started working at the Austrian Academy of Sciences at the age of twenty-nine, followed by full membership in 1867. In 1898 he was chosen as a president of the Academy and remained its president until 1911. His professorship at the University of Vienna lasted 45 years between 1856–1901. Suess's lectures were widely acknowledged and remarkably popular between the students.



Fig. 1: Portrait of Eduard Suess published in the "Geologische Rundschau" for his 80th birthday (Steinmann, et al., 1911).

Eduard Suess could truly inspire his students with rhetorically perfect explanations and excellent colourful drawings. His lectures usually represented his ongoing research and scientific questions he was working on. In the initial years of his professorship, Suess held lectures in paleontology, followed by lectures in geology with an emphasis on stratigraphy and lithostratigraphy. Later on, his lectures were focused on tectonics. During this period E. Suess worked on his opus magnum "The Face of the Earth". In complement to lectures Eduard Suess went to fieldtrips with his students. Most of them took place around Vienna and Vie

na Basin. Later on, fieldtrips extended into the Lower Austria and the Alps and even further to Italy and Sicily. Suess did not just lecture during the fieldtrips but also took active part in students endeavours, where he would again feel young in their company. As noted by V. A. Obruchev, Eduard Suess was a humble person despite of his popularity and acknowledgement. In addition to his scientific career, he was also a public figure and a politician. Suess was member of the Austrian Landtag and thereafter member of the Austrian Reichsrat. He shared monarchist political views and criticized liberally oriented political parties supporting a unified Austria-Hungary (Obruchev & Zotina, 2009). Nevertheless, Eduard Suess saw himself in the first place as a scientist, geologist, and philosopher. He played an important role in the development of an aqueduct system to supply Vienna with drinkable water. Another Suess's important contribution to the development of Vienna was the regulation of the Danube River to stop its frequent flooding of the city. His remarkable scientific contribution manifested itself in the multi-volume work "The Face of the Earth", composed of his own philosophical views, re-worked, and summarized scientific literature and scientific exchange with numerous scientists and philosophers from around the world (Obruchev & Zotina, 2009; Şengör, 2015). One of these scientists was a young Russian geologist Vladimir Afanasyevich Obruchev.

Vladimir Afanasyevich Obruchev (1863-1956)

Vladimir A. Obruchev was born in 1863, in a small village of Klepenino located in Tver Governorate¹. His mother was of German origin and taught him German and French during his childhood. Obruchev graduated from the St. Petersburg Mining University in 1886 and in his early career he translated foreign scientific research articles for publishing in Russian journals. One of these articles, or to be more precise, a series of books, was written by the German geographer and traveller Ferdinand von Richthofen about China², which raised an immense interest in Obruchev for Asia and the origins of loess depos-

¹ Tverskaya Guberniya (English: Tver Governorate), an administrative division of the Russian Empire between 1796 and 1929. Nowadays Tverskaya Oblast (English: Tver Oblast).

² Ferdinand von Richthofen. China. Ergebnisse eigener Reisen und darauf gegründeter Studien. Verlag von Dietrich Reimer, Berlin, 1877.

its. After graduating St. Petersburg Mining University Obruchev participated between 1886–1888 in scientific expeditions to Central Asia³ under the supervision of Ivan Vasilyevich Mushketov⁴.



Fig. 2: Photograph of Vladimir Afanasyevich Obruchev in 1886 (Geological Institute RAS, 1885).

The results were published in numerous scientific journals, but Obruchev also wrote a series of expedition essays for general public. This expedition resulted in Obruchev's main scientific interests, such as the origin of loess deposits, aeolian and fluvial depositional environments and permafrost. After the expedition, I. V. Mushketov proposed Obruchev a position as an exploration geologist in Irkutsk, where he studied coal and gold deposits, and vast Siberian territories⁵.

One could keep talking about Obruchev's extraordinary biography for a long time. As a matter of fact, there are numerous publications and books dedicated to his life. However, we would like to complement at this point his biography from the

year 1891 by making use of his correspondence with Eduard Suess.

Beginning of the correspondence

V. A. Obruchev–E. Suess

The Geological Archive of Vienna has 42 Obruchev's letters and 24 maps in excellent condition stored in Cabinet 8 / Box 9. Suess's letters are on the other hand located in the archive of the Russian Academy of Sciences (RAS) in Moscow (pers. comm. RAS). There are 63 letters from Suess to Obruchev, but it was not possible for us to retrieve original scans of the letters from the RAS. The first letter from Obruchev to Suess, which is available to us, is from 1/13 May 1892 (Julian/Gregorian)⁶ and was sent from Irkutsk. However, Obruchev mentions his letter from 5/17 December 1891 and in the collected edition of Obruchev's scientific heritage (Обручев, et al., 1964), the first available letter from Suess is dated from 6 July 1891. In this letter Suess mentions one of the first Obruchev's publications on the gold deposits in Olekminsko-Vitim Mountain range, which was published in 1891. The correspondence between Suess and Obruchev, therefore must have begun in the first half of 1891.

Interestingly is that Obruchev in 1891 was a very young geologist with only two published publications. We do not know why and how Suess reached out to Obruchev, as there were other more prominent Siberian geologists such as I. D. Czerski⁷ and G. N. Potanin⁸. We speculate that Suess, in order to obtain more information on Siberian and Asian geology at first reached out to I. V. Mushketov, who might have further forwarded him to Obruchev, prior to his knowledge of German and interests in Siberian geology. Another possibility is that Suess actually reached out to Obruchev directly as he was the only permanent

³ Obruchev's first expeditions between 1886–1888 under the supervision of I. V. Mushketov to the Karakum Desert, in Transcaspian Oblast. The Transcaspian Oblast was an administrative region of the Russian Empire until 1924. Nowadays the area corresponds approximately to Turkmenistan and southwestern Kazakhstan.

⁴ Ivan Vasilyevich Mushketov (Russian: Иван Васильевич Мушкетов, 1850–1902), was a Russian geologist and geographer. He is well known for his exploration work in Russia and China, including regions of Tian Shan and Turpan Valley. Mushketov was professor and scientific supervisor of V. A. Obruchev.

⁵ V. A. Obruchev. Geological research of the Olekminsko-Vitim Mountain range and its gold-bearing placer deposits in 1890. (*В. А. Обручев. Геологические исследования Олекминско-Витимской горной страны и её золотоносных россыпей и 1890 г.* < Изв. Вост.-Сиб. отд. РГО >, 1891, т. 22, № 2–3.

⁶ Gregorian calendar was adopted on the 6th of February 1918 by the Russian Socialist Federative Soviet Republic (RSFSR).

⁷ Jan Stanislaw Franciszek Czerski (Russian: Иван Деметьевич Черский, 1845–1892), was a Polish palaeontologist, geologist, geographer, and explorer of Siberia, who was exiled to Transbaikalia for participating in the January Uprising of 1863. He was one of the first to develop tectonic structure of Lake Baikal and Central Asia.

⁸ Grigory Nikolayevich Potanin (Russian: Григорий Николаевич Потанин, 1835–1920), was a Russian ethnographer and natural historian. He is well known for his exploration of Inner Asia and as a political activist supporting the Siberian Independence movement.

geologist in the far East. In fact, even Obruchev was surprised by Suess's request on Siberian geology:

« Diese Schrift scheint Ihnen unbekannt zu sein, da ich mir sonst nicht erklären kann, weshalb Sie Ihre ehrenvolle Anfrage an einen Neuling in der Geologie von Sibirien, wie ich einer noch bin, richten, anstatt sich an die Autorität von Herrn I. Czerski zu wenden;... »

« This writing seems unfamiliar to you, as I cannot otherwise explain why you would direct your honourable request to a newcomer in Siberian geology like myself, instead of turning to the authority of Mr. I. Czerski;... » – V. A. Obruchev to E. Suess, Irkutsk 1/13 May 1892 (Letter 1, p. 1).

At the same time, Obruchev sent Czerski's publications on Siberian geology and discussed the origin of the Lake Baikal. He argued that lake Baikal is actually a graben-structure and not as proposed by Czerski of orogenic origin (Letter 1, p. 4). Obruchev also mentioned that he got a proposal (under procurance of I. V. Mushketov) to participate in Potanin's expedition to the Eastern Tibet⁹.

In the following years (1892–1894), V. A. Obruchev participated in expeditions to Mongolia and China under the supervision of Grigory Nikolayevich Potanin, where he conducted a series of topographical and geological observations. During the day he collected geological data and mapped the area and at night summarized the results, wrote reports and articles to the Russian Geographical Society and maintained correspondences with his colleagues, including Eduard Suess.

His first expedition route (German: *die Marschroute*) began on 15/27 September 1892 from Kjachta to Urga¹⁰, which he reached on 23 September / 5 October covering over 30 km per day. Obruchev shared his short but extensive results with Suess from Peking on 9 January 1893. In his letter (Letter 2, p. 4) he sketched a map of the expedition route, with geological description and orientations of the major depressions and faults. It is interesting to note, that Obruchev

thanks Suess for wishing him “*Glückauf*”, which is a traditional greeting of German and Austrian miners and in general means good luck.

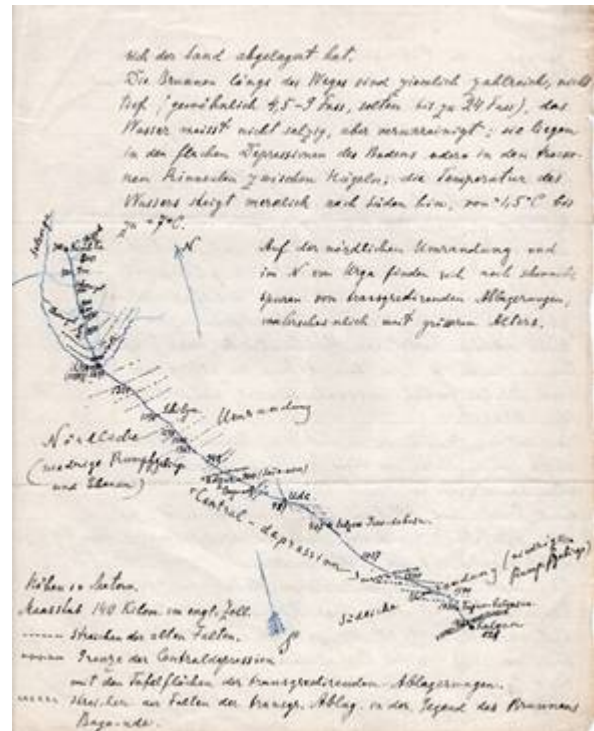


Fig. 3: Geological sketch of the Kjachta-Urga-Kalgan¹¹ route by Obruchev (Letter 2 from Obruchev to Suess, p. 4).

After months of expeditions, Obruchev sent a letter to Suess on 24 September 1893 from Su-Chow¹², with unpublished results from the Nan-Shan Mountain range. In addition, he kindly asked Suess not to publish them until they would be officially released through the Russian Geographical Society. Moreover, Obruchev let Suess to know where his further expeditions would take place and asked him for places and regions of particular interest (Letter 3, p. 1–10).

Between 1893 and 1895, the correspondence between Suess and Obruchev was mostly an exchange of geological data and ideas. Obruchev sent Suess information on geological structure of the Inner Asia, specifically Nan-Shan and Tian-Shan regions. The data consisted predominantly of lithological descriptions, tectonic structure, and measurements of the major faults.

⁹ Second Chinese–Tibetan expedition during 1892–1893 to study Eastern Tibet under the supervision of G. I. Potanin. Potanin would get seriously sick and will have to abort his expedition. However, Obruchev would continue the expedition on his own.

¹⁰ Urga, until 1924 former name of Ulaanbaatar, the capital of Mongolia.

¹¹ Kalgan, nowadays Zhangjiakou in northwestern Hebei province, northern China.

¹² Su-Chow, former name of Suzhou city in the Jiangsu province.

Paleontological material was however of exquisite interest for both scientists, as it provided information on paleogeographical environment and stratigraphy. Obruchev, in his letter to Suess from 9/21 January 1895 from St. Petersburg, asked Suess for his help with the interpretation and preparation of paleontological material from the Nan-Shan region and sent part of it to him (Letter 5, p. 4–5). We can see how the scientific exchange between the two geologists evolved during these years, from exchanging existing reports and literature to sharing ideas, unpublished data and even samples. Furthermore, Obruchev named one of the mountain ridges (Fig. 4) in Nan-Shan after Suess¹³:

« Ich habe mir erlaubt, Ihren berühmten Namen einem bis jetzt unbekanntem Gebirgszuge zu geben, welcher die Fortsetzung der Dislocationslinie der Rittergebirges bildet, von letzterem aber durch eine breite Bresche getrennt ist und deshalb ein Recht auf einen besonderen Namen hat die Huldigung eines jungen Forschers dem Autor des „Antlitz der Erde“. »

« I have taken the liberty of giving your famous name to a previously unknown mountain range, which forms the continuation of the Ritter Mountains' fault line, but is separated from the latter by a wide gap. Therefore, it deserves a special name as a tribute from a young researcher to the author of "The Face of the Earth" » – V. A. Obruchev to E. Suess, Su-Chow 30 May 1894 (Letter 4, p. 8).



Fig. 4: Western part of the Suess Mountain ridge. From (Обручев, 1901).

In 1895, Obruchev returned to Irkutsk from St. Petersburg to study for the next four years the

geology of Transbaikalia for the construction of the Trans-Siberian Railway. His observations and ideas had a major impact on the understanding of the geological structure of Siberia. Between 1895 and 1898 both scientists exchanged their ideas and literature on the Inner Asia and Transbaikalia.

Obruchev meets Suess

After seven years of correspondence, Obruchev and Suess finally met in person in Vienna:

« Ganz unverhofft werde ich in kurzer Zeit das Glück haben Ihnen persönlich meine Hochachtung darzubringen, denn in diesen Tagen, am 9/21 oder 10/22 Oktober reise ich in Familienangelegenheiten nach Zürich und nehme meinen Weg über Wien, um dort 2 Tage zu verbringen, wahrscheinlich am 13/25 oder 14/26 Oktober. »

« Unexpectedly, I will have the pleasure of personally expressing my highest respect to you in a short time. In these days, on 9/21 or 10/22 October, I will be traveling to Zurich for family matters and will make my way through Vienna to spend two days there, probably on 13/25 or 14/26 October. » – V. A. Obruchev to E. Suess, St. Petersburg 2/14 October 1898 (Letter 12, p. 1).

He kindly asked Suess to find for his family an inexpensive hotel, not far from Suess's apartment and that they would soon have an opportunity to discuss the results from Transbaikalia in person. Obruchev could not hold off his excitement to discuss Siberian geology with Suess and proceeded in his letter with short description of his thoughts and ideas (Letter 12, p. 2). We can only speculate and fantasize, what the two scientists talked and discussed about, when they first met. Did they discuss and shared ideas in Suess's little apartment over the map of Asia? Or maybe they went to one of the traditional Viennese cafés for a cup of *mé-lange*? What we know however, is that Suess organized and paid a hotel room for Obruchev and his wife¹⁴ in "Hotel Nordbahn"¹⁵, which is located a couple of minutes away from Suess's apartment at the Afrikanergasse 9. Obruchev returned to Vienna on 17 November 1898, however it is uncertain whether Suess and Obruchev actually met

¹³ Suess Ridge nowadays Da Tong Shan, located north of Qinghai Lake in the Qilian Mountain System.

¹⁴ Elizaveta Isaakovna Lurie (Russian: Елизавета Исааковна Лурье, 1863–1933) was Obruchev's wife until she passed away in 1933.

¹⁵ Hotel Nordbahn, nowadays "Austria Classic Hotel Wien" located in Praterstrasse 72, 1020 Vienna.

during these dates (letter 24). Interestingly, he deliberately mentioned that he would come incognito to Vienna, without letting Suess know the exact address. Possibly, to exclude the possibility for Suess to pay for Obruchev's room.

An unexpected finding from the Gobi Desert

In following years, Obruchev sent Suess new results of Russian geologists A. P. Gerasimov¹⁶ and A. Giedraitis¹⁷ from the Asia and Transbaikalia. In addition, he also sent maps and paleontological material from China, which consisted of gastropods, bivalves, fish remains and some fractured and disintegrated remains of unknown origin from the Gobi Desert. Suess painstakingly cleaned and reconstructed those disintegrated remains and was astonished with the finding. They represented the teeth of the herbivorous mammal *Rhinoceros*¹⁸, which put in doubt the idea of Gobi Formation formed as part of the saline, mediterranean sea. Suess immediately pointed out that *Rhinoceros* remains indicated freshwater, lacustrine environment. Obruchev however, was more cautious in making final conclusions but accepted Suess's idea later on after studying remains more in detail and gathering additional information (Letter 19, p.2).

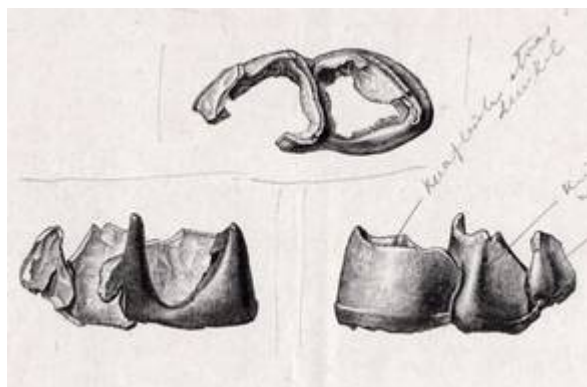


Fig. 5: A drawing of the *Rhinoceros* remains from the white marls of Gobi Desert (Letter 17 from Obruchev to Suess, p. 3).

The *Rhinoceros* finding resulted in a joint publication: „*Ueberreste von Rhinoceros sp. Aus der östlichen Mongolei*“ published in *Verhandlungen der kaiserlich-russischen Mineralogischen Gesellschaft* (Suess & Obruchev, 1899). Furthermore, their publication and findings led to additional expeditions into the Gobi Desert.

An interesting detail is that during these months of their correspondence Obruchev ended his letters with wishing all the best to Suess's family instead of regular: „*Hochachtungsvoll W. Obrutschew*“, which can be translated as „*Yours sincerely V. Obruchev*“. A minor but interesting detail in the development of their relationship.

Obruchev in Europe

On 15/27 May 1899, Obruchev travelled to a health resort in Bad Ems, Germany. From there he planned to go to Switzerland, where his intention was to learn more about Central Gneiss and eruptive rocks. For the August he planned to go to Bohemia and from there to Berlin and Vienna. In his letter from 6/18 of May 1899, Obruchev asked Suess if he could recommend him some interesting geological locations in Switzerland and if his son Franz Eduard Suess¹⁹ could show him around in Bohemia (Letter 19).

« Hochgeehrter Herr! Ihren Brief soeben erhalten, beantworte nächstens, besten Dank für Andeutungen über Litteratur. Die unnötigen Bogen 21-23 vom chines. Bericht bitte zurückzuschicken hierher Friedrichsburg 27. Mit den besten Grüßen Ihr ergebener W. Obrutschew. »

« Dear Sir! I have just received your letter and will respond shortly. Thank you very much for the hints on literature. Please return the unnecessary pages 21-23 of the Chinese report here to Friedrichsburg 27. With best regards, yours faithfully, V. Obruchev. » – V. A. Obruchev to E. Suess, Bad Ems 4 June 1899 (Letter 20).

¹⁶ Alexander Pavlovich Gerasimov (Russian: Алекса́ндр Па́влович Ге́расимов, 1869–1942), was a Russian geologist and geographer. Between 1895 and 1899 worked on the Trans-Siberian Railway and between 1897–1907 under the supervision of V. A. Obruchev on gold deposits in the Lena River region.

¹⁷ Antanas Giedraitis (Russian: Анто́н Э́дмундович Ге́дройц, 1848–1909), was a Russian-Lithuanian geologist, who worked under the supervision of V. A. Obruchev between 1895–1898 on the Trans-Siberian Railway.

¹⁸ *Rhinoceros* is a genus of one-horned rhinoceroses.

¹⁹ Franz Eduard Suess (1867–1941), was an Austrian geologist, son of Eduard Suess. His major scientific interests were Bohemian Massif and the origin of tectites, a term introduced by him.



Fig. 6: Postcard from Obruchev to Suess, sent from Bad Ems, Germany in 1899 (Letter 20).

