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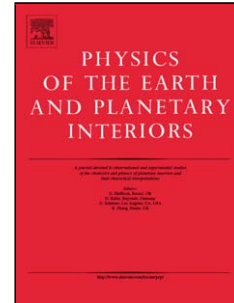
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MONTESUS DE BALLORE, A PIONEER OF SEISMOLOGY: THE MAN AND HIS WORK

by

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ABSTRACT

Ferdinand de Montessus de Ballore was one of the founders of scientific seismology. He was a pioneer at the same level of Perrey, Mallet, Milne and Omori. He became familiar with earthquakes and volcanoes in Central America (1881-1885). After his experience in El Salvador his interest for understanding earthquakes and volcanoes oriented all of his life. Back in France he worked out a most complete world catalogue of earthquakes with 170.000 events (1885-1907), and completed his career being the head of the Chilean Seismological Service (1907-1923). Many of his ideas were in advance of later discoveries. He was an exceptional writer and published more than 30 books and hundreds of papers.

INTRODUCTION.

In 1959 Cinna Lomnitz, then Director of the Geophysics Department in Chile, showed me a photo of Montessus de Ballore taken from a journal. It was a collection of small points giving the appearance of a face. This is the only photo we have from him, he told me. Later on, in 1972, I was looking for books published by Montessus. Then I was told that a retired professor of engineering of the University of Chile was selling his books. I went to his home and learned from him that the Montessus family existed in Chile but with the name of Bacarreza, since only his daughter had children. He gave me the address of the granddaughter and I went immediately to see her. Mme Maria Bacarreza de Hermann was a charming old lady, and she gave us a chest complete with books, photos, writings and other belongings of the great man. All of this material is now in the Library of the Department of Geophysics of the University of Chile. This finding permitted, in 1973, the commemoration of the 50th anniversary of the death of Montessus de Ballore with active participation of the French Embassy in Chile, and the presence

of well known seismologists like K. Aki, L. Knopoff, J. P. Rothé and P. L. Wilmore.

Ferdinand de Montessus de Ballore, together with Perrey, Milne, Mercalli, Wiechert and others, belongs to the selected group of scientists that initiated the scientific study of earthquakes by the end of the nineteenth century. Seismology at the time was only beginning to develop. Robert Mallet had collected a catalogue of 7000 historical earthquakes in 1858. Later on, Alexis Perrey made a more detailed research for 21 regions of the Earth. The quantitative evaluation of earthquakes began with the Rossi-Forel intensity scale of ten levels in 1873. In 1883, Mercalli extended the definition of intensity and Cancani defined a scale of 12 levels in 1902. On the other hand, in 1880, Milne began with the search for instruments capable of recording the complete displacement of an earthquake at a site. The first recordings were obtained in 1889 in Potsdam and in 1892 in Strasbourg. Finally, Wiechert (1900) and Galitzin (1903) succeeded in constructing reliable 3-components seismographs.

Montessus de Ballore was born in 1851, within a well-established family belonging to the French nobility. He had access to the best possible education, and succeeded in entering the Ecole Polytechnique. There he received training in mathematics and physics that corresponded to the top level at the time. As the students of Polytechnique were strongly connected to the military, he joined the army and became an expert in artillery.

Fig. 1.

Although an unlikely early career for a future seismologist, his choice opened him the way to the encounter of the earthquake phenomena. In fact, in 1881 he was sent to Central America to establish cooperation with the Salvadorian Army. There he discovered earthquakes and volcanoes, his admiration was without limits, and from there on he tried to understand the profound reasons of their existence. Being back to France in 1885 he devoted himself to the study of earthquakes at a world level, while keeping his engagements with the French Army and Ecole Polytechnique. In 1906 he left the Army, and in 1907 he went to Chile to become Director of the Seismological Service. There he established one of the best seismological networks of the time. During his tenure at the Service he carried out

an impressive work on the collection and interpretation of worldwide earthquake data. He died in Chile in 1923.

In this article we will describe the main works of Montessus de Ballore, and their actual interest in seismology. In particular, we will show that his approach is not only descriptive but that he was deeply interested in understanding the physical nature of the earthquake generation process. In this text we refer to the English titles of his publications, but show the original titles, mostly in French or Spanish, in the References.

EL SALVADOR: DISCOVERY OF EARTHQUAKES AND VOLCANOES

French influence in El Salvador was important during the second half of the 19th century. Thus, it was natural for President Zaldívar to ask France for assistance in artillery training of young Salvadorian officers. Montessus de Ballore was named head of the French military mission in 1881. He moved to Salvador with his wife, Mme. Jeanne-Rosalie Poussigüe, and accomplished his task with the same efficiency he had shown in the French Army.