The correspondence between the two geologists continued even during Obruchev's vacation (Fig. 6). They exchanged literature with each other, discussed some specific details but also shared their plans for the Summer. In Bad Ems, Obruchev stayed until 2 June 1899, from there he travelled to Eifel, Sieben- and Vogelgebirge (possibly meant Vogelsberg) to learn about basalts, trachytes, porphyry and melaphyrs. From Germany he and his family planned to travel to Switzerland, thereafter, visit the Brenner Railway in South Tyrol, Munich, and the Ore Mountains on the way to Berlin, where he attended the Seventh International Geographical Congress²⁰, with a talk on "Orography and Tectonics of Transbaikalia" (Letter 23). From the postcards sent by Obruchev, we found out that he changed his travel route and went from Berlin to Vienna before the congress (Letter 25). Obruchev arrived in Vienna on 19 September 1899 and probably met with Suess on the next day. He didn't stay long in Vienna and left to Pest²¹ on 21 September 1899. In Pest through mediation of Suess, Obruchev met Hungarian geologist and geographer Lajos Loczy²², who undertook expeditions to Asia. From Pest, Obruchev returned to Berlin on 27 September 1899 (Letter 26). The Seventh International Geographical Congress in Berlin took place between 27 September and 4 October 1899. We don't know how long Obruchev stayed in Berlin but the next

available for us letter from him was sent on 28 September / 10 October 1899 from St. Petersburg (Letter 27). In his letter Obruchev sent literature and maps of Transbaikalia, a resume of the geographical congress, drafts of China reports, and mediated meeting between Suess and D. A. Klementz²³ (Letter 27). At the end of 1899, Suess's wife passed away. Obruchev expressed his condolences in his letter from 4 January 1900 (Letter 29). However, he continued in his letter with discussions on Asian geology and expeditions of other geologists and geographers. In August 1900 Obruchev visited "The Exposition Universelle" in Paris and later on possibly also visited Suess in Vienna. He wrote about his experience to Suess from Paris

:

« Hier in Paris konnte ich leider keinen einzigen von meinen bekannten oesterreichischen Geologen begrüßen, weder Ihren Sohn, noch Prof. Diener²⁴ und Loczy. Auffallenderweise ist der Congress nicht sehr belebt – viele Geologen fehlen – und die Wunder der Ausstellung verursachen, dass die Sitzungen auch nicht von allen Anwesenden besucht werden. Es sind auch wenig interessante Vorträge gewesen und ich bin ziemlich enttäuscht was Inhalt und äusserliche Ausstellung des Congresses anbelangt... »

« Here in Paris, unfortunately, I could not welcome a single one of my well-known Austrian geo-

²⁰ Seventh International Geographical Congress took place in Berlin from 27th September to 4th October in 1899.

²¹ Interestingly, Obruchev uses Pest, although Pest, Buda and Obuda were unified into Budapest in 1873.

²² Lajos Loczy (1849–1920) was a Hungarian geologist and geographer, who participated in East-Asia Expedition between 1877 and 1880 under the supervision of Graf Béla Széchenyi.

²³ Dmitri Alexandrovitch Klementz (Russian: Дми́трий Алекса́ндрович Кле́менц, 1848–1914), was a Russian anthropologist and archaeologist, who participated in the expedition to Turfan (Xianjiang, China).

²⁴ Carl Diener (1862–1928) was an Austrian geologist, geographer, and paleontologist. His well known for stratigraphic and faunistic studies in the Alps, most prominently for proposing Anisian Stage in Middle Triassic.

logists, neither your son, nor Prof. Diener and Loczy. Noticeably, the congress is not very lively – many geologists are missing – and the wonders of the exhibition hamper participants to attend the sessions. There have also been few interesting lectures, and I'm rather disappointed with the content and overall organization of the congress... >> – V. A. Obruchev to E. Suess, Paris 23 August 1900 (Letter 34).

In this letter, Obruchev addressed for the first time Suess as a “friend” and “teacher”:

« *Die Rückreise geht Mitte September über München und, vielleicht, Wien, wo ich dann wieder die grosse Freude haben werde, Sie, verehrter Freund und Lehrer, zu begrüßen...* »

« The return journey will be in mid-September via Munich and, perhaps, Vienna, where I will again have the great pleasure of greeting you, dear friend and teacher... » – V. A. Obruchev to E. Suess, Paris 23 August 1900 (Letter 34).

Professor Obruchev

In the next year, Obruchev, under mediation of I. V. Mushketov, was selected as professor of geology in a newly founded Technological Institute of Emperor Nicholas II in Tomsk²⁵. He wrote regarding his professorship and change of his study area to Suess and asked for his informal approval:

« *...im Herbst bleibe ich wahrscheinlich in Tomsk stecken, wohin man mich als Professor der Geologie beim neugegründeten Technologischen Institut beruft; ich habe zugesagt und sage nach diesem Sommer Abschied der sumpfigen Taiga von Olekma-Witim, denn ich will mich Centralasien widmen und den Tien-Shan erforschen...Ich glaube, dass Sie diesen Entschluss billigen werden?* »

« ...in Autumn, I will likely get stuck in Tomsk, where I have been appointed as a professor of geology at the newly established Technological Institute. I have accepted the position and will say farewell to the marshy taiga of Olekma-Vitim after this Summer because I want to dedicate myself to Central Asia and explore the Tien-Shan mountains... I believe that you will approve this decision? » – V. A. Obruchev to E. Suess, St. Petersburg 8/21 April 1901 (Letter 39, p. 1).

In the years 1901 to 1912, Obruchev worked as dean and professor at the Technological Insti-

tute of Tomsk, where he organized and established mining faculty, held lectures on physical geology, petrography, field geology, and geology of mineral deposits. Furthermore, he organized expeditions to Dzungaria and conducted several exploration studies on gold deposits. The idea of studying Dzungaria, Altai, and Tian-Shan was already born during Obruchev's stays in Vienna and discussions with Suess. Obruchev would later call Dzungaria as “*The Gates to China*” (Обручев, et al., 1958). Despite of the responsibilities Obruchev faced, he never forgot about his old friend, mentor, and professor. Obruchev sent a postcard to Suess from a train to Siberia, congratulating him to his 70th birthday (Letter 40). The next available letter to us at the Geological Archive of Vienna is from 8/21 September 1911, sent from Tomsk. Unfortunately, letters between 1901 and 1911 from Obruchev do not exist or were lost. In his letter from 1911, Obruchev congratulated Suess with his 80th birthday and wrote about his personal situation in Russia:

« *...Sie hätten schon lange das Recht den Lebensabend im Kreise Ihrer Lieben ruhig zu geniessen ohne sich den Kopf wegen des Antlitzes unseres Erdballs zu zerbrechen, auf dem so viele Ungerechtigkeiten geschehen. Die Verhältnisse in Russland geben ihr das Recht, so zu denken, aber ein Forscher findet eben in der Betrachtung der Naturereignisse Trost und Erholung von der Aergernissen und Niederlagen im Lebenskampfe. Dieses fühlte ich besonders in diesem Sommer, als ich fern von Tomsk war, selten Zeitungen las und ganze Tag die hässliche russische Gegenwart vergessen konnte.* »

« ...for a long time have you had the right to peacefully enjoy your retirement surrounded by your loved ones without worrying about the Face of the Earth, where so many injustices occur. Current conditions in Russia give you the right to think this way but a researcher finds solace and comfort in observing natural events, escaping from the annoyances and defeats in life's struggles. I felt this particularly during this summer when I was far from Tomsk, rarely reading newspapers, and being able to forget about the ugly Russian reality throughout the whole day. » – V. A. Obruchev to E. Suess, Tomsk 8/21 September 1911 (Letter 41, p.1-2).

²⁵ Nowadays: National Research Tomsk Polytechnic University (TPU), a technical university in Tomsk, Russia.

Expulsion and retirement of Obruchev

The publicity of Obruchev and his publications in liberal-progressive newspaper “*Siberian Life*”²⁶ drew attention of the government. Obruchev’s eldest son²⁷ was expelled from the Tomsk Polytechnic University and even had to leave Tomsk. Obruchev himself was requested to leave the position as professor:

« *Mir befiehlt das Ministerium in nächster Zeit in eine andere Schule überzugehen, weil ich nicht regierungsfreundlich gesinnt bin und einen schlechten Einfluss auf meine Kollegen ausübe, speziell der Vermehrung akademischer (in russischem Sinne) Jünglinge unter den Studenten im Wege stehe.* »

« I was ordered by the ministry to change the school in the near future, as I am not supportive of the government and exert a negative influence on my colleagues, particularly hindering the proliferation of academic (in the Russian sense) youth among the students. » – V. A. Obruchev to E. Suess, Tomsk 8/21 September 1911 (Letter 41, p. 3).

Obruchev was however not the only known professor who was affected by the government policy. The series of expulsions of liberals and freethinkers during the years of 1911 and 1912 are known as “*The Kasso Case*”²⁸. Despite political and personal problems, Obruchev still maintained correspondence with Suess and sent him his results on Siberian gold deposits (Letter 41). However, expulsion from the university and Tomsk heavily undermined health condition of V. A. Obruchev. He wrote to Suess from Nervi by Genoa²⁹ on 28 April 1913, that he couldn’t answer his letters because of pneumonia and influenza. Obruchev left Russia, with his wife and youngest son³⁰ and travelled south, to the warmth of the Mediterranean Sea to complete his healing. They travelled through Vienna and Austria but did not

meet Suess, as ice-cold weather conditions could weaken Obruchev’s health (Letter 42). Letter 42 from 28 April 1913 is the last letter available to us at the Geological Archive of Vienna. It is however not the last letter in the correspondence between Obruchev and Suess. From the published letters and works of Obruchev in “*Selected Works. Volume 6*” (“*Избранные Труды. Том 6*”) published by his eldest son Vladimir Obruchev, we know that Suess sent a postcard to Obruchev on 17 January 1914. We can therefore assume that the correspondence lasted at least until the end of January 1914. Eduard Suess passed away on 26 April 1914 and with his death, ended the correspondence between the two geologists.

Obruchev, despite of forced retirement and expulsion, continued to work on his results from previous expeditions and develop new ideas and theories in active tectonics until the October Revolution in 1918. For active tectonics or tectonics of recent geological time, Obruchev introduced a new term – *neotectonics*. Moreover, during this period, he wrote one of his famous science fiction novels “*Plutonia*”. After the revolution, Obruchev was reinstated as professor at the Taurida National University³¹ in Simferopol, Crimea (Обручев, et al., 1958).

In following years, Obruchev worked as professor at the Moscow Mining Academy³², where he complemented and continued to develop the idea of the ancient vertex of Asia and importance of *disjunctive dislocations* based on the work of E. Suess “*The Face of the Earth*”. Moreover, Obruchev played an important role in establishment of the permafrost institute in the Soviet Union. The remarkable scientific contribution and popularization of Earth Sciences through science fiction novels such as “*Sannikov Land*” and “*Plutonia*”, made V. A. Obruchev one of the most influ

²⁶ *Siberian Life* was a Russian daily newspaper published in Tomsk between 1897–1919 and distributed in Siberian cities.

²⁷ Vladimir Vladimirovich Obruchev (Russian: Владимир Владимирович Обручев, 1888–1966) was an eldest son of V. A. Obruchev who studied geology at Tomsk Polytechnic University. He participated in his father’s expeditions to Dzungaria and later on to Mongolia and Altai. Moreover, he published a multi-volume work of selected publications and biography of his father V. A. Obruchev.

²⁸ The Kasso Case was a series of forced resignations of liberal professors and students from Russian universities at the hand of minister of education Lev Kasso in 1911.

²⁹ Nervi is nowadays a city district of Genoa, Italy.

³⁰ Dmitry Vladimirovich Obruchev (Russian: Дмитрий Владимирович Обручев, 1900–1970) was a Russian paleontologist and the youngest son of V. A. Obruchev.

³¹ Nowadays: Vladimir Vernadsky Taurida National University, currently located in Kyiv, Ukraine.

³² Moscow Mining Academy was renamed several times. Nowadays, it is National University of Science and Technology (MISIS) located in Moscow, Russia.

ential geologists of the 20th century (Обручев, et al., 1958). Despite of his extraordinary scientific career and tremendous amount of work, Obruchev didn't forget about his friend and mentor E. Suess and in 1937 he published his biography. In 1956, V. A. Obruchev passed away in Moscow at the age of 92.

The Face of the Earth

The Face of the Earth (German: "Das Antlitz der Erde") is the multi-volume work of Eduard Suess, his *opus magnum*, and his legacy. It is based on the theory of contraction and covers the geology of the entire Earth. *The Face of the Earth* embodies the geological knowledge of his time. Suess didn't collect the geological data outside of the Alps, instead, he corresponded with numerous scientists and geologists, who shared with him data they collected. It is divided into four volumes, in the first volume Suess discussed the formation of the continents and mountain ranges, lets the reader imagine the Earth without its atmosphere and hydrosphere. Imagination is the key element in reading his work. Suess also discussed the importance of dislocations and most importantly of

regressions and transgressions, which shaped the face of the Earth. Volume two is the synthesis of observations of the Pacific and Atlantic Oceans, followed by descriptions and analysis of Palaeozoic, Mesozoic, and Tertiary Seas. The third volume is dedicated to Eurasia and Northern Europe. In writing of this volume, an important contribution was made by Russian geologists, particularly by V. A. Obruchev, who was the main correspondent and support in unravelling the geology of northern Siberia and eastern Asia.

The main questions discussed by Obruchev and Suess were the formation of the Asia and Lake Baikal. The area around Lake Baikal was referred to as *The Amphitheatre of Irkutsk* (German: *Das Amphitheater von Irkutsk*). It is however unclear, which area exactly the *amphitheatre* covers. Based on the map from Volume III/1 (left image in Fig. 7), the area comprises regions east and south of Lake Baikal, followed by regions around Yenissei and Angara rivers in the North (shaded areas on the left image in Fig. 7). However, based on the overview map of the Vertex of Eurasia from Volume III/2 the *amphitheatre* covers only areas west / northwest of Lake Baikal.

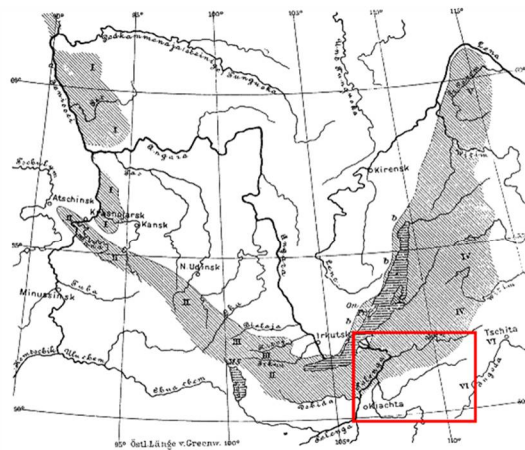


Fig. 7: Left image: „The Amphitheatre of Irkutsk” from „Das Antlitz der Erde”, p. 16. Red rectangle represents an approximate location of the map on the right. Right image: Geological map with corresponding legend sent from Obruchev to Suess (Map 15).

The idea or geological evolution model of *The Ancient Vertex* (German: *Der alte Scheitel*) was firstly introduced by Czerski. Suess and Obruchev

would continue to develop and complement the idea of an *ancient vertex*. For Obruchev, it remained as one of the main scientific research

topics. The Ancient Vertex of Eurasia comprises large areas south of Lake Baikal, Gobi Desert, Turpan Depression (Fig. 8), Tian-Shan, and Nan-Shan Mountain systems. All of those regions were studied by V. A. Obruchev and other Russian geologists and geographers. The *vertex*, based on

Suess, forms the primary Precambrian basement of Eurasia, around which mountain folds gradually were formed and therefore the entire continent expanded. Since the Cambrian period it has undergone extensive fracturing through *disjunctive dislocations*³³.

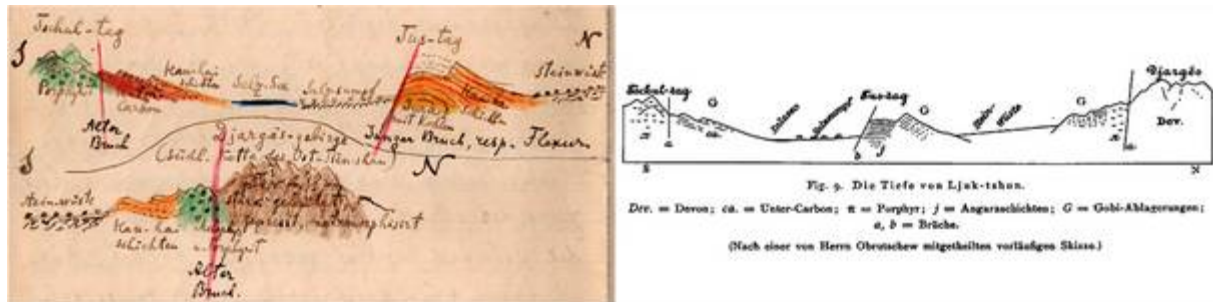


Fig. 8: Geological profile of the Turpan Depression, eastern Tian-Shan. Left image: original profile by Obruchev (Letter 6). Right image: Obruchev's profile published in "Das Antlitz der Erde", volume III/1, p. 214.

As acknowledged by Suess himself in the "The Face of the Earth" Obruchev has contributed significantly to the writing and editing of the volume III/1:

« Hier habe ich mit herzlichem Danke zu erwähnen, dass Hr. Obrutschew mich nicht nur durch viele briefliche Mittheilungen erfreut, sondern mich auch bei der Ausarbeitung der nachfolgenden Seiten bei längeren und wiederholten Besuchen mit seinem persönlichen Rathe so sehr unterstützt hat, dass Alles was hier über den Bau Sabaikalien's gesagt werden soll, so weit es überhaupt Lehrreiches enthalten mag, diesen Mittheilungen und Rathschlägen zuzuschreiben ist. »

« Here I must sincerely thank Mr. Obruchev, not only for numerous letters but also for providing me with invaluable personal advice during his prolonged and repeated visits while working on the following pages. Everything that is to be said here about the structure of Transbaikalia, as far as it may contain any informative content, is to be acknowledged to these correspondence and recommendations. » – Eduard Suess in „Das Antlitz der Erde“, Volume III/1, p. 60.

Conclusion and final remarks

The correspondence between V. A. Obruchev and E. Suess lasted for 23 years (1891–1914). Obruchev's letters from the Geological Archive in Vienna, give us extensive insights in their scientific exchange. They exchanged with each other literature, reports, collected data, maps, sketches, geological profiles, photographs, and even samples in form of rocks and fossils. Their correspondence facilitated development of new ideas and discussions, enabling them to analyse the same data from different perspectives. Moreover, it resulted in a joint publication and complemented their own works and publications.

For the young Obruchev, Suess was a mentor, professor and possibly even the "window to Europe"³⁴. For the much elder and well-established Suess, Obruchev was a guide into vast and unexplored territories of Siberia and Asia. Moreover, Obruchev would help Suess to navigate through tremendous amount of Russian literature

³³ As noted by Şengör, 2015, *disjunctive dislocations* represent faults. Suess interpreted them as normal faults, however, those are now known to be thrust faults.

³⁴ "Window to Europe" is a metaphor used for the city of Saint Petersburg, highlighting its unique position and access to the Baltic Sea. We used this term for Eduard Suess, as we think acquaintance with Suess, helped Obruchev to build his scientific career and reputation beyond the Russian Empire and USSR.

and keep him always up to date. Obruchev and Suess have also mediated new contacts to each other, such as Lajos Loczy to Obruchev and Dmitri A. Klementz to Suess.

In light of extensive scientific exchange between the two geologists, we can also see how their personal relationship developed over the time. In the first years (1891–1898) of their correspondence, Obruchev wrote to Suess in a very formal way and the content of the letters was mostly geological data and descriptions. In the following years (1898–1901), Obruchev met Suess in person. From this point of time, he shared his vacation plans and greeted Suess's family in his letters. In the last years of their correspondence (1913–1914), Obruchev addressed Suess as “*Hochgeehrter Meister und Freund*” and “*Hochverehrter und lieber Freund*”, which can be trans-

lated as “*Highly esteemed Master and Friend*” and “*Highly esteemed and dearest Friend*”. During this period, Obruchev, together with geological data, shared personal problems and struggles with Suess. Obruchev contributed considerable amount of data and knowledge to Suess's opus magnum “*The Face of the Earth*”, particularly to the chapters regarding the geology of Siberia and Asia. Interestingly, although “*The Face of the Earth*” gained considerable popularity in Europe, it has never been published in Russia or in the Russian language. Was Suess's work truly groundbreaking, despite of its major flaws, as noted by Şengör in 2015? Perhaps not, but it's unprecedented contribution to the foundation of modern geology is undoubtful, especially in terms of emphasizing the importance of scientific exchange and collaboration.

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Eduard Suess' concept of eustatic sea level movements during his research in the Moldanubicum in Lower Austria: The cross-section Eggenburg-Horn

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Abstract. At the Archive of the History of Geology at the University of Vienna exists a partial estate of Eduard Suess, the first professor for Palaeontology and Geology at the University. A very interesting, drafted and coloured document is a cross-section between the medieval towns of Eggenburg and Horn, 60 km north of Vienna. The creation of this cross-section can be dated back to the years between 1859 and 1862. Suess also mapped the sediments of the "Eggenburg Sea" in the area (Tertiary, Miocene age). The names of the fossils deposited in the "Eggenburg Sea" were listed by Eduard Suess during his fieldtrips in this area. They bear witness to the theory of sea level movements – eustatic sea level movements – developed by Eduard Suess. Here he formulated his first ideas about an ancient sea, later named Tethys.

Keywords: Eduard Suess – eustatic sea level movements – Geology of Lower Austria – Bohemian Massiv – hand-crafted cross-section

Editor's Note: All map sheets open from right to left. Sheet 1 is on the right-hand side (east), the last sheet (18) is on the left-hand side (west). The author has numbered the individual sheets of the cross-section from right to left.

Introduction

Eduard Carl Adolph Suess was born on 20th August 1831 in London and died on 26th April 1914 in Vienna. He was one of the well-known geologists of the time. With his important scientific publications such as *Das Antlitz der Erde* – "The Face of the Earth" (Suess, 1883, 1888, 1901, 1909) he laid the foundation of the history of the Earth at the beginning of the 20th century.

During the new organisation of the estate of Suess in the Geological Archive the author discovered the hand painted cross-section. It gives us a detailed geological introduction to the area of Eggenburg and Horn and to the history of the local geology. In his field research in northwestern Lower Austria, Suess concentrated on paleontol-

ogical and geological studies. Part of these studies were located between the two towns of Eggenburg and Horn. The geological setting belongs to the area of the Moldanubicum, a part of the Bohemian Massive. Between Eggenburg and Horn existed the "Eggenburg Sea", sediments of Miocene age and the Bunte Serie with metamorphic sediments.

In the following discussion the single sheets of the cross-section are presented in connection with Eduard Suess' publication of the Imperial Academy of Science in Vienna, his comments in his *Erinnerungen-* (Memories) and in his book *Das Antlitz der Erde*. And finally, the result of these field studies in the Bohemian Massive led Suess to a new theory, the eustatic sea level movement, today known as transgression and regression.



Fig. 1. Portrait of Eduard Suess (1913). Geological Archive. Inv. Nr. GA 1. Size: 11,3 x 15,3 cm.

Geognostic map of a part of Lower Austria

The following geological map of the area (Fig. 2) with an overview of the location was the basis of the discussion in the proceedings of the Imperial Academy of Science by Eduard Suess (Suess, 1866, p. 91). Suess used the map during his fieldtrips in the area of Eggenburg and Horn. This map was the first geological map for this area done by the geologist Johann Czjzek (1805-1855).

The Bohemian Massiv and the Moldanubicum show the typical reddish colours and the Bunte Serie with its metamorphic sediments, such as marble, quartzite, graphite shists and amphibolites which are crossing the Moldanubicum in black strips from north to south. Green and yellow colours on the right side – east – document the sediments of the Vienna basin. A very unique part of the map are the cross-sections surrounding the geological map, giving an insight to the rock formations.

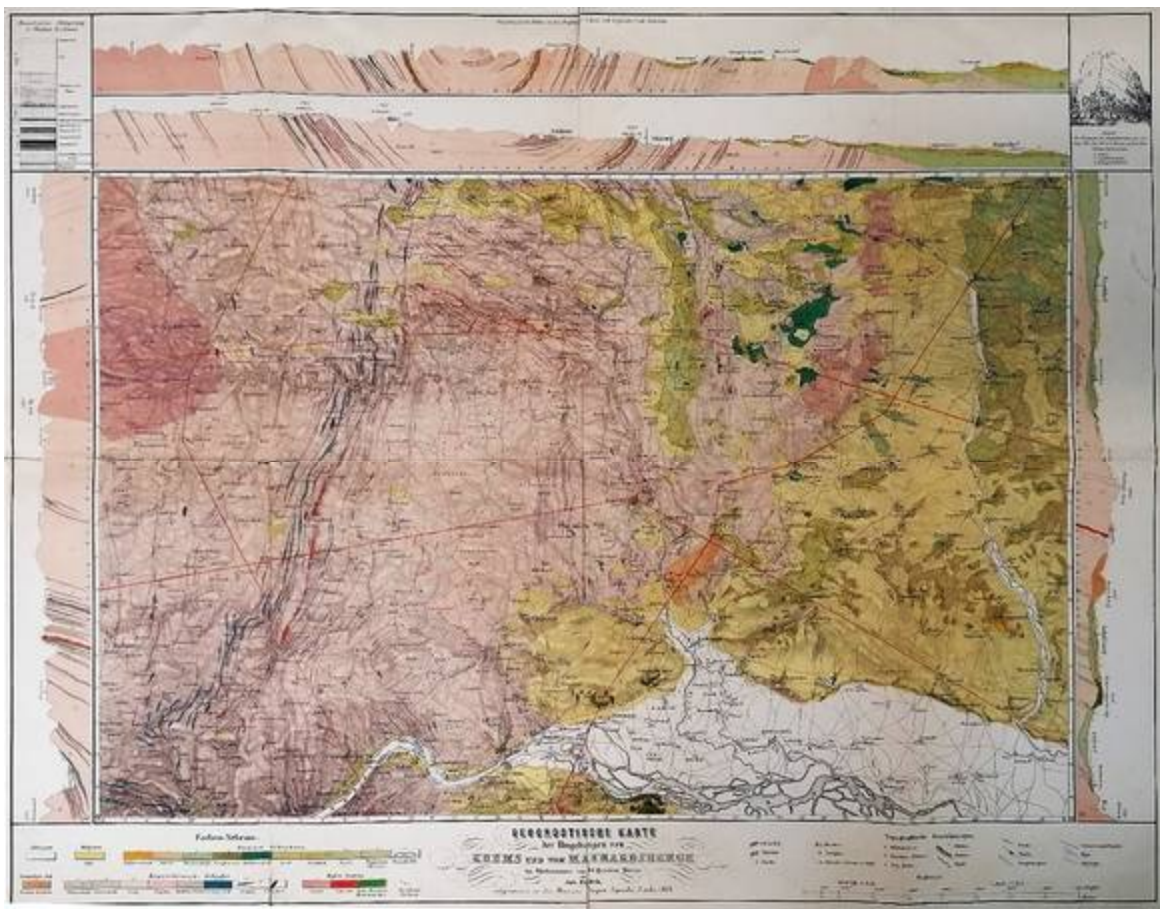


Fig. 2: Johann Čzjzek (1849), Geognostische Karte der Umgebungen von Krems und dem Mannhartsberge (1848). Geological Archive, Inv. Nr.: KS 1/ L 4.

The cross-section Eggenburg-Horn

The Eggenburg-Horn cross-section, drawn by Eduard Suess with watercolors and black ink, has a total length of 433.5 cm and consists of 18 individual sheets of strong, smooth paper with these dimensions: height 39.2 cm and a variable width of each from 22.5 to 24.5 cm.

The sheets are bound together with strips of linen, so that this cross-section also held up well during the field excursions in the Eggenburg area

that Suess made with his students and colleagues.

In the Geological Archive exists a document about the excursion to Eggenburg in Cabinet 1, Box 20. Eduard Suess had created a sheet with the date of the excursion and the signatures of the participants. 21 students und interested people took part in this impressive excursion. The author was able to decipher the signatures of 19 participants (Fig. 3).



Transcription:

*Theilnehmer an einem Ausflug nach Eggenburg.
3.-6 April 1863.*

[participants on the excursion to Eggenburg]

Seemann, Hörnes, Stiny, Wolf, Hochstetter, A-tisching, Goldschmidt, Peters, Lepron, Prenner, Suess, Karrer, Kornhuber, Lorenz, Hohenegger, Wolfinau, Sommeruga, Hoffer, Peyritsch

[Destinations]:

3. Freitag 7 Uhr Fahrt nach Horn

[3. Friday trip to Horn by train]

Samstag Horn nach Eggenburg

[Saturday Horn to Eggenburg]

Sonntag Calenderberg Gauderndorf

[Sunday Calenderberg Gauderndorf]

Montag Zogelsdorf, Burg Schleinitz, Maissau Rück-fahrt

[Monday Zogelsdorf, Burg Schleinitz, Maissau re-turn of the trip]

Fig. 3. Eduard Suess: Participants on an excursion to Eggenburg. 3.-6 April 1863. Geological Archive, Cabinet 1, Box 20. Size: 34,5 x 21 cm.

The creation of the cross-section Eggenburg-Horn can be dated back to the years between 1859 and 1862.

In his memories, published posthumously in 1916, Suess mentioned that he was studying the area in the surroundings of Eggenburg:

“The free weeks of the summers of 1860 and 1861 were devoted to studying the former shores of the extended Mediterranean Sea in the sunny wine-growing region that accompanies the edge of the Bohemian-Moravian

*Mountains from Retz to the Danube.*¹ (Suess, 1916, p. 137).

In 1866 Suess published a sketch of the cross-section from the western slope of the Vitus Berg via Eggenburg in a westerly direction to a prominent point, Galgenberg near Horn (sheet 16, 17) in the session reports of the Imperial Academy of Sciences in Vienna (Suess, 1866, board 1). Here Suess mentioned that between 1859-1862 he determined the Horn layers with the barometer and had them calculated in Vienna by the paleontologist and surveyor Ferdinand Stoliczka (1838-1874).

On the first sheet (= reverse side of the colored cross-section) of the original, the heading in black ink reads: "Eggenburg-Horn" and an additional

note done by the geologists Leopold Kober (1883-1970) and Alexander Tollmann (1928-2007):

Cross-section drawn and labeled by Eduard Sueß. Pencil inscription by Leopold Kober. Alexander Tollman.

*Explained in the 1860s*².

On the 3rd sheet (Fig 4) of the cross-section the colours of the individual rock layers are described below the graphic representation of the view from Eggenburg:

Sand – yellow-orange, Tegel – blue, Granite (basement) – red, limestone – green

The color violet stands for mica schist and is drawn for the first time on sheet 6; it is the dominant colour of sheets 7-12.

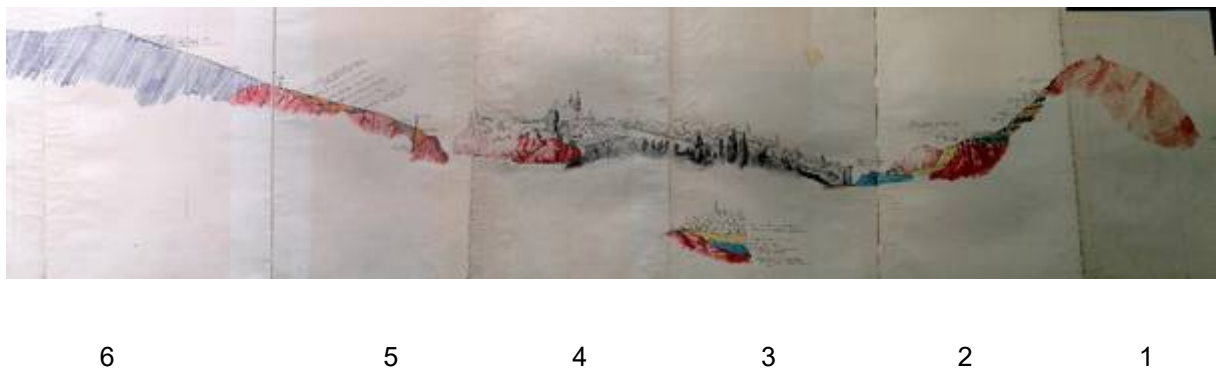


Fig. 4: Cross-section Eggenburg-Horn, sheet Nr. 1-6

In the following is a description of each sheet of the cross-section. The rock sequence of sheets 8-11 is not discussed as only purple-colored rocks, indicating mica schists with no obvious rock alteration and observation is present.

In his first review in the session reports of the Imperial Academy of Sciences Suess mentions that no noteworthy observations can be seen from Horn to the east.

*There are opposite slopes with similar tertiary strata which occur for a distance of several hours*³ (Suess, 1866, p. 87).

The distance between Eggenburg and Horn is 13 km.

The description of the path and the details of the fossil finds at the specific locations are recorded in great detail. His knowledge of the fossils

¹ Die freien Wochen der Sommer 1860 und 1861 waren dem Studium der einstigen Ufer des erweiterten Mittelmeeres an dem sonnigen Weingelände gewidmet, das den Rand des böhmisch-mährischen Gebirges von Retz bis an die Donau begleitet.

² Profil gezeichnet und beschriftet von Eduard Sueß. Bleistift-Beschriftung von Leopold Kober und Alexander Tollmann. Ausgeführt in den sechziger Jahren des 19. Jahrhunderts

³ Gegen Osten an jenseitige Abhänge, wo auf einer Strecke von mehreren Stunden, ähnliche Tertiärschichten vorkommen.

is worth noting. Eduard Suess is also a successful paleontologist. He states that the fossil finds provide clear evidence of the existence of a former sea.

On the first sheet of the cross-section east of Eggenburg, the Vitus Berg "Vitus Berg Ost" is shown, the red color stands for the granitic rock. From the Vitus Berg downwards in a westerly direction (sheet 2), the horizontally parallel layer sequences up to the "Basement of the Gerichtslehner" in the appropriate colors: blue-ochre, green and orange. At the base of the Vitus Berg near the "Gerichtslehner" lies the "marl with Lucina" colored in blue, above which Suess describes the following layers from the footwall to the hanging wall with significant fossils:

Panop. zahlreich aufrecht, O. digital., Pect., Mytil., Tapes Basteroti, sehr viel Pema [Panopea numerous upright, Ostrea digitalina, Pectunculus, Mytilus, Tapes basteroti, very much Pema; yellow].

Above that is the yellow-orange layer with the fossils:

Knollen mit Tell. Zonaria, Tumida, Turrit., Tr. patul.

[tubers with Tellina zonaria, Tumida, Turiella patula].

Today this corresponds to the Gauderndorf formation (Steininger, Roetzel, Şengör, 2015, p.24). The green and orange series are now part of the Zogelsdorf formation. The following fossils were deposited at the base of this formation (green color):

Nullip. Kik [Nulliporen Limestone, green].

Venus Pectuncul. [Venus Pectunculus].

Nullip. [Nullipors].

Hart. Lichtbraun Kik mit vl Quarz

[Hard light brown lime with lots of quartz; green].

große Pectines, große grem. Stke.

[large pectines, large grem. stone cores; yellow].

Serpulitenkik [Serpulitenkalk; green].

tax and Grus [Stones and Grus; yellow].

Serpulitenkik [Serpulitenkalk; green].

St.u. Grus [Stones and Grus; yellow].

Locker, groß. Blöcke u. Gran. darin Groß. Pectunculus

[Loose, large blocks of granite in Great Pectunculus; green],

Sand, T. Hörnesi selten, Pecten Bank und P. Malvinae, R3

[Sand, Terebratula Hörnesi, Pecten Bank, Pecten Malvinae. R3; yellow-orange].

Lockrer Kik mit vl Granit Trüm, T. Hoernes, Balan., Echinol

[Loose limestone with lots of granite debris, Terebratula Hörnesi, Balanus holgeri, Echinolamp. Linkii].

Above this sequence of layers, the granite base rock begins again, leading to the summit of Vitus Mountain.

On the 3rd and 4th sheet, Eduard Suess recorded the distinctive buildings and structures of the town of Eggenburg and the medieval town wall.

In the session reports of the Imperial Academy of Sciences (Suess, 1866, p. 103), Suess mentions the basement below the Gasthof zur Sonne lying 15 feet below the pavement with the fossils Mytilus Haidingeri, Ostrea lamellosa and Mytilus debris.

The 5th sheet indicates granitic subsoil. Above there are small sequences of sediments and tegel in the colors yellow-orange for "sandstone" and blue for Tegel.

Here Suess notes the fossils contained in the sedimentary rocks from the footwall to the hanging wall:

Ostrea longirostris, Mytilus, Cerithium plicatum, Tellina, Venus, Cerithium margaritaceum und plicatum, Lutraria sanna, Tellina multilamellata, Lamna, Mylobatis, Halitherium.

These fossils are indicative of the stratigraphic units today of the Kühnring Subformation and Burg-Schleinitz Formation.

The 6th sheet, west of Eggenburg, is shown in the uniform color violet for mica schist and a note of the fossils contained in the rock Tegel in the color blue:

T. Hoernes, Korallen, Pectl. Fichteli, [Terebratula hoernes, corals, Pectunculus fichteli]

Myt. Haidingeri, Turr. Cathedral., Panop. Meradi, Cardita crasia, Pinna, u.s.w. [Mytilus

haidingeri, Turritella cathedralis, Panopea menardi, Cardita crasia, Pinna, ect.].

Today, these sediments also belong to the Burg Schleinitz Formation.

The cross-section is continued to the west with violet watercolor paint in oblique lines, characteristic of mica schist, up to the settlement of Maria Dreieichen (7th - 13th sheet). It is a rock sequence with no further discussion or evidence of any other geological event.

In the publication of the session reports of the Imperial Academy of Sciences (Suess, 1866, p. 103) Suess presents the rock sequence in minute detail with the fossils found.

This is again followed by the granitic rock in red watercolor paint, which piles up in the direction of Horn to form the Galgenberg (15th - 18th sheet) and appears as the basement near the town of Horn.

Eduard Suess did not date this hand-colored cross-section, but in his book "Erinnerungen" he gives the period between 1860 and 1861 when he went to Eggenburg for intensive research (Suess, 1916, p. 137).

He summarizes the nature observations around Eggenburg, which led him a few years later to the conclusion and a new thesis, that the observed height conditions and the different sea deposits in this area would not be possible through the raising of a land, but only through the lowering of a water level.⁴

"Only fifteen years later [...] I dared to express this view publicly. First all the facts, such as the altitude, the fossil Conchylia, etc., had to be traced as precisely as possible. Today it is known as the doctrine of the eustatic sea level movements. This was established in the Eggenburg area". (Suess, 1916, p. 139).

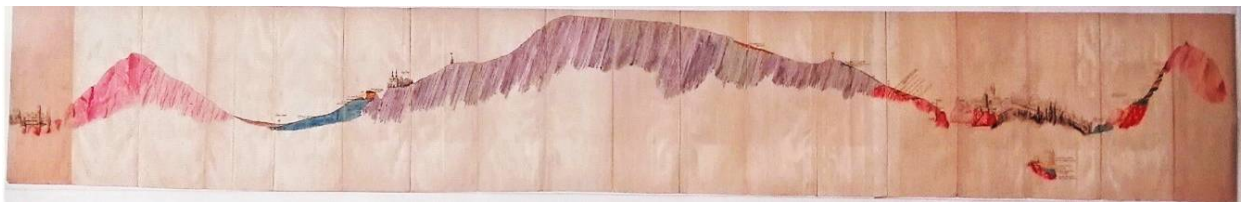


Fig. 5: Copy of the Cross-section Eggenburg-Horn. Geological Archive, Inv. Nr. GA 39. Size:433.5x24cm. (Hamilton, 2021).

A short description of these Eggenburg strata is already given in Franz Ritter von Hauer's work "Geologische Uebersichtskarte der österreichischen Monarchie" from 1869 (the punctuation and arrangement of the text have been retained here):⁵

Eggenburg, layers of. Neogene.

1866 Suess, Akad. Vol. 54, Part I, p. 113. -
Eggenburg, small town in Austria below the

Enns, district of Ob. Mannh. Berg [Mannhartsberg], OSO. of Horn.

The fourth and highest of the stages, counted from the bottom, into which Suess divides the Neogene Tertiary formations of the extra-Alpine Vienna Basin at the foot of the Mannhart.

It is divided into two limbs, the lower one of solid sandstone (Molasse sandstone) with

⁴ Zuerst mußten die Tatsachen, wie die Höhenverhältnisse, die fossilen Konchyliden u. a., so genau als möglich verfolgt werden [...]. Aber erst fünfzehn Jahre später, [...] durfte ich es wagen, diese Ansicht öffentlich auszusprechen. Heute nennt man sie die Lehre von den eustatischen Strandbewegungen. Im Gelände von Eggenburg ist sie geboren.

⁵ Eggenburg, Schichten von. Neogen.

Suess, Akad. Sitzungsab. Bd. 54, I. Abth., p. 113. – Eggenburg, Städtchen in Österreich unter der Enns, Kreis Ob. Mannh. Berg, OSO. von Horn.

Die von unten gezählte vierte und oberste der Stufen, in welche Suess die neogenen Tertiärbildungen des ausseralpinen Wiener Beckens am Fusse des Mannhart gliedert. Sie zerfällt in zwei Glieder, dessen unteres aus festem Sandstein (Molasse-Sandstein) mit Panopaea Menardi, Pholodomya, Solen u.s.w., und deren oberes vorwiegend aus Kalkstein, zum Theile Nulliporenkalk mit Pecten aduncus, Echinodermen, Terebratula Hörnesi u.s.w. besteht. Nach Suess ist dieser Nulliporenkalk nicht als ein Aequivalent des Leithakalkes zu betrachten, sondern über ihn erst würden der Schlier und über diesen die Vertreter der Marinschichten des Alpinen Beckens folgen, deren höchste Stufe der Leithakalk bildet.

Panopaea Menardi, Pholodomya, Solen etc., and the upper one predominantly made of limestone, partly Nullipore limestone with Pecten aduncus, Echinoderms, Terebratula hoernesii, etc. consists. According to Suess, this Nullipore limestone is not to be regarded as an equivalent of the Leitha limestone, but only above it would the Schlier follow and then the representatives of the marine layers of the Alpine basin, the highest level of which is the Leitha limestone (Hauer, 1869, p. 169).

Eustatic sea level movements

Suess explained the term “eustatic sea level movement” in his book “Das Antlitz der Erde” (The Face of the Earth) ⁶ (Suess, 1888, p. 680-681; 688):

The globe is sinking; the sea follows. But while the subsidence of the globe is localized, the subsidence of the ocean spreads over the entire wetted surface of the planet. A general negative movement occurs [...] and refer to this group as eustatic movements.

The formation of ocean basins causes episodic, eustatic, negative movements. [...]

The thick sediments of prehistoric times and the erosion of the mainland, which are in many places measure thousands of feet, show how significant these quantities were and are. There is a very slow but continuous filling of the oceanic areas, which must bring about a general displacement of the seas from their depths, and at the same time the transgression is facilitated by the progressive degradation of the mainland. The formation of the sediments causes continuous, eustatic, positive movements of the beach time.

Suess discussed the negative and positive movements of the sea level, today it is referred to as transgression and regression of the sea level.

Conclusion

The most impressive part of the cross-section Eggenburg Horn are the sheets Nr. 1 to 6 with the representations of the geological conditions and fossil finds.