Very soon, his curiosity was attracted by the originality of the archeological monuments and, in particular, the Indian ceramics. But, above all, he discovered there the phenomenon that would transform his life: the impressive activity of earthquakes and volcanoes in Central America. He became fascinated by it, and spent all of his free time doing research in the field and in libraries, trying to understand the profound significance of these events. It is necessary to recall that there was neither a physical model, nor any organized scientific research on the subject at that time.

Fig. 2.

Thus he decided to collect data during all of his stay in El Salvador. The results were published in the book “Earthquakes and Volcanic Eruptions in Central America from the Spanish conquest up to present”, first in Spanish in 1884, and later on in French (1888). In this book he considered several questions related

to earthquakes: he showed that there was independence from climatic and astronomical events, something that was popular at the time. Nevertheless, he concluded that there was more seismic activity during the night.

But the main impression he took out of his research was that El Salvador, or even Central America, was not large enough to have the variety of information that was necessary to really understand the phenomenon. His choice was to collect all known data at a global scale, and this project took him the rest of his life.

His military commitment in El Salvador finally changed again his destiny. President Zaldivar was preoccupied with the conflict with Guatemala. Very soon political differences between both countries lead to war and Montessus actively participated in it. The war ended in an unexpected way with the victory of El Salvador thanks to the death of Barrios, the Guatemala President. Nevertheless, the conflict weakened the position of President Zaldivar, and soon there was a rebellion against him that put into power a new President. Given the new situation Montessus decided to go back to France in 1885, since he had been closely associated to Zaldivar.

BACK TO FRANCE: WORLD SEISMOLOGY

Back in France he returned to the Army, but he also became director of studies at the “Ecole Polytechnique”. In this double position he could combine the military obligations with his personal commitment to research in seismology.

During the 25 years he stayed in France he published 23 articles on the historical seismicity of different regions of the world. In order to obtain first hand information about earthquakes he kept a permanent correspondence with specialists of all countries, writing continuously letters all of his life. His personal files with data about world wide earthquakes grew up to 170.000 events. It was the largest known collection at the time. These files are now at the National Archives in Paris.

He finally published in 1906 his book on “Earthquakes (Seismic Geography)”. This impressive work gave a complete account of the state of seismology at the time, and described the seismic activity of the complete world. Moreover, he succeeded in establishing some general laws for the earthquake generation process. In particular, he established the geographic distribution of

earthquakes, and realized that they were associated to instability of the crust related to the relief. His data showed two great lines of seismicity cutting at 67° : one was the Alpine-Caucasian-Himalayan zone and the other was the Circum-Pacific zone. He was careful to quantify the size of earthquakes by using the Intensity measured at different points, and he was the first to introduce Roman numbers to indicate intensities. For the quantification of the activity of a region he proposed to use the size of the area with 1 earthquake by year as the unit. He also tried another method selecting Centers and cumulating the number of earthquakes within 20 km of the Center. Next, a circle proportional to that number was drawn around each Center.

He used not only qualitative data, but he considered the information coming from instruments, even though they were not numerous at the time. He reports instruments observing near and far earthquakes, and even waves traveling around the Earth. The relationship between faults and earthquakes is also clearly established by him.

Fig 3.

Since “Seismic Geography” contains mostly observations, he published in 1907 another book, “The Science of Seismology”, containing the physical principles he could obtain to explain the enormous quantity of data he had gathered. The book was presented by one of the good friends of Montessus, the well known Viennese scientist Edouard Suess. Many subjects were discussed in this work: a) A criticism of the notion of epicentre, based on what is now called the fractal structure of isoseismals (curves of equal intensity). Indeed, by using isoseismals he came to the conclusion that there was a complex surface of rupture rather than a single point source. b) A classification of seismic events into Microseisms, Macroseisms and Megaseisms. c) The distinction between aftershocks and premonitors. d) The relationship between submarine earthquakes and tsunamis and, in particular, the draft of “homoseistes” showing the advance in time of the tsunami wave, generated by the 1868 Peruvian earthquake, across the Pacific. e) A synthesis of instrumental seismology, describing seismographs and seismograms, and observing that large earthquakes could be registered by instruments all over the world. f) Two sections on the geological effects of earthquakes and on the damage produced in buildings.

The work contained in “The Science of Seismology” was rewritten by Montessus in a language that made it accessible to the general public in a shorter book entitled “Modern Seismology”, which was published in 1911.