Suess linked numerous discoveries of fossils with the geological settings. He had published these ideas at the session reports of the Royal Academy of Science in Vienna with the geological conditions. There he combined the findings of the two disciplines of paleontology and geology. The combination of these two disciplines led Suess to new and fundamental insights. The representations of the geological conditions around the Eggenburg area are evidence of these new theories. Also the excursions with his students added to his research.

The theory of eustatic (beach motion) sea level fluctuations arise from transgression and regression of shorelines as a sea floor elevation changes over geological time. Suess developed this fundamental theory during his geological excursions through the rolling hills of the Molasse area surrounding the town Eggenburg in Lower Austria. In his “Erinnerungen” (Memories) he describes how this theory was born and that the area surrounding the granite hills were not established through the raising of the land, they were developed by the sinking of the sea level and the fossils he found underline his theory

In essence, this fundamental idea of sea level movements in the geological record was born there in Eggenburg and is finally used as a widely accepted theory around the world.

⁶ *Der Erdball sinkt ein; das Meer folgt. Während aber die Senkungen des Erdballes örtlich umgrenzt sind, breitet sich die Senkung der Meeresfläche über die ganze benetzte Oberfläche des Planeten aus. Es tritt eine allgemeine negative Bewegung ein [...] und bezeichnen diese Gruppe von Bewegungen als eustatische Bewegungen.*

Die Bildung der Meeresbecken veranlasst episodische, eustatische, negative Bewegungen. [...]

Die mächtigen Sedimente der Vorzeit und die an vielen Orten nach tausenden von Füssen messende Abtragung der Festländer lehren, wie bedeutend diese Mengen waren und sind. Es findet ein sehr langsames, aber unausgesetztes Auffüllen der oceanischen Gebiete statt, welches eine allgemeine Veränderung der Meere aus ihren Tiefen hervorbringen muss, und zugleich wird die Transgression durch die vorschreitende Erniedrigung der Festländer erleichtert.

Die Bildung der Sedimente veranlasst ununterbrochene, eustatische, positive Bewegung der Strandlinie.

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Victor M. Goldschmidt, Vladimir I. Vernadsky and the Birth of Geochemistry

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Abstract. Geochemistry was founded almost simultaneously during the first half of the XXth century by V.M. Goldschmidt in Norway-Germany and V.I. Vernadsky in Russia-France. The life of these two prominent scientists is briefly described, as well as the fate of their geochemistries.

Keywords: Geochemistry – Ecology – V.M. Goldschmidt – V.I. Vernadsky – science history.

Geochemistry is now a most important, if not the most important branch of Earth and Planetary Sciences. This is notably illustrated by the success of the Goldschmidt conferences, jointly organized by the Geochemical Society (USA) and the European Association of Geochemistry, which assemble every year thousands of Earth Scientists, alternately in Europe and America.

The relations between Geology and Chemistry (hence the name Geochemistry) had been somewhat ambiguous since the early days of both disciplines. The father of modern chemistry, Antoine Lavoisier (1743-1794), who started his career as a geologist, was among the first to claim that mineralogy could not be advanced without chemistry. Another great chemist, Jöns Jacob Berzelius (1779-1848), saw no reason to separate both disciplines, making mineralogy and geology a subdivision of chemistry. In fact, these branches of science took rapidly their individuality, mainly because of the place where they were performed: open nature for geology and mineralogy, man-made laboratory for chemistry. They saw their respective development along separate lines, geology and mineralogy being reserved for naturally occurring substances, chemistry for those created by man. A somewhat flexible limit, as most substances apparently created by man already exist in nature or are found later through the progress of analytical techniques.

The turning point: the phase rule

Interestingly, a turning point occurred at the end of the 19th century, with the introduction of thermodynamics to the study of multicomponent systems. It relates physical parameters (pressure, temperature, entropy) to the conditions of formation of the different phases (minerals, rocks), defined by their chemical composition. First attempts had been done by Nicolas Leonard Sadi Carnot (1796-1832), a mechanical engineer in Napoleonic army, who thought that improving the efficiency of steam engine would be of great help to the army. Sadi Carnot published in 1824 a seminal book on the power of fire (Sadi Carnot, 1824). But he died soon from cholera, all his personal belongings or writings were destroyed by fear of contagion. This work of Carnot dealt with the theoretical analysis of heat flow in steam engines. It adumbrated what is now known as the second principle of thermodynamics. The first principle, which states the conservation of energy and defines the internal energy of a system as the difference between heat and the work exchanged by the system with its surrounding, was formulated only later in the 1830s. By the middle of the century the principles of chemical thermodynamics were then firmly established. It took twenty more years to find a possible application in Earth Sciences. This was done by a physicist of Yale university, Josiah Willard Gibbs (1830-1903), who wrote a

monograph titled "On the Equilibrium of Heterogeneous Substances", published by the Connecticut Academy of Science (Gibbs, 1874-1878). This work, which covers about three hundred pages and contains exactly seven hundred numbered mathematical equations, begins with a quotation from Rudolf Clausius that expresses what would later be called the first and second laws of thermodynamics: "The energy of the world is constant. The entropy of the world tends towards a maximum."

Among Gibbs seven hundred equations is a very simple one, named the phase rule. In a simplified form, it relates the number of chemical components (C) and mineral phases (P), depending on the degrees of freedom, namely the external variables (e.g., pressure and temperature) that can be changed independently without changing the system: $F = C - P + 2$ (2 stands for pressure and temperature). For instance, for a pure mineral phase (one component), $F = 2$, meaning that one can change both pressure and temperature without changing the system. The phase rule opened the possibility to connect chemistry (chemical components) and geology (minerals and rocks), a process which will be formulated as geochemistry. But Gibbs was an extremely rigorous man, discussing in a rather hermetic style the ultimate details of his reasoning. As a result, his writings are extremely difficult to be properly understood, and it took years before they were assimilated by fellow chemists and, even longer, by earth scientists.

The father and grandfather of geochemistry (Müller, 2014)

The first geology papers directly inspired by Gibbs theories make for many the birth of geochemistry. The best known articles were written in Norway by a young geologist, Victor Moritz Goldschmidt (1888-1947) (VMG), during the preparation of a thesis under the direction of the great petrologist Waldemar Christofer Brögger (1851-1940). The PhD thesis of Goldschmidt (Goldschmidt, 1911), dealing with contact metamorphism in the Kristiania (now Oslo) region, contains a first draft of his model. But the real publications, which clearly show the filiation with Gibbs by extending the phase rule to minerals, appeared a decade later, in a series of memoirs published by the Norwegian Academy of Sciences (Goldschmidt, 1923-1927). A complete list of V.M.

Goldschmidt publications can be found in the book by B. Mason (Mason, 1992), the most complete biography written to date (See also Glasby, 2006).

A common view in the West is that these publications mark indeed the birth of geochemistry, even if Goldschmidt himself did not use this name in his last book, published after his death by Alan Muir (Goldschmidt & Muir, 1954). But, at the same time, the name of geochemistry and a first outline of the new discipline had been published by a Russian scientist, Vladimir Ivanovitch Vernadsky (1863-1945). The most significant publication by Vernadsky is a book (Vernadsky, 1924), directly written in French after a series of invited lectures in the Sorbonne.

The key papers by Goldschmidt and Vernadsky, which brought to both authors instant celebrity, are practically contemporaneous. In a major paper published in 2014, Axel Müller attributes a distinct priority to Vernadsky, whom he called the "grandfather of Geochemistry", against Goldschmidt, the "father" (Müller, 2014). Such a conclusion is justified by the fact that Vernadsky is older than Goldschmidt by a generation, even if both died almost at the same date. Also, the work of Goldschmidt has been significantly influenced by Vernadsky. When he was a student in Oslo, the young Goldschmidt paid several visits to Vernadsky in Sint Petersburg. He exchanged with him a long series of letters (Müller, 2014), which show that both scientists, not only knew each other very well, but also that they had a mutual influence on their respective work. The first letter by VMG, written in German, is very formal, starting with "Very Honored Herr Professor" ("Hochgeehrter Herr Professor"). Goldschmidt thanks Vernadsky for having sent his publications to a young student. Then, the tone of the letters is more familiar, showing that both became rapidly good friends, especially after a visit of Vernadsky to Oslo in 1927.

In 1929, Goldschmidt was offered a professorship in Göttingen. He promptly moved to Germany with "his father, mother and the housemaid" (Müller, 2014). He continued his correspondence with Vernadsky, who then changed the language of his letters from French to German. In a letter dated June 18, 1931, Goldschmidt invited Vernadsky to visit him in Göttingen. He said that he had unfortunately no funding to pay an honorarium, but that he would be happy to have him as a guest in his

home. Vernadsky accepted gladly, in a tone which illustrates their friendship (“Sehr geehrter Herr College and Lieber Freund”, Very Honored Colleague and Dear Friend). They intended notably to discuss geochemical and biochemical problems, such as the carbon dioxide content of the oceans, the chemical composition of marine organisms, the radioactivity of geological materials, etc. (Müller, 2014). Vernadsky spent a few days in Göttingen, giving a series of lectures at the university. The correspondence continued to at least 1935, until both were taken by political problems, Goldschmidt forced to return to Norway, Vernadsky bothered by the dramatic situation in Ukraine and the coming war between Russia and Germany.

In short, “it is reasonable to propose that Vernadsky’s work initiated the turn of V.M. Goldschmidt towards geochemistry” (Müller, 2014). This does not avoid that both kept their independence, shown by the significant differences between “their” geochemistry. It can be supposed that their friendship was a way to support each other, at a time where most Earth scientists did lack the chemical background to understand the new discipline. But now comes a crucial question: how two geologists, one very young, the other somewhat older, educated as classical geologists, could know enough chemistry to understand the work of Josiah Willard Gibbs, at a time when their professors had not the necessary knowledge.

V.M. Goldschmidt’s familial situation

For Goldschmidt, who was a sort of “wonderkid” during his early years, it is clear that his chemical education was given to him by his father Heinrich Jacob Goldschmidt (1857-1937), a chemist at the Polytechnikum of Zurich (Switzerland). In fact, the familial situation of Viktor Moritz was rather complicated. Born to an unknown father, he had been adopted by Heinrich Jacob, who took great care of him and treated him as his own son. Many indications suggest that Victor Moritz biological father was a friend of the family, Victor Meyer (1848-1897). Since 1872, Victor Meyer, educated in Heidelberg and Berlin, was professor at the ETH Zürich. He was married with Hedwig Davidson, who gave him five daughters. The name of Hedwig’s father was Moritz Davidson. Then it might well be that the young Goldschmidt received his double name (Victor Moritz) from both his biological father and grandfather. Victor Meyer left Zürich shortly

before the birth of VMG, to become professor at Göttingen, then Heidelberg. But he suffered progressively from strong mental depression and committed suicide in 1897.

It can be speculated that it is because of this complicated situation that the Goldschmidt family left Switzerland, firstly to Göttingen (Germany) and finally to Oslo (Norway). Heinrich Jacob was named professor of chemistry at the local university. He remained in Norway until his retirement in 1929. The young Victor Moritz had then the education of a young Norwegian, mastering so rapidly the local language that, after few years, few could believe that he was not born in Norway. He found in Norway the ideal combination of good university education, notably under the great petrologist W. C. Brögger and, very close to his home, the ancient granitic rocks which will help him to develop his theories. His thesis work on the contact metamorphism of Oslo granites (which incidentally turned out later to be more low-pressure regional metamorphism), was defended in 1909, published two years later (Goldschmidt, 1911). Doctor at the age of 21, he wanted to have a permanent position in the local university. But his colleagues found him to be too young. Then Brögger did intervene in his favor, saying that “VMG will be known as a great geologist, even greater than me”. Not a small compliment from a person having himself a very developed ego! Then VMG received a call from Sweden, and the faculty reacted promptly, appointing VMG as ordinary professor, the youngest professor even in any Norwegian university. This honor notwithstanding, VMG left Oslo for Göttingen (Germany) a few years later, to the disappointment of many fellow Norwegians who were not far to consider the move as a passage to the enemy.

Vernadsky: Education in Paris

Vernadsky’s situation was more complicated. Born in Sint Petersburg in a wealthy Russo-Ukrainian family, V.I. Vernadsky studied mineralogy and soil science (pedology) at the imperial university of the town. In 1888, as was commonly done in Russia in those years, he visited several places in Europe, in order to do some work which later could lead to a Ph. D thesis in Russia. He first wanted to study crystallography with Professor Arcangelo Sacchi (1810-1893) in Napoli (Italia), but Sacchi was no longer active (Gumilevski, 1961).

Then he spent almost two years by the famous Paul Heinrich von Groth (1843-1927) in München (Germany), to be acquainted with the use of crystallographic instruments. The scientific work was interesting, but the life in Germany a bit too rigid for his taste. Like many young educated Russians of the time, he was attracted by the French literature and way of life. He asked Paul von Groth to recommend him to Ferdinand André Fouqué (1828-1904), Professor at the Collège de France in Paris, who was working on the theory and practice of the polarizing microscope. Fouqué answered with some delay to Von Groth recommendation, invited finally Vernadsky to come to Paris.

Vernadsky had there a very pleasant life, staying with his family in Passy. He used to walk every day to the College de France, “spending hours by the bouquinistes – library display along the Seine to find and read classical books of the French literature” (Touret & Besudnova, 2021). F. Fouqué had asked him to work on the then poorly known aluminum silicates, first of all sillimanite. He determined the optical properties of this mineral, discovering also the two other polymorphic varieties (kyanite, andalusite). He worked notably with F. Fouqué’s assistant, Alfred Lacroix (1863-1948), who would remain a close friend for the rest of his life. The work at the Collège de France included the synthesis of sillimanite, a task then considered to be almost impossible. Facilities for mineral synthesis were at the Ecole des Mines, under the direction of a great chemist and expert in thermodynamics, Henri Le Chatelier (1850-1936), who was precisely translating in French the works of J.W. Gibbs. At the difference of the friendly F. Fouqué, Le Chatelier was rather severe, not too appreciated by his students who did complain that his courses were difficult to understand. But he developed a real friendship with Vernadsky, spending hours to explain him the details of Gibbs work. The experimental work at the Ecole des Mines was very successful. Vernadsky succeeded rapidly to synthesize sillimanite (very simple, wrote he in his journal). He also identified the trend of stability conditions for the three polymorphs (low pressure for andalusite, high pressure for kyanite, high temperature and pressure for sillimanite). This was the first indication of a P-T diagram that has become today a milestone in metamorphic petrology.

Back in Russia, Vernadsky quickly used the material that he had accumulated in Paris and Munich to obtain two doctorates, one in Petrology in 1890, the other in Crystallography six years later. He was then nominated professor at the University of Sint Petersburg, considered as a leading authority in Russia. But, attached to a democracy that he has experienced during his travels in Europe, he had difficulties to support that autocratic regime of the tsar– as well as the equally autocratic communist regime after the revolution of 1917. He resigned from the Sint Petersburg in 1910, to protest the student repression. On several occasions, he was in danger to be arrested, only protected by his scientific stature. He avoided the risk in travelling outside of Moscow, notably to his real home country, Ukraine. He founded there an impressive list of institutions, e.g., the Ukrainian Academy of Science and National Library, a university in Crimea, etc. He belonged to the small group of ethnic Ukrainian who had a dual Russian-Ukrainian identity. But he also considered that his Ukrainian culture was part of the Russian Imperial culture and he refused to be a Ukrainian citizen when this was possible in 1918 (Wikipedia, English).

Vernadsky also travelled frequently to France to visit his friend Alfred Lacroix, in the meantime promoted director of the Museum d’Histoire Naturelle. He met also frequently other personalities, notably Marie Skłodowska-Curie (1867-1934) whom he advised on the places where she could find radioactive minerals. He was not impressed by the rather primitive condition of Marie Curie lab – we have much better working conditions in Moscow, wrote he in his journal (Vernadsky, 1998). In consequence, he proposed to Alfred Lacroix to settle permanently in Paris to organize an Institute for Radioactive minerals – Marie Curie’s future Institut du Radium – but his offer was turned down because he was not a French citizen!

Vernadsky was very much attached to his home country, either Russia or Ukraine, and he came always back after his voyages abroad. With his favorite student Alexander Fersman (1883-1945), he participated to an Academy of Science project to catalogue Russia natural resources, travelling through the entire country to find important mineral deposits. During these travels, he became aware of the ecological disasters that

man can inflict to nature by overexploitation or mismanagement of the agriculture. This had notably resulted in the 'Great Famine', which culminated in 1921-1922, but had already started in 1891. This dramatic experience convinced him that human activity can deeply influence natural processes, a notion which will become an important aspect of his geochemistry. During these difficult years, Vernadsky did contact his French friends to obtain some funds: Excerpt from the French journal *La Justice*, May 13, 1892: "M. Vernadsky, professor at the Moscow university, has organized in Tamboff rescue kitchens according to Tolstoï method... (He) informs the committee... that, thanks to the already received 8000 Francs, he has opened 24 kitchens for 1500 people in the region of Morchansk and Kirsavovka. These kitchens have been called "Cuisines parisiennes" and the region will be called "Région des secours français"... They are the only ones where the miserales starving can eat bread not mixed with herbs or earth". Moreover, Vernadsky did collect in Russia another 45359 rubles with the Committee to help the hungry people. He opened new dining rooms, which fed about 5000 people. (Source *Retronews*, translated from French, see also Drobzhnev, 2016).

The second stay in France (1922-1925):

La Géochimie

In 1921, Alfred Lacroix, then Professor of the Museum of Natural History, invited Vernadsky to give a series of lectures on geochemistry in Paris. At that time, Lacroix had the status of "secrétaire-perpétuel" of the Academy of Sciences. This rather strange name, still in use today, means that the "secrétaire-perpétuel" is actually the most important person in the Academy. He runs the affairs of the Academy, stays in office for as long as he wishes, may invite people at will, while the president, who changes every two years, is more a representative person, without any real power. Lacroix's laboratory at that time employed several people who showed considerable interest to Russia, notably his young assistant Jean Orcel (1896-1978), who later became a major specialist in radioactive minerals.

There were also people from Russia and Eastern European countries, whom Vernadsky met with pleasure. He could notably discuss with the

petrographer Elizabeth Jérémine (1879-1964), a former assistant of F.Y. Levinson-Lessing, member of the first expedition of Alexandre Fersman to Khibiny in August-September 1920. She emigrated from Russia in 1921; the same year, she was registered as researcher in the mineralogical laboratory of the Museum, where she stayed for the rest of her life (Orcel, 2009). A very good petrographer, she became the favorite assistant of Alfred Lacroix, working also on meteorites with Mireille Christophe-Michel-Lévy, the daughter of Auguste Michel-Lévy (1844-1911), former companion of A. Lacroix at the Collège de France.

Other members of Lacroix mineralogical laboratory came from other Eastern countries (Romania or Hungary) between 1920 and 1950, e.g., François (Ferenc) Kraut (1907-1983) from Hungary, who discovered the first traces of meteorite impact in Rochechouart (Limousin, France) (Kraut, 1967). For some reason, France seems to have been extremely attractive for Eastern students in geology during this period. In the place where most professional geologists are educated (the Institute of Geology of Nancy, now Higher National School of Geology), almost half of the graduates from 1923 to 1934 bear Russian names. Vernadsky was then very pleased to stay in Paris, but after some time he felt that he had to go back to Russia. When he returned to Moscow, Vernadsky brought back a number of mineralogical samples, now kept in the State Geological Museum of the Russian Academy of Sciences (Touret and Besudnova, 2021).

In May 1922, a new invitation was issued by the Sorbonne Rector Paul Appel (1855-1930). With the blessing of the Presidium of the Russian Academy of Sciences, Vernadsky traveled to Paris from Petrograd with his wife and daughter. He went through Prague in Czechoslovakia, where his son George lived at the time and where his daughter Nina remained to study. Then, with his wife alone he spent a night in Vienna and finally came to Paris through Switzerland (Vernadsky, 1998).

Both arrived in Paris by train at the Gare de l'Est (Eastern station) on July 8, 1922, met by Alexandra Golstein (1850-1937), a political emigrant and known writer. Alexandra took them to Passy, the place where Vernadsky had lived in 1889. But,

again, Passy was too far away from the intellectual heart of Paris, the vibrant Quartier Latin. A few days later Vernadsky rented an apartment 7, Rue Toullier, much closer to the Sorbonne (Touret and Besudnova, 2021). With his wife, he did stay there for over three years between 1922 and 1925, sometimes visiting his children in Prague (Vernadsky, 1991).

The first task of Vernadsky in Paris was to give a lecture on geochemistry every Friday at the Sorbonne, which he began in December 1922. Vernadsky impressed his audience by the quality of his French, and the lectures met rapidly with great success (Vernadsky, 1998a). He had also ample time to do scientific work, often in the laboratory of A. Lacroix at the Museum d'Histoire Naturelle, also in the École des Mines, the École de Pharmacie or several libraries, including the Bibliothèque nationale. He spent also much time discussing international cooperation within the framework of several organizations, which at this time were extremely active in Paris.

After the end of the First World War, these organizations were established to restore and develop destroyed scientific relations in Europe. The League of Nations (Société des Nations), first international organization to promote peace and international cooperation and predecessor of UNESCO started in 1920, with P. Appel as the French representative and President of the French Association. Two years later a Committee for Intellectual Cooperation was established, including Albert Einstein (1879-1955), Marie Skłodowska-Curie (1867-1934), and the philosopher Henri Bergson (1859-1941). Vernadsky had frequent discussions with this Committee. He argued for the promotion of Russian science in international scientific cooperation, and the involvement of Russian scientists in the international scientific community, both those who remained in Russia after the events of 1917 and those who emigrated abroad. In February 1923, Vernadsky met under the patronage of P. Appel with H. Bergson to discuss how Russian scientists could be better integrated into international cooperation. At the same time, negotiations were underway to establish a major Russian philosophical center in Paris (Sorokina, 2003).