THE CHILEAN SEISMOLOGICAL SERVICE

In 1906 there was a most destructive earthquake that affected the city of Valparaiso, the main coastal resort in Chile. Pedro Montt, then president of the country, realized that there was no expertise about earthquakes in Chile, and took the wise decision of asking the different Embassies to look for a first class seismologist. Montessus de Ballore was already well known at the international level. He had been participating in international meetings, kept abundant correspondence with the best seismologists, and his publications were well appreciated by the scientists everywhere. The Chilean Embassy in France contacted him, and he accepted immediately, arriving in Chile in September 1907. His main task was to develop the Chilean Seismological Service starting from zero. This he did very rapidly, installing one of the best seismological networks at the time. Indeed, the first issue of the Bulletin of the Seismological Society of America published, in the first page, a map of the distribution of seismological stations in Chile.

In Chile, he continued his research work on world wide earthquakes. He published his most impressive collection of data about historical earthquakes in 1916 under the title of “General Bibliography of Earthquakes”. It consists of eight volumes with the titles of all of the works he consulted on different regions of the Earth, like Northern and Central Europe, Circum-Mediterranean countries, Asia, Africa, Oceania, America and Antarctic territory. He also included a bibliography on general subjects such as the physical basis for seismology, geology and engineering.

Fig. 4.

His commitment to understand the earthquake process in Chile, gave rise to several publications centred on earthquakes of the southern Andean region. This

work on the “Seismic History of the Meridional Andes, south of parallel 16°” is also a monumental work in six volumes, including Southern Peru, Bolivia, Chile and Argentina. In particular, volume 5 deals with the Valparaiso 1906 earthquake, the one that motivated his arrival to Chile.

The observations about Chilean earthquakes were published in the “Bulletin of the Chilean Seismological Service”, a careful description of Chilean earthquakes with 13 volumes concerning the years 1906-1915. Some volumes of the Bulletin were “Memoirs” devoted to more general seismological subjects: the lack of periodicity of Chilean earthquakes, the seismic rules of construction, and seismology at the time of Greeks and Romans, among others. The Bulletin was continued by M. Carlos Bobillier who succeeded Montessus de Ballore in 1923.

Fig. 5.

The “Art of building in Earthquake Countries”, published in 1907, is a compendium of the knowledge about seismic engineering collected in the most advanced countries. The high quality training he had in Physics and Mathematics in “Ecole Polytechnique” helped him to understand in depth the physics of structures subjected to earthquakes. His courses about earthquake resistant construction started in 1909 in the Engineering School of the University of Chile. They had a large influence, and are still remembered today. The importance of horizontal motion, the behaviour of soils, the role of reinforced concrete and the selection of the best materials and structures for buildings are carefully analysed in the book.

The Belgium scientist Armand Renier indicates correctly that the whole work of Montessus de Ballore is the result of a well conceived program that was carefully put into practice.

Evidently, his role as creator and organiser of the Chilean Seismological Service was the culmination of the scientific work of a person who was at the top of the knowledge at the time. It is interesting to recall an anecdote that reflects his personality: He suffered a personal attack in the press from somebody who accused him of not being able to predict earthquakes. This is a subject that is under discussion still now! But Montessus answered in a most correct way, explaining the state of scientific knowledge about the problem, and the need of collecting well

recorded earthquakes in order to arrive to a profound understanding of the nature of the process.

During all of his life he was a practicing catholic, and his actions always followed the highest standards. He had active participation in the Conferences of Saint Vincent de Paul. Nevertheless, his deep liaison with the church did not stop him from using his fine irony to punish Father Moreaux, who did not consider a sin to use the work of Montessus, and that of other seismologists, as his own.

He was a person of exceptional culture, with a wide spectrum of interests, well beyond his engagement in the Army. Being in El Salvador, he was also interested in Salvadorian archaeology, and in the ethnography and the traditions related to earthquakes and volcanoes. He was also an excellent professor, mastering several languages, including Latin and Greek. Later on, in Chile, he published a fascinating study about the relationship of earthquakes and the so called voices of an ancient couple of Egyptian statues named after Memnon. Direct studies of the original writings about the phenomenon lead him to deny a connection of the destruction of one of the statues with the occurrence of an earthquake.

During his life he received honours from the French Academy of Sciences, the Seismological Society of America, the “Ecole Polytechnique” and the University of Chile. Numerous distinctions and medals keep his memory alive.

Finally, he was essential in building the Chilean Seismological Service in order to record earthquakes in one of the best natural laboratories in the world.

POSTUME PUBLICATIONS

His death in 1923 was a great loss for the seismological community, and in particular for Chile. Being as he was, he continued to work up to the last moments. Two of his late works were published in France after his death, in 1923 and 1924, under the responsibility of his brother Robert.