Vernadsky and Bergson became close friends. They met frequently in Paris, as well as few people

strongly influenced by Bergson ideas: the philosopher and theologian Edouard Le Roy (1870-1954), or the philosopher, geologist, paleontologist and priest Pierre Teilhard de Chardin (1881-1955), who had developed a new concept about the place of man in the evolution of the Earth. Obviously, the communication between the French scientists and the Russian academician had a mutual influence on their scientific views and ideas. It led to the development of the biosphere doctrine and its transition to a new concept, the noosphere, a concept that Vernadsky would integrate into its geochemistry. The noosphere represents the highest stage of biospheric development, its defining factor being the development of human rational activities (Vernadsky, 1945).

This stay in Paris proved to be very successful for Vernadsky. He conducted a number of mineralogical and geochemical studies, the results of which were published in scientific journals in France, England, Czechoslovakia and Russia. But his major achievement was his book *La Géochimie*, based on the lectures that he had given at the Sorbonne in 1923-1924. Directly written in French, this book focuses on the classification of minerals by their geochemical properties, the concept of geochemical cycles and, above all, the role of life in the formation of the planet Earth. It was the first time that a book was devoted to a discipline which, in few years, should take a prominent position within Earth and Planetary sciences. The name "geochemistry" was used earlier, either by Vernadsky or by his student Alexandre Fersman (1883-1945), but only to describe the chemical composition of some minerals or rocks. For the first time, *La Géochimie* then developed an entirely new concept, including the role of mankind, taken as a geological parameter, in the evolution of our planet. Vernadsky had the elegance to acknowledge the long influence of French scientists in the development of his new discipline. The book is dedicated « to the memory of my dear master », Ferdinand Fouqué and, in the Preface, Vernadsky mentions « fruitful discussions with A. Lacroix, who read all the text in proofs ». He added that « (he) found in his laboratory at the Museum d'Histoire Naturelle all means of scientific work and the possibility to achieve this work ».

A second series of lectures was also prepared for printing. Having revised these materials, Vernadsky wrote on his return in Russia the

monograph *Biosphere*, published in 1926 in Leningrad, a few years later translated into English and French (Vernadsky, 1929), recently republished in an annotated and extended version (Vernadsky, 1998b). The following year *Essays on Geochemistry*, were published almost simultaneously in German (1927) and Japanese (1930) (Vernadsky, 2006). Many researchers, especially English-speaking, believe that it is more *Biosphere* that signaled the emergence of geochemistry as a new scientific discipline. But this idea does not pay justice to the fact that the name and basic concepts were already present in the earlier published *La Géochimie* (Touret & Besudnova, 2021).

In his journal, Vernadsky noted that 1924 "was one of my successes in Paris", "la Géochimie came out and was a great success" (Vernadsky, 1991, p. 136). He had also many other activities during this very successful year, notably research on radioactive minerals at the Radium Institute, the Department of Basic Research on Radioactivity, headed by Maria Sklodowska-Curie (Vernadsky, 1991). Before coming to Paris, Vernadsky was engaged in the study of a mineral named after Pierre and Marie Curie, curite, just discovered in Shinkolobwe (Congo). He was assisted by Catherine Antonovna Shamie (Chamie), (1888-1950), "an unremarked remarkable woman" (Sedova, 2013). Their joined paper was published in this golden year (Vernadsky & Chamie, 1924).

Meant for two years, the invitation of P. Appell should have ended in 1924. But a grant of 30 thousand francs from the Fondation Rosenthal, « to study the amount of living matter in the biosphere », allowed Vernadsky to extend his stay in Paris. He spent then more time studying the biosphere, resulting in more works published in France: a report on "La matière vivante dans la biosphère" (Living Substance in the Biosphere"), later reprinted in "La Biosphère" (Vernadsky, 1929) and an article on "L'autotrophie de l'humanité" (Autotrophy of the Humanity) (Vernadsky, 1925)). During all this period, Vernadsky and his wife left sometimes Paris during the summer for some vacation in the countryside. They visited notably the resort of Bourbon-Lancy, known for its sulfur springs, 350 km southwest of Paris and the town of Roscoff on the Brittany peninsula, in which a sea biological research station was located, and since 1899 a health center using sea water for treatment. Then they came back and remained in

Russia, with only a short and last visit of Vladimir to Paris in 1936, to lecture on radiology at the Sorbonne.

The Geochemistry of V.M. Goldschmidt

When *La Géochimie* was published in Paris, V.M. Goldschmidt did publish a series of papers on the laws of element distribution in the Earth, that many regard as marking the foundation of "his" geochemistry (Mason, 1992, Glasby, 2006). Written in German – VMG was working at this time in the University of Göttingen- these papers were published in the Proceedings of the Norwegian Academy of Science (Goldschmidt, 1923-1927). These papers were preceded by a publication on the evolution of igneous magmas through fractional crystallization, also published in the Proceedings of the Academy of Science (Goldschmidt, 1922). They were followed by many publications until 1938, in which Goldschmidt established the main frame of "his" geochemistry.

Among the main advances in the geosciences propelled by Goldschmidt's research during this period was the geochemical classification of the elements into siderophile, chalcophile, lithophile and atmophile elements, also related to their position in the Periodic Table. Furthermore, from the study of meteorites containing iron-nickel, troilite (FeS) and silicates he calculated the partition of the elements between metal, silicate and sulfide melts, and eventually used those data to estimate the absolute abundance of the elements. This was based on the realization/assumption that (some) meteorites provided an unaltered sample of the material that coalesced to form the Solar System.

VGM and his coworkers also stressed the importance of the atomic radius and charge of ions to explain, among other things, the compatibility or incompatibility of elements in minerals. They showed how the crystal chemistry could be described as an infinitely extended network of regularly spaced ions rather than individual molecules explaining substitutions independent of charge and valence. Furthermore, Goldschmidt calculated the element distribution of the crust based on the bulk composition of glacial clays, described the breakdown of a rock through chemical weathering, formulated the geochemical cycle of the outer part of the Earth: the redistribution of elements between the Earth's crust, atmosphere,

hydrosphere, atmosphere and biosphere and subsequently the carbon cycle. (Internet site of the Department of Geosciences, University of Oslo

https://www.mn.uio.no/geo/english/research/goldschmidt/about_goldschmidt/index.html)

Contrary to Vernadsky, who took more than 20 years to elaborate "his" geochemistry, the conception of the new discipline by Goldschmidt was very short: almost everything was ready between 1922 and 1927, the rest being mainly applications by Goldschmidt himself or by his co-workers. VMG made almost no use of the word "Geochemistry". The first time when he made use of this word was in a title of a book describing exhaustively his new discipline, published only in 1954, seven years after his death (Goldschmidt & Muir, 1954). The main reason for this delay was the political problems that he faced at the end of his life in a Europe progressively hit by WWII. In 1929, already full professor of petrology and mineralogy at the University of Oslo, he had accepted to become professor at the famous university of Göttingen. He had there outstanding working conditions, good scientific friends, was repeatedly nominated for Nobel prize (11 nominations in total, but he never got the prize for himself, leaving it to other scientists who had worked on direct consequences of his work).

Despite the good working conditions, V.M. Goldschmidt became rapidly perturbed by the political situation in the Third Reich. Issued from a Jewish family, he had not paid much attention to his faith during his youth. But the Jewish persecution by the Nazi regime led him to show openly his Jewish origin while in Göttingen. Protected by his scientific stature, he was well treated by his university. But the treatment inflicted to other non-Aryans by the Nazis led him to resign from Göttingen and return to Norway in 1935.

In Norway, VGM continued his research, publishing the ninth part of his *Geochemical Laws*, which he called his "Ninth Symphony." In it, he arrived at a table of cosmic abundances, from a combination of meteoritic and solar data, which provided the basis for later theories of the origin of the elements. "Goldschmidt's perception of the fundamental significance of meteorite compositions for geochemistry is another example of his

scientific genius" (Mason 1992). He was the director of the Råstofflaboratoriet (State laboratory for raw materials), that he had founded in the Tøyen Geological Museum in 1917. In this position, he had a key responsibility for the prospection of radioactive minerals in Norway and management of radioactive products, notably the heavy water that Norway was the only country in the world to produce in its Telemark factory. These responsibilities put him in a difficult position when Germans did invade Norway in 1940.

The Germans did respect the scientific stature of the former professor of Göttingen university, but they also made all efforts to put him on their side. They had installed in Oslo a pseudo-government under the direction of the chief of the local Nazi party, Vidkun Quisling, a name hated in Norway until today. Quisling minister of propaganda was a certain Gulbrand Lunde, who had been VMG assistant several years earlier. There is no doubt that Goldschmidt was on the side of Norway, there are many signs showing that he was actively involved in the resistance against the German invasion. For instance, he convinced the director of Norsk Hydro to sell the reserves of Telemark heavy water to the French, just before those being confiscated by the Germans. But he had also a rather complicated personality, which caused him some problems with his colleagues in Oslo.

A former student of Goldschmidt, Tom Fredrik Weiby Barth (1899-1971), who had been the director of the Geological Museum when V.M. Goldschmidt was in Göttingen but had then a prominent position in the Geophysical Lab. Washington DC, USA, decided to come back home to defend his country. Tom Barth landed in Norway a few days before the German invasion, not so well received by V.M. Goldschmidt who apparently did not fully appreciate to have by him such a high-quality scientist. VMG did only allocate a small working place to Tom Barth, a desk in the basement of Tøyen, and provided him with a minimum of financial resources. He leased him a flat in his magnificent house near Holmenkollen, which should later become Tom Barth's own house. But the flat was not cheap, Tom Barth had to sublease a room to a German, soon accused to be a spy (unproved rumor says that the accusation could have been issued by VMG himself). He (VMG) wrote also a letter which was supposed to remain confidential, but soon became known by a large

public. In this letter, VMG did compare Barth to Lunde, stating that he did prefer the second. The controversy would resume after the war, well after VMG death, with another set of rumors stating that VMG had accused Tom Barth to be an “agent double”, an accusation which could have put Tom Barth’s life in danger. These rumors again were soon proven to be totally unfounded, and they did not change the esteem that Tom Barth had for his ancient professor. After the war, Barth returned to the US to become professor at the University of Chicago. In 1949, he came back again in Norway, professor at the Toyen Geological Museum and soon one of the first world figure in Earth Sciences (e.g., the first president of the newly founded IUGS). Tom Barth was the director of my (JT) Ph D thesis in Southern Norway. I have well known him from 1957 until his death in 1971. I never heard a strong word of Tom Barth about VMG, just laudative comments about his scientific genius.

Despite all efforts that VMG had done to look cooperative with the Germans, he was soon taken by the war. He was arrested as a Jew in 1942, sent to the Berg concentration in Tonsberg, where he became seriously ill. Thanks to the intervention of Gulbrand Lunde, he was freed some weeks later, but soon arrested again. This time Gulbrand Lunde was no longer there, he had died in the meantime in a drowning accident. Placed in a group of Norwegian Jews to be sent to Auschwitz, VMG could escape on the pier, freed by the policeman, named Karl Marthinsen, who did survey the group. Who has persuaded Karl Marthinsen to free VMG is not precisely known. It was said at this time that the decision could have come directly from Berlin. But this is not likely, for obvious time reasons. More plausible is the action of a watchmaker from Tøyen, who came on the pier to help VMG and who knew Karl Marthinsen, having been with him in the military few years ago. VMG was then exfiltrated to Sweden by another policeman who told later that he was ordered to carry a loaded gun, with the order to shoot down VMG at the first sign of contact with the Germans.

In Sweden, VMG was offered again the Swedish citizenship. Like in preceding occasions – the first one when he had been nominated in Oslo, the second after his resignation from Göttingen-, he refused, not wanting to be the only Norwegian academician who could benefit of this privilege when his nation was still at war. Then he was

transported to Scotland, by a British intelligence unit (Gladby, 2006).

Despite much information transmitted to the Allies about the situation in Norway and the state of German science on radioactivity, his former contacts with Germany made VGM somewhat suspect to British and fellow Norwegians. A policeman who had helped him to go to In Scotland, VGM was maintained in a semi-isolation in the Macaulay soil Institute in Aberdeen, assisted by Alex Muir, who helped him to finalize his book. At the end of the war, he wanted to go back to Norway, which he did in June 1946, not welcomed again by some of his countrymen. He had been seriously ill in Scotland, treated in hospital for heart disease. He had apparently recovered but died suddenly one year later from cerebral hemorrhage, only a few days after a cancer operation, most likely for malignant melanoma. He also had a blood disease causing elevated levels of hemoglobin.

Even though his scientific achievements were already known in the entire world, VMG death occurred in almost complete anonymity. None of his colleagues was present at his funeral. He had prepared three urns in olivine for the ashes of his parents and himself, which were placed in a chapel of the Vestre Crematorium in Oslo. But, after some time, a new law required that dead persons should be officially buried. Goldschmidt family had no descendants, a letter was sent to the University asking for a decision, without proper answer. The university did not want to take the responsibility of a grave. The director of the Geological Museum in Oslo, Johannes A. Dons (1920-2021) was an excellent structural geologist, but he failed to identify the genius of VMG (Dons, 2000). He did contact the Mosaic Congregation in Oslo, but VMG had been circumcised in Göttingen, they could not find his name in their papers. Finally, the urn which should contain the ashes was kept for several years behind a radiator in Tøyen Geological Museum. But when it was opened few years later, it was found to be empty. Nobody knows for sure where the ashes could be, most likely in the ground near the crematorium. Then, the three urns were placed in anonymity in the memorial grove for unmarked graves at the Vestre Gravlund cemetery (Siw Ellen Jacobsen, journalist, Oct. 30, 2020). More than 70 years later, there are still no street, square or place named after V.M. Goldschmidt in Norway, but well a V.M. Goldschmidt

Strasse in Göttingen, the street of the new Mineralogical Institute of the university. Conversely, dozens of places are named after V.I. Vernadsky in the former Soviet Union, including the famous Vernadsky Geochemical Institute and Museum in Moscow, a prestigious street and metro station (Prospekt Vernadskogo), also in Moscow, the National Academy and Library in Ukraine, and many others.

VGM book on geochemistry, completed and edited by Alec Muir, was only published in 1954, seven years after his death (Goldschmidt & Muir, 1954). At this time, geochemistry had already escaped from his author, developed in US universities or in Finland (Rankama & Sahama, 1950). The discovery of advanced instruments for measuring trace elements or isotopes, many of them conceived or developed during the war, has greatly enlarged the scope of the discipline, which will rapidly become one of the most important branches of Earth and Planetary Science. Most developments took place in the US, in the best universities of the East- or the West coast, to spread rapidly over the entire world.

V.M. Goldschmidt and V. Vernadsky geochemistries

Relying extensively on thermodynamics, geochemistry according to V.M. Goldschmidt is purely chemical. It aims at a better understanding of the conditions of formation of rocks and minerals, first of all to obtain more economical resources. The Earth is seen as an inexhaustible reservoir, which would restore by itself any damage caused by the exploitation. In this respect, it must be recognized that geochemistry has been extremely successful: estimated oil reserves, for instance, only assumed to be few 10's years in the sixties, have been systematically enlarged by new discoveries. But it was also progressively realized that overexploitation was not without danger, being the source of the environmental problems that we know today. This risk was much earlier foreseen by V. I. Vernadsky who, trained as a pedologist, had warned in his book that human activity could modify natural processes and, if not properly controlled, lead to planetary disasters. Vernadsky had been much impressed by the great famines of the years

1931-1932, which caused millions of deaths in Ukraine and in the neighboring countries. In this respect, he can be credited of the invention of ecology.

Sadly, his message was ignored, including in his own country. Like the Western World, Soviet Union was under high pressure to find natural resources, which it did with remarkable success. Despite his scientific prestige, Vernadsky was not able to influence the politics of the communist regime. His main disciple was Alexandre Fersman, who had a personal relation with Lenin, but less worries about any possible environmental problem. Foolish initiatives, such as the use of atomic bombs to create underground cavities in the Kola peninsula, drying out the Aral Sea in Kazakhstan, were responsible for the greatest ecological disasters known on Earth in modern times.

After WWII, the fate of geochemistry according to Goldschmidt or Vernadsky was quite different. When he did his lectures at the Sorbonne university, Vernadsky was quite popular in France, elected to the Academy of Science at the evening of his last lecture. But this was more a success of curiosity, French geologists at this time did lack the physico-chemical background to understand fully his message. Then, the cold war made a drastic separation between the East and the West. Goldschmidt geochemistry exploded in the US, and a new generation of French geochemists, educated in American universities, claimed when they returned to their home country that they had discovered a discipline which had been discovered in Paris more than 30 years ago. In France, the name of Vernadsky was almost forgotten, only remembered by few tenants of the Gaia hypothesis, more considered as philosophers than real scientists. Important developments of the Vernadsky school, *e.g.*, the work of D.S. Khorjinskii on metasomatic processes (Khorjinskii, 1970) were either ignored, or not understood at their real importance. The situation gradually changed during the last 20 years or so, mainly under the pressure of ecological problems. It is now realized that both Goldschmidt and Vernadsky must be credited of the discovery of geochemistry, also that several problems that our planet faces at present could have been avoided by adhering earlier to the rules that he had defined.

Acknowledgments:

We are indebted to Zoya Besudnova, Vernadsky State Geological Museum, Moscow for having provided us with much unpublished information on the life of V.I. Vernadsky. Much first-hand information on VGM was provided to one of us (OAC) by the late Gustav Olov Svante (Olav) Arrhenius

(1922-2019), who lived with VGM in Sweden and remained very close to him until his death.

Because of serious health problems, the senior author was not able to work on the final stage of the paper. The decisive help of Pascal Richet in these difficult circumstances is gratefully acknowledged;

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History of geology in Liechtenstein

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Abstract. Liechtenstein is an ideal terrain for geosciences, but the scientific exploration began not earlier than the end of 19th century. Before there was only a utilitarian prospection. The beginning of scientific researches was initiated from abroad. Nowadays popularization is developing, thanks to generalist scientific societies, and public institutions. There is still no geological institute, but cooperation with the neighboring countries prove that science ignores national boundaries.

Keywords: Liechtenstein – Geography – Geology – History – Geosciences – Rhine valley

Introduction

In comparison to other countries Liechtenstein is not very well known, because with only 160 km² it is merely a dot on the alpine map (Fig. 1), though in a tectonically interesting location. There is no much scientific literature on the topic and our present schematic overview is the first publication about the history of geosciences in this country. Since over two centuries the Principality of Liechtenstein is one of the most stable independant states from political, cultural and economic point of view, its landscape is not stable at all: there are permanent visible changes, due to geological processes and human intervention at nearly every point of the territory. The history reaches from the oldest stones ever found, until to the newest rocks which are presently in formation. Some examples of human investigations are additionnal historical landmarks. A list of institutional actors is certainly useful to anybody who wants to make a scientific study or compare with the neighbouring countries. Note that most literature about Liechtenstein is in German.

1- Geological history

1.1- *Liechtenstein ideal terrain for Geosciences*

Liechtenstein is an alpine country, that is celebrated as an ideal terrain by those geologists and geographers who studied it. Daniel Miescher, in his reference book *Geologie Liechtensteins*, speaks of an “*interesting geological variety*” (Miescher 2014). In a precedent article we explained, why this area is “a paradise for the geographer” (Deicha I. 2002).

The oldest stone cited by Miescher is an erratic block near the Pfälzer Hütte. It is 350 million years old (Fig. 2). The newest formation is visible along the road leading to the castle of Vaduz, where a pretty touristic fountain is now completely covered with thick tuffa deposits (Fig. 3). This compact rock appeared in less than 50 years. The tectonic structure can be summarized as Helvetic, Penninic and Austroalpine nappes, cut by two parallel valleys (Rhine and Samina) filled with sediments, and rubble from landslides (Fig. 4)

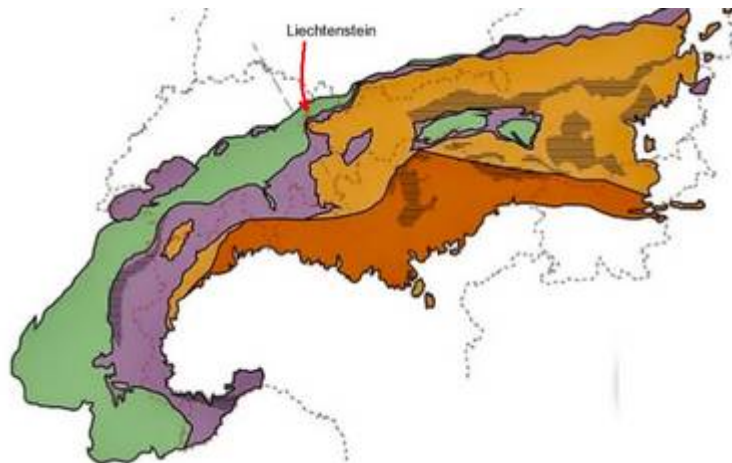


Fig. 1. Liechtenstein is in the middle of the Alps. Tectonic overview (Miescher, 2014, p. 9).

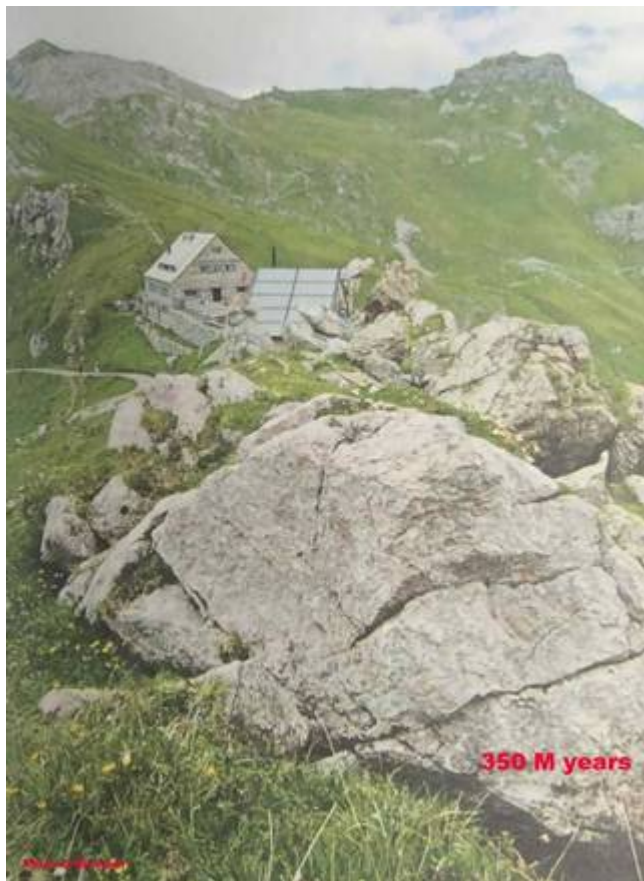
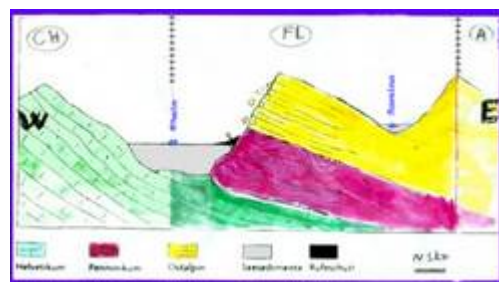


Fig. 2. The oldest rock of Liechtenstein, the Bettlerjoch-breccia 350 million years old (Miescher, 2014, p.76).



Fig. 3. The newest rocks formed by current tuffa-deposits are barely 50 years old. Petrifying fountain in Vaduz – Schlosstrasse (Photo by the authors).

Fig. 4. Draft of an East-West tectonic section; FL= Liechtenstein, CH= Switzerland, A= Austria; (according to Miescher, 2014, p. 114).



1.2- Evolution in progress

The landscape evolution is visibly in continuous progress everywhere: For decades we have always liked to observe how the petrifying fountain is still growing slowly. On the western slopes of the mountains erosion can be very important, so that the famous touristic trail *Fürstensteig* must be rebuilt every year, and every field geologist has always new rocky outcrops to explore (Fig. 5). The groundwater level is subject to seasonal changes. Nearly every day alluvions in the Rhine are changing dramatically, as well as the throughput of creeks.

Besides this continuous evolution let's remember that we are in a region submitted to brusque natural phenomena like landslides, floodings and earthquakes (Deichmann 2011). Mud flows (*Rüfen*) eventually reach the bottom of the valley and make some land unbuildable, the historic Rhine overflow of 1927 was a nationwide disaster, and the two last tremors recalled the importance of geologic phenomena to everybody, as well to poets (Helbert 1992) as to MPs (Albrich 2022)¹. Many anthropic constructions try to limit the resulting dangers.

2- History of human investigations

2.1- Utilitarian investigations

Since the Middle Ages stone quarries are exploited at several places (Frommelt 1934). The *Schloss Vaduz*² and other medieval castles were built partially with limestone tuffa (Fig. 6). Other buildings are of "Balzner Marmor" extracted in the southern part of the country.

Two hundred years ago, people eventually

mined and exported some other mineral resources (Broggi, 2022a, p.18). Historians remember that "in 1800 gypsum was Liechtenstein's most important industrial export product" (Vogt, 1990). Gypsum was extracted in quarries above Masescha and milled in Vaduz Mühleholz. Even iron ores were extracted in Valorsch until the 17th century. Smelted with charcoal they produced a small quantity of steel (Falk, 2011). Environmental specialists are now renaturing a zone in the north of the country, where peat was extracted until the 20th century (Broggi, 2022b, p.156).

In the beginning of the 20th century the construction of new roads, drainage channels and hydro-electric power-stations provided new geological knowledge. The national electricity provider *Liechtensteiner Kraftwerke* (LKW) began to work in 1927 (Lawenawerk, Saminawerk, Pumpspeicherkraftwerk). For the first time the Liechtenstein mountains were pierced from part to part, with the assistance of geologists. The dumps of the underground penstock, connecting the Steg reservoir in Samina valley to the power station in Vaduz, attracted researchers³. At this occasion microscopic liquid and gaseous inclusions were discovered in Triesen Fylsch fissures in the fifties.

A road tunnel was dug in 1947. Half a century later soil drillings were performed to get groundwater or to investigate the possibilities of geothermy (Naef, 2011),

Internet sources say that "Liechtenstein has few natural resources, aside from alluvial gravel used by the concrete industry. Gravel extraction from the river interfered with groundwater flows and was banned after 1972."⁴. Indeed gravel extraction had even caused a bridge-collapse in the seventies. (Fig. 7).

¹ During our presentation at the INHIGEO meeting at les Eyzies, we reported about a seismic tremor occurring a few days ago, at the very moment when the Liechtenstein Parliament was debating about... earthquake insurances!
Video <https://www.youtube.com/watch?v=FvDdRI0iOGc>

² Photograph illustrating the link. <https://www.mindat.org/loc-263790.html> referring to Sella *et al.* (1970).

³ Citation from: <https://www.mindat.org/loc-263789.html>

⁴ Wikipedia https://en.wikipedia.org/wiki/Geology_of_Liechtenstein



Fig. 5. The western slope of the Dreischwestern massif (2000 m). Foto taken by the authors from the bottom of the Rhine valley (450 m). The "Fürstensteig", a narrow path leading to the snowy ridge must be rebuild every year. Clearly visible below are the canyons of temporary torrents (Rüfen). They transport plenty of erosion material after every intense rain on the summits.



Fig. 6. Schloss Vaduz was build with material quarried nearby.



Fig. 7. The collapse of the bridge between Schaan and Buchs in the seventies was caused by gravel extraction from the river Rhine (photo by the authors).

2.2- Scientific investigations

The exploration by foreign geologists began in the 19th century (Wanner, 2011). Due to the smallness of the country, there is no geological nor geographical institute, but individual researchers with foreign scientific affiliations publish very good work. From time to time, Liechtenstein was even represented at international scientific meetings. We recently found in our family archive a document related to the 19th and 21st International Geological Congress (Fig. 8)⁵. As an example of scientific investigation by foreign institutes we may evoke the development of the fluid inclusions studies by the *Centre d'étude des Inclusions* in Paris in the middle of the 20th century (Poty, 2017).



Fig. 8. The document signed by Prime Minister Alexander Frick, certifying participation of Liechtenstein in at least two International Geological Congresses (authors' archives).

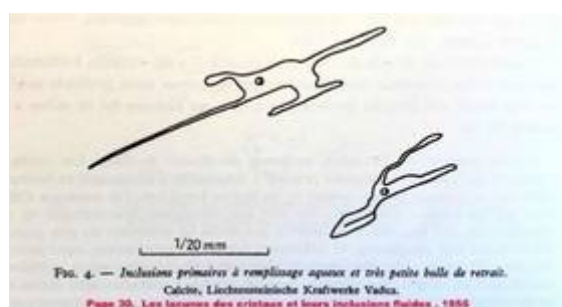


Fig. 9. Aqueous filling and a small gas bubble inside of a calcite crystal from Vaduz illustrating the first French reference book on inclusions (Deicha G., 1955, p. 30).

Georges Deicha (1917-2011), the precursor of the European studies on fluid inclusions illustrated his reference book with materials from Liechtenstein (Fig. 9) (Deicha G., 1955, p.30).

2.3- Outreach activity

In the general public the interest of geosciences is almost always associated with domestic geography, archaeology, mountain sports, or environmental concerns. Geology as a science, was poorly represented in previous years. For instance in museums there are very few exhibits. In the school curricula, basics in Geology did not appear as an own scientific matter, but together with geographical or environmental items. In the fifties there were some *Strahler* (rockhounters) who sold crystals to tourists, those who quoted honestly the origin of the stones could help scientists.

Nowadays we can say, that there is a trend to develop seriously scientific knowledge, and geosciences are in progress. In the last decades geology was the theme of several installations in the public space in Malbun⁶ also in Bendern (“ Stone Path”) or around a fountain in Vaduz (Fig. 10).



Fig. 10. The “Fountain of the County of Vaduz” (der Grafschaftsbrunnen) is an installation where each rock comes from one of the villages in the neighbourhood (photo by the authors).

3.1- 3- Institutional Actors

Associations

Interested local scholars meet and publish in

⁵ Liechtensteiner Vaterland 26.07.2017 p. 8 „Bezug zu Liechtenstein noch unerforscht“ in „Dr. Deicha hält die Eröffnungsrede“; <https://deicha.li/application/files/4715/0425/1492/2017Vaterland26JuliAusschnitt.jpg>

⁶ The agency Liechtenstein Tourismus recommends Daniel Miescher's geological trail in the alpine resort Malbun: <https://www.outdooractive.com/de/route/themenweg/liechtenstein/geologiepfad-malbun/61853184/>

different generalist associations, who edit bulletins, also with contributions about earth sciences. Let's cite three of these associations, devoted to history, to alpinism and to science. They all have a rich fundus of literature, they can be useful to prepare a field research, and they are a meeting place of the best connoisseurs of the region.

Der Historische Verein für das Fürstentum Liechtenstein (HVFL)⁷ is the historical association of the country, one of the oldest learned societies, landowner of some historical sites and editor of an annual bulletin *Jahrbuch des Historischen Vereins* (The first studies *Liechtenstein's Geology* were issued there in 1951 and 1952) (Allemann, 1956).

Der Liechtensteiner Alpenverein (LAV)⁸ is the national mountaineering club, member of the international network *Arc Alpin*, landowner of two mountain huts and editor of a quarterly bulletin *Enzian* and an annual report *Bergheimat*. LAV is the editor of the reference book *Geologie Liechtensteins* by Daniel Miescher.

Das Naturwissenschaftliche Forum (NWF)⁹ is the Liechtenstein Scientific Society, for science outreach, and relations to international academic organizations (European Physical Society EPS, International Astronomic Union IAU, European current research on fluid inclusions ECROFI, International commission on History of Geosciences INHIGEO). NWF is the editor of the latest bibliography on history of geosciences (Deicha C., 2022).

3.2- Collections

In the catalogue of the local museum visitors are warned that « scientific collections and museums are usually associated with research institutions or carry out the research themselves. However, Liechtenstein does not have its own institute or higher education institution for natural science disciplines. For this reason, the natural

history research of the country before 1970 was limited to more or less accidental works? »¹⁰.

In Vaduz, the *Landesmuseum* principally devoted to the local history and archaeology has a small geological exhibition constituted by nine polished blocks used as seatings for visitors, three fossils and a table allowing visitors to touch various stones... not even all of local origin ! (Fig. 11). There are also regional collections (Fig. 12) not limited by the boundaries of the Principality. Private collections can be preserved if the family takes care of them (Deicha S., 2019), but generally they are not accessible to public.



Fig. 11. The small permanent exhibition devoted to geology in the Landesmuseum Vaduz (photo by the authors).



Fig. 12. Regional collection with calcite containing fluid inclusions (Deicha, 1952), quartz from Switzerland, and gypsum from Liechtenstein. The private collections can be preserved if the family takes care of them.

⁷ www.historischerverein.li

⁸ www.alpenverein.li

⁹ <https://dachverband.li/naturwissenschaftliches-forum>

¹⁰ www.landmuseum.li

3.3- Governmental actors.

There are only 70 geological samples in the Natural History Collection of the Office of Environment (*Naturkundliche Sammlungen / Amt für Umwelt*). We notice that there are far more numerous artefacts about Zoology and Botany than about Geology. To our knowledge there is no accessible collection, but field research can be easily performed by every young scientist who wants to gather samples by himself in the new outcrops. Almost as an anecdote, there is a sample of lunar rock in the showroom of the "Treasure Chamber" in the center of Vaduz. It is very popular among tourists, but unfortunately it is not accessible to scientists, because it is encapsulated in a glass sphere !

The Liechtenstein Government¹¹ operates an archaeological office (Amt für Kultur) who has a certain legal control of the heritage of hidden treasures in the soil, and their scientifically correct handling. This office is established for archaeologists, but can also be useful for geologists.

A geological map was realized by Franz Alemann in the fifties and is currently re-edited by the government (Fig. 13): "*Geologische Karte Liechtensteins*" (Cadisch, 1953). All Liechtenstein-relevant literature is systematically collected by the National Library (Landesbibliothek)¹² and can easily be consulted there by everyone.

4- Comparison with the neighbours

4.1- Geosciences beyond boundaries

The country is inbedded in a regional Landscape, that includes the Swiss cantons St. Gallen and Grisons in the South and West, and the Austrian federal Land Vorarlberg in the North and East. They form together a coherent region of the German-speaking cultural space with strong ties

to cities with Universities and Institutes (Innsbruck, Zürich), over-regional specialized learned societies (Geological Societies, Mineralogical Societies, Geographical Societies) and enough readers to satisfy scientific editors.

The Principality of Liechtenstein belongs to the eight *Alpine countries*, and is member of the Alpine Treaty Convention¹³. Most of the field activity (investigations of geologists or geographers, paedagogic excursions of schoolclasses, etc.) ignore the national boundaries, especially to the two neighbours: Austria and Switzerland

4.2- Austria

The Geological Map of Vorarlberg includes also Liechtenstein, whose upper tectonic nappes are an extension of the austrian Austoalpin. Most regional books and publications and also the Association of Vorarlberg Friends of Nature deal with this subject¹⁴.

4.3- Switzerland

The visit of the *UNESCO-heritage Tektonik Arena Sardona* beginning only few kilometers south-west from the Swiss-Liechtenstein frontier can be recommended. The operators are rightly proud to say: "This region is unique in the world: nowhere else are the results of the processes that led to the formation of mountains as evident as they are here". This large national park (twice the area of Liechtenstein) is indeed a vivid museum of the alpine geological history¹⁵.

5- Conclusion

Let us underline that, according to Josef Biedermann, until 1970 Liechtenstein was still a *terra incognita* on the map of investigations in natural sciences (Biedermann, 2022). In so far as the history of geosciences in Liechtenstein has never been described, there are certainly plenty

¹¹ www.llv.li

¹² www.landesbibliothek.li

¹³: https://www.alpenverein.at/portal/natur-umwelt/av-naturschutz/alpenkonvention/liste-ak/01_geschichte-ak.php

¹⁴ <https://vorarlberg.naturfreunde.at/>

¹⁵ www.unesco-sardona.ch

of opportunities for the next generations of scientists. Perhaps the name Liechten-Stein may catch the attention, because in German *Stein* means stone!¹⁶

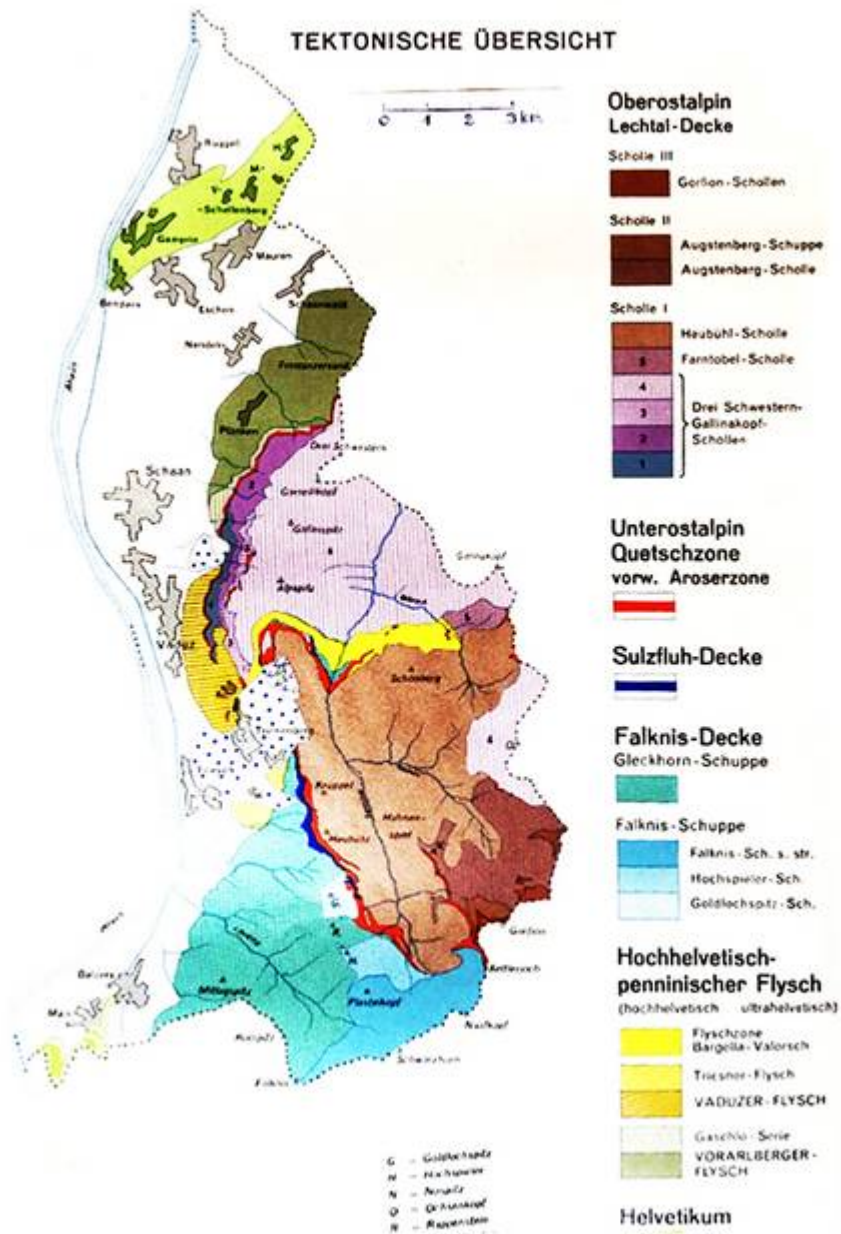


Fig. 13. Tectonic map of Liechtenstein (Cadisch, 1953).

¹⁶ Liechtenstein is the family name of the reigning house. It originates from Burg Liechtenstein, which lies since 1130 deep in Lower Austria. It is not Schloss Vaduz, which the Liechtenstein family bought in 1712 from another noble family that had gone bankrupt. There are several hypotheses for the etymology of the name: either a mansion built of light-coloured limestone or of a light material (leichter Stein), or the founder of the dynasty discovered a luminous precious stone (Licht-Stein). In any case, there is no link with Liechtenstein's geology.

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From deep time to physics: the contribution of geology to the interpretation of some fundamental concepts

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Abstract. Our objective is to show how geology may help to make progress in the understanding of some fundamental concepts and issues dealing with space, time and movement. This leads us to the very theory of relativity in physics. A thought experiment is presented where geology has fully played a role. Deep (geologic) time is a way to speak of very slow movements, involving imperceptible changes of the ordinary space we live in. According to the relative speeds involved, what is space becomes time (when we accelerate the movements of the mountains); conversely, time may become space (at the scale of the femtoseconds where the sand grains in the egg-timer are immobile). This is not just an allegory: we can never stop, thinking we have reached a pure time and a pure space; because we are inside the world and we can only compare what moves more (on which we build time) to what moves less (on which we build space) within a relational thinking. In this context, conventions are necessary, in particular that of the constancy of a standard movement: this is what we do today with light. The uniformity hypothesis in geology plays the same role. The links between space, time and movement is discussed in various fields of geology (sedimentary sequences, metamorphism, metasomatism, magmatism, ...) as they are omnipresent in prehistory.

Key words: deep time – space – movement – geology – physics – relational rationality – relativity theory – epistemology

Foreword

“*Geology is the sister of time*”
(Pierre Termier, 1913)

My knowledge in the history of geology is limited. I am both a geologist and a physicist, interested in the philosophy of science. I am particularly involved in highlighting the need and relevance of a *relational* (and not *substantial*) rationality in various fields of knowledge. Relation-based thinking has been discussed by many researchers; it is also called *complex* reason by French philosopher Edgar Morin (2005). Here I propose an epistemological look at the history of geology on the particular question of the trilogy time / space / movement. I will show how geology and its *deep time* inspired my reflection on the fundamental concepts of space and time in physics. Actually, the fertilization went both ways, from geology to epistemology and physics, and from epistemology to geology. This led me to some surprising conclusions, particularly that of envisaging a profound

link between the concepts of time and space (Guy, 2015, 2019).

In a first part, I will make some reminders about deep time in geology. In a second part, I will delve into space: paradoxically, space was not discussed as such by geologists. I will then present my founding thought experiment that was inspired by geology. We will end with some consequences of the vision of space and time derived therefrom, both from a general standpoint and in geology. I will make an allusion to prehistory that was the main topic of the conference.

1- The contribution of geology to the discovery of deep time

Let us start our first part. In order to prepare this work, I have read several books. Stephen Jay Gould in his *Time's arrow and time's cycle* (1990) discussed the pioneering role of Hutton and compared his understanding of time with that of Newton. In *Les Travaux du Comité français d'Histoire*

de la Géologie (1980), François Ellenberger, Gabriel Gohau, Goulven Laurent and Jacques Roger, discussed the parting between short and long time and the role of different contributors such as De Luc, Gregory, Hutton, Lamarck, etc. Anthony Hallam (1983) explained the major controversies about the age of the earth. Gabriel Gohau (1987) in his *Histoire de la géologie* tells us about general concepts found in geology and its history. François Ellenberger (1988, 1994) in the two volumes of his *Histoire de la géologie* proposes a general vision and stresses the role of the elders. In his book on *A natural history of time*, Pascal Richet (1999) reminds us how physicists helped geologist in the measurement of time, but also tells us that the dialog between geologists and physicists was not always fraternal. Claudine Cohen (2022) in her *Imaginaires de la préhistoire* describes the facets and issues of geological deep time and the link between science and imagination; it is an important issue when we discuss relational rationality.

We can extract some lessons, among many, learned from the history of geology. For Aristotle (4th century BC) the earth is like the world, eternal and subject to incessant local changes that render it globally unchanging (Richet, op. cit.). Plato (358 BC) speaks of unlimited duration and constancy of processes. James Hutton (1788) (many quotes from Hutton may be found in the books of François Ellenberger) is known for his contribution to highlighting the continuous changes of the earth's surface. This author speaks of the *"interchanging of sea and land"*, the *"vicissitudes of sea and land more than once"*. *"The land is perishing continually"*. *"The rising up of a continent from the bottom of the sea (is due to) an expansive power"*. *"Our solid earth is everywhere wasted"*. Georges-Louis Leclerc de Buffon in his *Histoire naturelle générale et particulière* (1749-1789, 1884) uses experimentation and physical deductions. John Playfair (1802) promotes Hutton's work and associates the immensity of the duration and the planetary movement: in one as in the other, the extent of the duration provided is unlimited. Charles Lyell (1830) stresses that the slow and continuous action of the present causes produces the whole of the geological events. In brief we can say that the geologic phenomena are very slow, as they are still today, and we must await immense durations of time before we see significant changes: this is deep time.

Deep (geologic) time is relational, as based on the phenomena.

From my epistemological perspective, I would stress that, in the aforementioned works, the existence of time is not questioned; it is not defined either, although the works by Newton were known, especially in England by Hutton and Lyell. For his part, Newton (1687) defines an abstract, I would say substantial time, detached from phenomena: *"Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration; relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such an hour, a day, a month, a year"*.

2- The paradoxical absence of a discussion on space

In the previous lines, the scholars we quoted above did not find any problem with space. However, we understand the dimensions of time through spatiality: the immensity of time is understood through the slow changes of our surrounding, concrete, space, because of natural agents (erosion, mountain rising). The consequences of deep time on the understanding of geometric / geodesic space are not discussed.

Newton (1687) detached everything, as much space as time, from objects: *"Absolute space, in its own nature, without relation to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces; which our senses determine by its position to bodies; and which is commonly taken for immovable space"*. Because of the general absence of discussion on space in geology, geological space seems to remain a Newtonian space, it rather looks as absolute. The question of the relation of space with material landmarks should be that of a relational character.

Ever since Antiquity, however, the geometrical representation of space has kept being studied by geographers and physicists. The geometric position of towns, mountains, harbours, etc. has been the subject of (mathematical) geography by the Greeks. In the 17-18th century, there was the development of triangulation and geodesy; the map

of France has been drawn, the shape of the earth as debated (Cassini, Bouguer, La Condamine, etc.). Guettard proposed a mineralogical map of France (1746), and initiated geological mapping in Europe. Geologists identified changes in concrete space within an abstract space they did not contest? The duality of meanings for these two “spaces” is discussed elsewhere (Guy, 2021).

So, we must still clarify the link and articulation between tangible space and concrete time as offered by geology, *even speaking of an identity of space and time*. Geology helps us to think about a strong, fundamental link between space and time. This renews our approach. Deep time refers to material space; both are relative to the phenomena, but each one is relative to the other.

Interlude: relational thinking

But before we go to our thought experiment it is useful to make a stop about relational thinking. The matter is to define the functioning of a relational rationality, and apply it to our subject. We speak of relational rationality when we cannot go outside the world; we can only compare objects with one another; we are then led to adopt arbitrary (open to free will) conventions to stop endless regressions in a (provisional) fiction. In this understanding, movement has the primary role. It is the support of the embodied cognition (imagination, intuition, body knowledge; cf. phenomenology). Relational rationality is opposed to substantial rationality, when we believe we can contemplate the world from the outside, each object being looked at independently from the others.

3- Space-time: a thought experiment inspired by geology¹

So let me present my founding thought experiment and show how geology took me so far away. In my understanding, time does not exist. It does not exist alone, as an independent substance of the world. It is abstracted from the world, from which it cannot, ultimately, be separated. Specifically, for me, time is abstracted from the motion in space of material entities at large. However, when we abstract time, we construct an object which has pragmatic effects that can be studied and discussed.

To understand time is to understand its abstract nature and the very process of abstraction leading to it. To tell it short, time and space are the same. To avoid too many words, I make use of what French philosopher Bergson called the philosophical intuition, I call it the comprehensive, relation-based thinking, made of images, that comes in composition, not in opposition, with the discursive, disjunctive, substance-based thinking, mostly made of words. For issues that concern us, we especially need both.

How to speak of space and time? Neither space nor time exist in itself, but they are based on the phenomena of the world as we saw above. Let us imagine a landscape with mountains, some of them displaying folded strata. Space: some benchmarks borne by the mountains, as geographical markers that are planted there, as a set of points connected by the GPS network. Time as the sun going across the sky, or as the clouds, or as a cart: their movement allows us to classify, to sequence the events: when the cart was here, I did this, when it was there, I did that. Or, another landscape, another vision of time and space: a volcano allows to build space; ocean waves allow to build time: their progress serves me as a clock.

In what we do, we can look at space without needing to look at time. But this is not the case, and this is the heart of my discourse: time and space are not only related to the world, but also relative to, or in relationship with each other.

For a proof, a change of scale is necessary. With geologists, let us think through tens, hundreds of millions of years. The geological folds, or stone waves, are then strictly identical to the ocean waves we imagined a short while ago: they move like them and can serve us to measure time. Which served us to define space now serves us to define time.

But conversely, if we live at the scale of nanoseconds, the sand in the hourglass does not move for the duration of our entire life; the ratio of the nanosecond to the second is the same as that of the second to the century. The grains of sand may serve us as a distance gauge. What was used to set time is now used to set space.

¹ This thought experiment has been reported in several other places, e.g. in French, in Guy (2018).

Over short time scales, the ripples of a river and its swirls are similar to a landscape, we can pinpoint its irregularities to locate us.

One will say it is a beautiful allegory, but at some point, we will be able to stop and say: here is space, here is time. Well, no, in this infinite transhumance that in a way transforms time into space and space into time, we cannot stop; we are inside the world and we cannot bring rulers and clocks from outside the world to measure it. We can only compare phenomena with phenomena and, from this comparison, build space and time.

So, if we stop, it is not that we would have found a pure time, a pure space, with words defined in advance, as waiting to be used; but this is because we are tired. We stop at a scale relevant to the phenomena that we want, or that we can, study, and make a provisional sharing, between what does not move too much, we build space on it, and what is defined by comparison, and that moves more, and we call it time; but we are not sure of the ultimate meaning of the very words we use to talk about them.

4- Consequences

4.1- General consequences

All this would need longer developments. Here are some first general consequences. Time and space are of the same nature (*movement*); they are separated thanks to the multiplicity of relationships, and the sharing of them in two classes defined in opposition to each other. Space is based on invariable, or less variable relations than those on which time is defined. The limit between space and time is arbitrary (subject to free will). We use a relation-based thinking that needs to be stabilized by a decision: that of a judgment by which we choose, within the same thought, a declared constant immobility (spatial frame), in composition with a declared, also constant, mobility (the standard movement, whether human or offered by the physical world), on which our knowledge builds and loops: the postulates of relativity theory are there. In order to define measurements, we need a standard mobile in a reference frame. There are hidden conceptual loops in this process (in a way we need movement to define movement) and endless regressions.

We define speed by comparing two movements, one of which is selected as a standard.

There are no longer rulers nor clocks but only a standard movement. So today we should not talk about the speed of light because light defines both the standards of space and time; or we can say that its speed is unity or rather say that light is the standard of movement. Initially, times are plural, as are spaces, supported by the multiplicity of local movements. We deal with one time, once the standard mobile is chosen. As a recipe: *social common time refers to the position of a mobile in 3D space* (think of the position of the sun or, nowadays, that of a photon in an atomic clock). All is not solved, the mystery of time is moved, but we have new keys to reread many issues, from humanities and social sciences to physics.

4.2- Epistemological consequences in geology

We may make some reference to the consequences in geology. The concepts in pairs, that we find in the history of geology, must be discussed and understood together (and not chosen separately). Processes versus fixity; cyclic time versus sagittal time (cyclic time, as well as rhythms, are allowed by space: Guy, 2020); uniformitarianism versus catastrophism, etc.; one should not try to argue how to choose one over the other. These concepts are defined in opposition / relation to each other and the boundary between them is a matter of convention / choice depending on the spatio-temporal scales, on what we are able to measure/see, and what we are interested in (choose what to keep constantly variable as compared with what is constant). We cannot do it in any other way and it is interesting to put the finger on the point where we have made the convention. We find the same approach in physics. What link can we see between geological uniformity and physical uniformity? The hypothesis of light constancy is transported to geology within the physical laws and is another way to speak of the same time rating for mineral dissolution, heat diffusion, etc., in geological processes.

We may stress the increasing part in the vocabulary of geology, on processes that always associate space and time This is found in all fields.

- Metamorphism: (p, T) paths, propagation of metamorphic zones / facies...
- Metasomatism: propagation of metasomatic fronts; contrasted velocities of fronts; replacement; epigenesis...

- Magmatism: fusion, solidification, assimilation, differentiation, ...
- Tectonics: shortening, subduction, extension, rising, thickening...
- Sedimentology: progradation, transgression, erosion, flooding... This expresses a link between stratigraphy (vertical vision) and large-scale processes (horizontal). The names of rocks such as limestone, sandstone, claystone etc. now come together with names of processes.

We should discuss names of rocks and other geological vocabulary within a space-time relational understanding. A dynamic, non-ontological vocabulary is a matter of scale. A rock name is at first substantial; a cut has been made between space and time on our human scale. On longer scales, a piece of granite is transient, between the solidification of a magma and the weathering at the surface of the earth. This joins the considerations of French writer Roger Caillois (1980) and others on the use of geological symbols in philosophy or in poetry. We must see the movement hidden in the rocks, whereas in standard philosophy, the stone is the symbol of fixity.

4.3- Consequences in prehistory/paleontology

In Prehistory, authors have discussed the spatial dynamics of territories, the waves of progression of archeological evidence in space and time (cut / polished stone, arrows, domestication of animals, agriculture, pottery, ceramics, etc.). Michel Rasse (2015) studied the propagation of Neolithization in Europe. Space and time themselves may be defined by archeological evidence. Prehistoric waves do not stop everywhere at the same time: there are superposition, succession, competition

of waves. The input of our present studies may be to bring some epistemological and lexical insights, and to discuss the place where some conventions are made, that sustain our choices to describe the history of ancient man.

We may end with a few quotes by a French geologist who was also paleontologist and prehistorian. Teilhard de Chardin (1957) spoke of different kind of waves:

“Let us remember the waves of stone rising interminably from the depths of the past...”

“One of the most important advances made by the human mind in the last century is to have overcome the illusion of the immobile...”

“Transformism, experimentally constructed, inclines us to think that the living groups appear, follow one another and interfere a little like waves. Each group, it seems, is born in a restricted zoological and geographical domain, from rather few individuals, arrived at a same organic stage and placed in similar conditions of environment; and, from there, it spreads with more or less success on the surface of the earth.” We can speak of waves for geology as well as for living and human groups; natural and human waves may compete or work together (Guy, 2016).

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A 1958 snapshot of oceanography: the 83rd CNRS international colloquium

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In May 1958, an international colloquium, *La topographie et la géologie des profondeurs océaniques*, was convened by Jacques Bourcart (1891–1965) in Nice-Villefranche, under the auspices of the C.N.R.S., with the proceedings published in 1959 (Bourcart, 1959). About half the participants were from France (including Monaco and Tunis), with international visitors coming from Great Britain, Italy, The Netherlands, Norway, Spain, Sweden and the United States. The conference comprised a week of presentations and discussions (a few per day), and four excursions, most notably on 11 May via the vessels *Calypso* and *Winaretta Singer* to explore “Coupes topographiques des vallées sous-marines de Nice.” Participants also viewed the film *Mars et Neptune* (Ertaud & Tailliez, 1957) about diving techniques and including pioneering underwater color footage.

The conference proceedings and pursuant discussions provide a disciplinary temporal snapshot not only of deep-sea marine geology and topography (as per the volume title), but also of tectonics and the nature of continental margins, as well as of physical and biological oceanography, and of developing methods in oceanographic exploration. Several papers focused on the Mediterranean, therein highlighting the state of tectonic thinking before plate tectonics, as well as the nature and composition of the sea floor, the origin of submarine canyons and seamounts, and the history of sea-level change and climate. The very last symposium topic represented “the elephant in the room” – a presentation by Bruce Heezen (1924–1977) on mapping the North Atlantic sea floor (and its mid-ocean-ridge rift) and favoring continental drift: “Géologie sous-marine et déplacements des continents.” The cartographic work of Heezen and Marie Tharp (1920–2006), was in this time frame (1957) getting its first scientific presentations and had yet to be published (Heezen *et al.*, 1959). Needless to say, the map and Heezen’s interpretation generated an animated discussion.

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The history of the Brazilian geological map and iron mining in Minas Gerais state: the contribution of John Casper Branner

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In 1919, the Brazilian geological map showed a synthesis of the geological units of the whole country, as well as its main mineral resources (Branner, 1919). The final layout of the map was done by John Casper Branner. He had done much of his studies and geological training in Brazil and most of his professional life was spent in successive trips and contacts in this country. Branner interacted with many geologists and experts in mining and metallurgy of that time, who worked in private companies or in governmental agencies. An important result of these activities was the synthesis of the national geological map. Luis Felipe Gonzaga de Campos, Orville Adelbert Derby, João Pandiá Calogeras, Antonio Olyntho dos Santos Pires, Roderic Crandall, E.C. Harder, R.T. Chamberlin were Branner's main interlocutors on iron ores and, in many cases, on the various parts of the map. The map represents a synthesis of early field activities, as well as Branner's work to aid the geological formation of the Brazilian people (Branner, 1915). His *Elementary Geology* of 1915 already brings together many synthetic elements on the geology of Brazil. Two criteria guided the organization of geologic units in the map, stratigraphy and economic geology. The map reveals the main mining activities in the first part of 20th century. Iron and manganese from Minas Gerais state have been given special attention with carefully descriptions. This suggests that the publication of the map is connected with changes in mining and steel legislation since 1915.

Branner, J. C. (1915). *Geologia elementar: preparada com referencia especial aos estudantes brasileiros e á Geologia do Brasil*. Francisco Alves & C., Rio de Janeiro, 396 p.

Branner, J.C. (1919). *Resumo da Geologia do Brasil para acompanhar o Mappa Geológico do Brasil*. Escola Superior de Agricultura de Mossoró, Mossoró (RN), 152 p

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Lichtenberg on “Geological Fantasies,” a reconsideration

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In a characteristically witty essay on “Geological Fantasies”, the physicist and aphorist Georg Christoph Lichtenberg took aim at theories of the earth’s origin, such as they were, at the close of the eighteenth century. The subject was profoundly important, he noted, and not just for the history of the earth, but for the history of the mind: “It is unbelievable what revolutions of the earth have done for revolutions of the mind. Just as one finds sea creatures on mountain peaks in the former, without trace of a sea far and wide, so one finds in the latter, with astonishment, conclusions without trace of a sure premise so far as the eye can see” (Lichtenberg, 1795). Less pointed versions of his observations are the standard fare of histories of geology, where free-wheeling speculation gives way to the calm observations and principles of a science. Yet there is more going on in Lichtenberg. Goethe observed that “Lichtenberg’s writings can serve as the most marvellous divining rod: where he makes a joke, a problem lies hidden” (Goethe, 1988). Indeed, Lichtenberg hoped that careful observers such as de Luc and De Saussure, who spent years climbing mountains, and others such as Werner and von Trebra, who spent much time in mines, might find a way to draw their experiences into a complete theory of the earth. But the “spirit of observation”, he noted, did not always lend itself to a sense of making connections and creating a whole. Lichtenberg showed considerable insight into the challenges of doing geology in a revolutionary age, and his reflections are apt for our own era, in which the geosciences are deeply tied up with the extractive industries and, at the same time, offer rich accounts of the earth’s history and dynamics.

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Goethe, J. W. von. (1988). *Maximen und Reflexionen*. In: Goethe, *Werke, Hamburger Ausgabe*, vol. 12. Deutscher Taschenbuch Verlag, Munich, p. 365-547.

Friedrich Voltz (1828-1855), discoverer of the Guiana Shield greenstone belt

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The German geologist Friedrich Voltz was employed in 1853 by the Dutch government as a member of a commission to assess opportunities for German settlers in Suriname. He surveyed the geology of all major rivers in the Precambrian basement in dugout canoes rowed by local indigenous and Maroon people, and collected over 900 rock samples from cataracts and other outcrops. He also collected botanical, malacological and ethnographical material. He described his findings in letters to the Dutch geologist Winand Staring, who published parts of them in Dutch journals in 1854 and 1855. Before Voltz could return to Europe and write a full report, he died in Paramaribo of yellow fever, a week before his 28th birthday. Thirty years later, the Leiden professor of geology Karl Martin, on his return from his own expedition to Suriname, also published part of Voltz's letters (Martin, 1888a) and drew the first geological map of Suriname, largely based on Voltz's observations and samples, and a few of his own (Martin, 1888b).

In his letters, Voltz recognized a W-E belt of greenstones stretching from British Guiana, previously surveyed by Robert Schomburgk, across Suriname into French Guiana, which was drawn by Martin on his map. This is the first mention of the gold-rich Maronian greenstone belt that extends over 1500 km in the Guiana Shield from eastern Venezuela through the Guianas and the Amapá state in Brazil, and continues across the Atlantic into the Birimian of West Africa. Voltz's letters were first published in full by the author (Kroonenberg, 2020), with extensive comments on the difficult social, political and logistical circumstances he faced. The letters themselves and the samples are stored at Naturalis National Biodiversity Centre in Leiden (Netherlands).

Kroonenberg, Salomon (2020). *De man van de berg. Friedrich Voltz (1828-1855), jonggestorven natuuronderzoeker in Suriname*. Walburgers Zutphen, 319 p.

Martin, K. (1888a). *Geologische Studien über Niederländisch West-Indien*. E.J. Brill, Leiden, 238 p.

Martin, K. (1888b). Aanteekeningen bij eene geognostische overzichtskaart van Suriname. *Tijdschrift Koninklijk Nederlands Aardrijkskundig Genootschap* 5, p. 444-453.

Historical stratotypes, Global Boundary Stratotype Sections and Points (GSSP) and Nature Reserves

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In the context of stratigraphy (*i.e.*, the study of the succession of strata), a stratotype is a geological section serving as a world reference for a geological stage, being a succession of strata of a given age. The name of the stage is deduced from that of the locality – or even the region – of its description, with the addition of the suffix "ian". Thus, the Burdigalian was defined near Bordeaux (*Burdigala* in Latin). Therefore, a stratotype is obviously a site of geological heritage. Most stratotypes were defined during the 19th century, largely in Europe, including about 40 in France, of which only 19 are still in use today (*e.g.*, Wever & Cornée, 2008-2018). A revision of the stratotypes is in progress, under the authority of the International Commission on Stratigraphy (ICS) of the International Union of Geological Sciences, with the aim of defining markers for the stage limits (base and top). We then speak of "global stratigraphic point" or "golden nail". For the moment, 5 have been defined in France, some of which are protected, like the Campanian-Maastrichtian limit located in Aquitaine at Tercis-les Bains (Landes). These international historical references that are the stratotypes deserve to be preserved, because they are pages of the history of our Earth. Thus, 8 French stratotypes are protected as national nature reserves, true holders of a label of scientific notoriety.

De Wever, P., Cornée, A. (Eds.) (2008-2018). Collection Patrimoine géologique [9 books dedicated to various stratotypes]. Muséum National d'Histoire Naturelle, Paris, Biotope, Mèze.

Geological nature reserve of Saucats–La Brède: 40 years of protection and preservation of the aquitanian and burdigalian (Lower Miocene) stratotypes

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The Geological Nature Reserve of Saucats-La Brède, located 20 km south of Bordeaux (Western France), was the first nature reserve created in France for the protection of geological heritage in 1982. Its purpose is to protect the historical stratotypes of the two stages of the Lower Miocene (Aquitanian and Burdigalian), which were defined there and are still today the global stratigraphic references of these stages.

These exceptional sites have a much older history, since indeed geological studies of the shelly sand levels ("faluns") of Saucats and La Brède were carried out from the beginning of the 19th century.

It was in 1858 that the Aquitanian stage was created by Charles Mayer (or Mayer-Eymar). This first study was completed by the work of many authors: J. R. Tournouër (1862), O. Linder (1868), E. Fallot (1888), A. Degrange-Touzain (1882), then in the 20th century by G.F. Dollfus, F. Daguin (1948), and more recently by P. Carbonel, P. Lozouet, B. Cahuzac, J.P. Colin, L. Londeix...

In 1892, Charles Depéret created the Burdigalian stage, which he placed above the Aquitanian, describing it as "the horizon of the faluns [*i.e.*, shelly sands] of Saucats and Léognan". Numerous publications have subsequently complemented this work. It is interesting to note that Depéret defined the entire Burdigalian stratotype in two regions: Bordeaux for the lower levels and the Rhone Valley for the upper levels.

In February 1979, in view of the risks of damage to these sites, a group of scientists, teachers, researchers and local personalities demanded the creation of a Geological Nature Reserve to protect the Aquitanian and Burdigalian stratotypes. This request had two objectives: to protect and to enhance this heritage. On June 13, 1980, an association under the French law of 1901, namely *l'Association pour la Réserve géologique de Saucats-La Brède*, was created and took the first urgent actions to protect the sites. The Reserve was officially created on September 1, 1982 (French decree n° 82.761, J.O. of September 5, 1982). We will visit the main sites of this reserve during the post-conference excursion of the Inhigeo Congress.

Cahuzac, B., Carbonel, C., Cluzaud, A., Colin, J.P., Faury, B., Gilly, Y., Lesport, J.-F., Londeix, L., Martin, N., Rocher, P. (1996). La Réserve Naturelle de Saucats-La Brède. *Echo des Faluns* n° 2, troisième édition (2020), 70 p.

Depéret, C. (1892). Note sur la classification et le parallélisme du système Miocène. *Bulletin de la Société géologique de France*, 3^e série, vol. 20, p. CXLV-CLVI

Mayer-Eymar K. (1858). Versuch einer neuen Klassifikation der Tertiär-Gebilde Europa's. *Trogen Verhandlungen der allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften*, 70-71, p. 165-199.

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Readings from Brazil on Peter Wilhelm Lund's bone caves in Minas Gerais

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The five memoirs of Peter W. Lund (1801–1880) published between 1836 and 1846 by the Royal Danish Academy of Sciences resulted from the exploration of at least 800 caves in the karst region of Lagoa Santa, Minas Gerais Brazil, which yielded around 12,000 pieces, between fragments and fossil bones, sent throughout the 1840s to Denmark. These are the most referenced Lund's works in the country to date (Paula Couto, 1950). This article considers that, contrary to what Brazilian publications claim, Peter Wilhelm Lund lacked isolation, 'protective isolation' (Rudwick, 1996), in his paleontological studies, amidst paleontological arenas where big names were fighting for big bones at the time. 'Protective isolation' means distancing oneself from the home community, testing new ideas with sympathizers but not with critics or with the whole community. But it implies risks of losing priorities. Lund widely published his first research results, which best explains the purpose of his paleontological work. These had begun without the slightest pretension of completing the work of Buckland, who did not mention Brazilian caves in his classic study and continued in disputes over priorities for new extinct animals, especially with Richard Owen. The paper examines some of the early Brazilian publications – such as the letters of the director of the School of Mines to the Emperor of Brazil, and the papers of the National Museum of Rio de Janeiro director. It also addresses the current Brazilian publications on Lund, not mentioned or little referred to in the foundational works originally published in Danish by Birgitte Holten and Michael Sterll (2011), and also highlights a little commented aspect of Lund's work on his considerations of the geological history of the continent and of “Brazil being the oldest continent on our planet”.

Holten, B. & Sterll, M. (2011). *Peter Lund e as grutas com ossos em Lagoa Santa*. Editora UFMG, Belo Horizonte,
 Paula Couto, C. (1950). *Lund, P. W. Memórias sobre a paleontologia brasileira*. Revistas e comentadas. Rio de Janeiro: Ministério da Educação e Saúde.
 Rudwick, M. (1996). Geological Travel and Theoretical Innovation: The Role of 'Liminal' Experience. *Social Studies of Science*, (26), p. 143-159

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French involvement in the geological studies of Southern Africa from the 17th to 19th centuries

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Portuguese explorers and settlers first colonized parts of Angola and Mozambique in the 16th Century. The Dutch established a colony at the Cape of Good Hope in 1652. Early French travelers in Southern Africa Jean Mocquet (1608) and Francois Pyrard (1610) described the mining of gold nuggets from Mozambique. In 1686 Guy Tachard led a group of Jesuit scholars to the Kingdom of Siam. They stopped over *en route* at the Cape of Good Hope, where Père De Beze was tasked (on behalf of Melchisedech Thévenot) with climbing Table Mountain, to find fossil evidence that the sea had once been there (Master, 2011). The astronomer Abbé de La Caille named a constellation (Mensa) after Table Mountain (1763). In 1784, the adventurer Francois le Vaillant reached the Orange River, where he discovered the first rounded pebble of tiger's eye (pseudocrocidolite) (Master, 2018). The botanist Pierre Sonnerat (1782) described the Paarl Mountain (Master, 2009). Louis Degrandpré voyaged to the Cape in 1786–1787, and wrote about the former sea levels there (Master, 2009). Short accounts of Cape geology were made by Jacques Milbert (1812). French missionaries Jean Arbousset and Eugène Casalis made the first geological observations of Basutoland (Lesotho) in the 1830s. Later the first vertebrate fossils and ichnofossils from there were described in 1870 by Fischer and Brogniart. Jules Itier (1844–1853) published the first colour geological map of the Cape. The French consul in Cape Town, Castelnau, published accounts of Cape geology and earthquakes (1858). Between 1882 and 1884, several French geologists (Guyot, Kuss, Lapierre and Zeiller) described the geology, coal deposits and plant fossils of Tete, Mozambique. After the discovery of the famous copper, diamond and gold deposits in the South African interior, many French researchers also studied them (Delesse, Desdemaine-Hugon, Meunière, Moulle, Boutan, Jacobs, Chartriand, Bordeaux, Garnier and de Launay). Master, S. (2009). Plutonism versus Neptunism at the southern tip of Africa: the debate on the origin of granites at the Cape, 1776-1844. *Earth Env. Sci. Trans. Roy. Soc. Edinburgh*, 100, p. 1-13.

Master, S. (2011). From Hondius and Thévenot to Playfair and Lyell: Unearthing the early history of geology in South Africa. *GeoSynthesis 2011*, Geol. Soc. S. Afr., 30/7- 1/8 2011, Cape Town, p. 1-2.

Master, S. (2018). The discovery and description of crocidolite and pseudocrocidolite (tiger's eye) from the Northern Cape (1784-1811). *Geocongress 2018*, Geol. Soc. S. Afr., Johannesburg, 18-20/7 2018.

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Reasoning about the Earth's Underground: visual evidence, imagination, and authenticity in the travel accounts of the naturalist Joseph A. Nagel (1748/49)

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This paper offers novel insights into the techniques of evidence- and trust-building in early-modern fieldwork practices in caves.

In the late 1740s, the Westphalian scholar Joseph Anton Nagel (1717–1794), later mathematician at the Viennese court and director of the Cabinet of Physics, was commissioned by Emperor Franz Stephan of Lorraine to investigate the Habsburg dominions' natural curiosities on-site. Two richly decorated handwritten accounts dedicated to Franz Stephan, in which Nagel reported on his trips to Lower Austria, Styria, Carniola, and Moravia remain from his numerous journeys. The destinations of his ventures were predominately geological features such as mountains, caves, and other karst phenomena, oftentimes with the purpose of collecting mineral and fossil specimens for the emperor's private collection. For his so-called "experiments", Nagel was accompanied by guides and draughtsmen. He had measurements taken and excavations made, maps and prospects drawn. The credibility of locals' and naturalists' assumptions as well as his own observations he had meticulously checked and discussed in relation to contemporary concepts about cave formation. Nagel thus was the very first from whom descriptions of caves and karst phenomena from different regions have been preserved, even if his treatises were solely to be read by the emperor and were not published.

Based on an edition project, rendering Nagel's travel accounts accessible to English-speaking scholarship, this paper deals with his practices and methods both in the field and on the paper, with which credibility and authenticity were communicated. It will be examined to what extent underground sites, their topography, and visual limitations stimulated or challenged the process of knowledge production. In which contexts did Nagel clearly distinguish between in-depth personal observation and imagination or combine both to develop a more convincing argument?

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Painting the mountains between art and Earth sciences during the second half of the 19th century: some French case studies

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The aim of this paper is to study the production of a new visual culture related to Earth sciences during the 19th century. It especially considers the influence of Earth sciences progresses on figurative arts, and the notions of territory and national soil as they're shaped by the Romantic culture. In this context, mountain paintings are particularly relevant since they embody multiple layers of both identity-related and scientific issues. To analyze these new images of the Earth, the main case study is that of the Savoyard painter Claude Hugard (1816-1885). A turning point in his career is the decoration for the mineralogy museum of the *École des Mines* in Paris (1852-1859), also inspired by that of the Natural History Museum's gallery of mineralogy. His subsequent work shows the influence of this collaboration with engineers and geologists, and in 1863 Hugard also works with Louis Figuier within the frame of the publication of *La Terre avant le deluge*. Thus, Hugard's case sheds light on the broader evolution of Earth sciences visual culture and its dissemination during the second half of the century.

Karl Mayer-Eymar and the history of messinian stage

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In 1867, the Swiss geologist Karl Mayer-Eymar, supported by the Italian Giuseppe Seguenza, proposed the Messinian stage (Mayer-Eymar, 1867). In his "*Tableau des terrains*", dated 1868, Mayer places the Messinian above the Tortonian and just below the Astian, which at that time represented the current Pliocene. In the same table, he divided the Messinian stage into three substages (from bottom to top): Billowitz strata, Inzersdorf strata, Eppelsheim strata, which, in 1881, were renamed into: Billowitzin, Inzersdorfin and Materin. Later, they were reduced into Billowitzin and Materin (Mayer-Eymar, 1889).

Today, the Messinian stage is not subdivided and represent the uppermost stage of the Miocene. It dates between 7.246 Ma and 5.333 Ma, follows the Tortonian and is followed by the Zanclean, the first stage of the Pliocene.

This stage is represented by sediments deposited in open marine, brackish and fresh-water environments. Mayer-Eymar proposed the Messinian stage, deriving the name from the town of Messina, in Sicily, in which neighbourhood crops out the marine facies.

The Messinian stage is well represented in Italy and, although without very representative paleontological characters, it is easily recognisable on the field. Over time, other terms were defined (Sarmatian, Pontic, Sahelian, etc.), but these are not easily correlated with the Italian series.

Already from the definition given by Mayer-Eymar, the evolution of the stratigraphy of the Messinian has been much debated, because of the regional extension of its outcrops and paleontological specificities.

In the Messina area, and in the whole North-Eastern part of Sicily, stratigraphic and tectonic problems make it impossible to have a reference section suitable for the formalisation of this stage. At last, Raimondo Selli in 1958 established the stratotype in the "Pasquasia-Capodarso" section, which is reduced in thickness but complete and continuous.

Mayer-Eymar, K. (1867). *Catalogue systématique et descriptif des fossiles des terrains tertiaires qui se trouvent du Musée fédéral de Zürich. Deuxième cahier*. Librairie Schabelitz, Zürich, 65 p.

Mayer-Eymar, K. (1881). *Classification internationale, naturelle, uniforme, homophone et pratique des terrains de sédiment suivie dans son cours de stratigraphie par C. Mayer-Eymar*. Manuscript, ISPRA Library.

Mayer-Eymar, K. (1889). *Tableau des terrains de sédiment*. Soc. Hist. Nat. Croatica, Zagreb, 35 p.

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Forma Vesuvii

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This work is aimed at reconstructing the morphology of the volcanic edifice of Vesuvius before the most famous eruption that occurred in 79 AD, destroyed the cities of *Pompeii*, *Herculaneum*, and *Stabiae*, and was described by Pliny the Younger. This result has been achieved by using both volcanological data and historical documents. The previous history of the volcano and the distribution of the deposits of the 79 AD eruption has been used as a guide for the reconstruction of the pre-eruptive morphology. This is consistent with the few indications given by the ancient writings and the frescoes found during archaeological excavations in *Pompeii* and *Herculaneum* and provided important information on the Avellino eruption relict morphology as well.

Principe, C., Paolillo, A., La Felice, S., Arrighi S. (2021). Forma Vesuvii – 2 Volcanic morphology at the time of the 79 AD Plinian Eruption. *Physis*2021/1-2 (LVI). p. 289-302.

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The puzzling archaeology of Gypsum Cave, Nevada (U.S.A.) and the question of When Humans First Arrived in North America

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In the 1920s and '30s, a vigorous debate raged among archaeologists concerning the timing of the arrival of humans in North America. It was well known that many species of the North American megafauna – mammoths, mastodons, saber-tooth cats, dire wolves, giant ground sloths, and many others – had become extinct near the end of the Pleistocene Epoch, but it was not known whether humans had been in North America prior to that mass extinction.

A prominent archaeologist who was committed to answering this research question was Mark Harrington. Contrary to many of his American colleagues, Harrington strongly suspected that humans had arrived in North America early — prior to the extinction of the megafauna. In 1930, he excavated Gypsum Cave, near Las Vegas, with high hopes of finding evidence that would confirm his early-arrival hypothesis. Harrington and his crew excavated the bones of Pleistocene camels, horses, and ground sloths, as well as many archaeological artifacts. In multiple trenches, he discovered Native American projectile points with wooden shafts that were stratigraphically beneath a layer of ground sloth dung. He was certain that he had found incontrovertible evidence that humans had been present in the cave prior to the extinction of the ground sloths (Harrington, 1930, 1933).

In the 1930s, radiocarbon dating was not available to confirm Harrington's conclusions. Decades later, radiocarbon dating revealed that the sloth dung was around 11,000 years old – a late Pleistocene age – while the wooden artifacts yielded a much younger, late-Holocene date of around 2,400 years (Heizer and Berger, 1970). Young artifacts had been found beneath old sloth dung! By then, evidence from other sites had firmly established that Harrington was correct in his suspicion that humans had arrived in North America prior to the extinction of the megafauna, but his Gypsum Cave story fell apart. To this day, the stratigraphic anomaly of Gypsum Cave remains a puzzle.

Harrington, M.R. (1930). The mystery of Gypsum Cave. *Scientific American*, p. 34-36.

Harrington, M.R. (1933). Gypsum Cave, Nevada. *Southwest Museum Papers*, No 8, Southwest Museum, Los Angeles, 107 p.

Heizer, R.F. & Berger, R. (1970). Radiocarbon age of the Gypsum Cave culture. *Papers on Anthropology of the Western Great Basin*, Contributions of the University of California Archaeological Research Facility, No 7, p. 13-16.

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Writing humans out of the landscape: antiquarians and geologists on the Parallel Roads of Glen Roy

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Some of the most spectacular landscapes in northern Europe feature terraces left by glacial lakes, notably in the Scottish Highlands at Glen Roy. This paper examines the famous 'Parallel Roads' as a way of understanding how local stories about the European landscape were replaced by geological ones during the decades around 1800. My aim will be to look at the different kinds of authority invested in knowledge, from Gaelic shepherds and guides to military surveyors, antiquarians, and geologists. What did it mean for geologists to scale up globally valid interpretations in a context dominated by military conquest, economic collapse, and cultural suppression? How do the universalizing aspirations of science relate to the perspectives of the people who live in what geologists define as field sites?

Pennant, Th. (1771). *A tour in Scotland*. John Monk, Chester, p. 253-257.

Rudwick, M. (1974). Darwin and Glen Roy: A 'great failure' in scientific method? *Studies in the History and Philosophy of Science*, 5, p. 97-185.

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Les affinités électives de Georges Cuvier

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Les relations professionnelles et académiques de Georges Cuvier ont été très nombreuses tout au long d'une carrière particulièrement féconde ; elles sont relativement bien connues grâce à sa correspondance, à ses publications et à ses rapports administratifs. Par contre, les informations sur sa vie personnelle, ses sentiments, ses relations amicales ou amoureuses restent parcellaires, ses archives privées ayant été détruites par sa famille après sa mort. Fort heureusement, un certain nombre de lettres, de journaux intimes et de témoignages apportent quelques lumières sur la personnalité et les fréquentations du grand naturaliste.

Christoph Heinrich Pfaff et Karl Friedrich von Kiemeyer, ses compagnons allemands de l'Université Caroline, la comtesse d'Héricy et son fils Achille, ses hôtes normands, Étienne Geoffroy Saint-Hilaire, Alexandre Brongniart et Constant Duméril, ses collègues naturalistes, Émilie Brongniart et Laure Brack ses amies parisiennes, ont fait partie du cercle restreint de ses relations. Son frère Frédéric et le préparateur Charles-Frédéric Laurillard ont accompagné le naturaliste dans ses travaux ; Adriaan Camper et Giovanni Fabbroni, ses confrères étrangers, ont eu de fructueux échanges avec lui ; sa femme Anne, sa fille Clémentine et sa belle-fille Sophie Duvaucel ont animé son cercle familial. Tous et toutes, grâce à leurs différents témoignages, nous permettent de mieux connaître l'homme, son caractère, ses sentiments, ses qualités, ses faiblesses, ainsi que les affinités électives du grand naturaliste.

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La chasse aux ossements fossiles: French women in vertebrate palaeontology

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A look at women who have contributed to understanding fossil vertebrates in France, shows that they have primarily been palaeoichthyologists and palaeomammalogists. Rare 19th (Mme de Christol, unknown dates) to early 20th century women were based mainly in Paris at the *Museum National d'Histoire naturelle*. Cuvier supported women in his own family and others worked at the museum (Taquet, 2006).

Madeleine Friant (1892–1974) seems to be the first woman in the 20th century, although she came from a medical background and achieved an assistant directorship of comparative anatomy. Friant is one of the few/only to sign Lady Maud Woodward's famous embroidered tablecloth (Milner, 2016). French palaeontologist and biostratigrapher Henriette Alimen (1900–1996) was one of the first women to submit a doctoral thesis in the field of prehistory and had a career focused on Quaternary geology and vertebrates in France and Africa, including hominids; she gained the Légion d'Honneur.

Most women have worked since WWII (e.g., Berta & Turner, 2020), such as Jeanne Signeaux (1902–1987) who was assistant to Camille Arambourg for 25 years in the Institute of Paleontology. Other French women VPs have 'operated' in different parts of the world related to former French colonial possessions and also language preference, principally in Africa, the Middle East, and Asia. One, Christiane Hélène Mendrèz-Carroll (1937–1978) conducted important research on South African dicynodonts before her tragic death. Many moved into other professions after their early research for lack of jobs and did not obtain an obituary or memorial, remaining almost 'invisible'. Apart from the capital, main centres have been Montpellier, Strasbourg and Lille.

Berta, A. & Turner, S. (2020). *Rebels, Scholars and Explorers: Women in Vertebrate Paleontology*. The Johns Hopkins University Press, Baltimore, 328 p.

Milner, A.C. (2016). Lady Smith Woodward's tablecloth. In: Johanson, Z., Barrett, P.M., Richter, M., Smith, M. (Eds), *Arthur Smith Woodward: His Life and Influence on Modern Vertebrate Palaeontology*. Geological Society, London, Special Publication 430, 89–111.

Taquet, P. (2006). *Georges Cuvier. Naissance d'un génie*. Odile Jacob, Paris, 539 p

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The recordings of the talks from those of you who have agreed their diffusion are available at the addresses below:

INHIGEO 2022 – All communications (17-21/09/2022)

<https://www.youtube.com/playlist?list=PLrHyJcVtILnI4-CpXWuoX9-451OS7xk3R>

INHIGEO 2022 - History of Neogene geology (21/09/2022)

https://www.youtube.com/playlist?list=PLrHyJcVtILnntOZB0PQb6yr_O_YaXz07O

INHIGEO 2022 - Prehistory & Geology (17/09/2022)

<https://www.youtube.com/playlist?list=PLrHyJcVtILnnFDpL3r6LONN1Xs1WfoOH8>

INHIGEO 2022 - History of geology: Varia (20 & 21/09/2022)

<https://www.youtube.com/playlist?list=PLrHyJcVtILnlgFTRIYW92SR5fiteRUNWn>

INHIGEO 2022 - French case studies in the history of geology (18/09/2022)

<https://www.youtube.com/playlist?list=PLrHyJcVtILnnzAfl0auzzFVdR7DCfiKZ7>

INHIGEO 2022 - History of geology: Concepts - (18/09/2022)

<https://www.youtube.com/playlist?list=PLrHyJcVtILnlqf0QRrTS0AfDSqJu0dx2J>

The freeze of the cover is taken from the book *La caverne de Font-de-Gaume aux Eyzies (Dordogne)*, by L. Capitan, H. Breuil et D. Peyrony (1910).

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That *History of geology* remains an active field of research is once more shown by this collection of 20 papers and 14 abstracts, the outcome of the 47th annual INHIGEO meeting that was held from September 15 to 24, 2022 in and around Les Eyzies (south-western France).

Whether dealing with Prehistory, geochemistry, geological exploration, great geologists, or medieval or Renaissance concepts, all these articles provide first-hand information that will prove valuable to all readers in various aspects of the history of geology.