The first one, “Seismic and Volcanic Ethnography”, is a personal collection of legends about earthquakes and the interpretations that men of different epochs, and regions, imagined about the origin, the understanding and the meaning of earthquakes, not only from a scientific point of view, but from a profound human relationship with an always present catastrophe. He classified the topics into pseudo-scientific theories (The Atlantida, the Aristotelian Theory of earthquakes),

mythology and the Bible, and religious beliefs and superstitions (like Sodoma and Gomorra, or other punishments from God). An important contribution is made by the analysis of the myths of the aborigines of southern Chile, the Mapuches, who had very precise descriptions of tsunamis and coastal uplifts, well inserted in the oral traditions as a consequence of the fights among the gods.

The second one, “Seismic Geology”, is an extension of “Seismic Geography”, to include a unifying scientific structure behind the generation of Earthquakes and Volcanoes. It is a most impressive presentation of the problem, well in advance of his time. He puts priority to relate earthquakes and volcanoes to the unstable nature of the folded architecture of geosynclines, as opposed to the flat structure of stable continental areas. He established in a clear way that earthquakes reflect the tectonic and epirogenic stresses that are responsible for the relief.

I would like to end this short description of the main features of Comte Ferdinand de Montessus de Ballore works and life, by expressing my admiration to the impressive work he accomplished in establishing a solid scientific basis to a young discipline that was only beginning to develop at that time. Besides, the history of seismology in El Salvador and in Chile would not be the same without him.

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FIGURE CAPTIONS

Fig. 1 Montessus de Ballore (arrow) with his class mates in “Ecole Polytechnique.

Fig. 2. Montessus de Ballore with his wife in El Salvador.

Fig 3. Montessus de Ballore as officer of the French Army. Photo published in the Bull. Seism. Soc. Am. in 1912.

Fig. 4. Montessus de Ballore and the seismic recorder installed in Cerro Santa Lucia (Santiago, Chile).

Fig. 5: World wide earthquake map given in “Modern Seismology”. The distribution shows mainly the Circumpacific and the Alpine-Caucasian-Himalayan zones that Montessus interpreted as the two main seismicity belts.

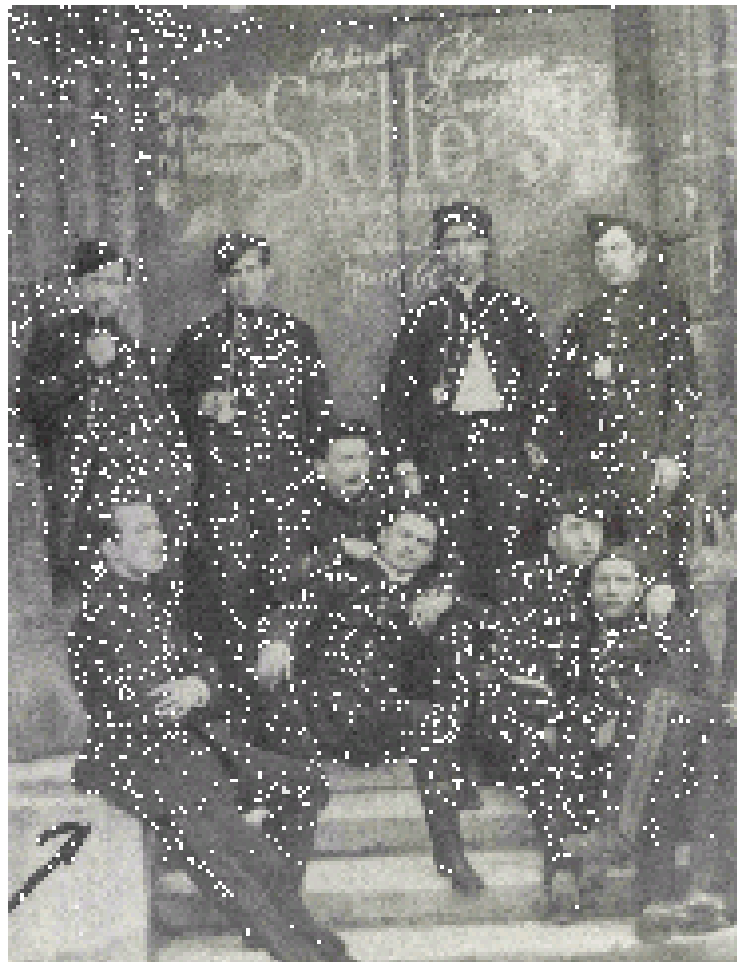


Fig 1



Fig 2

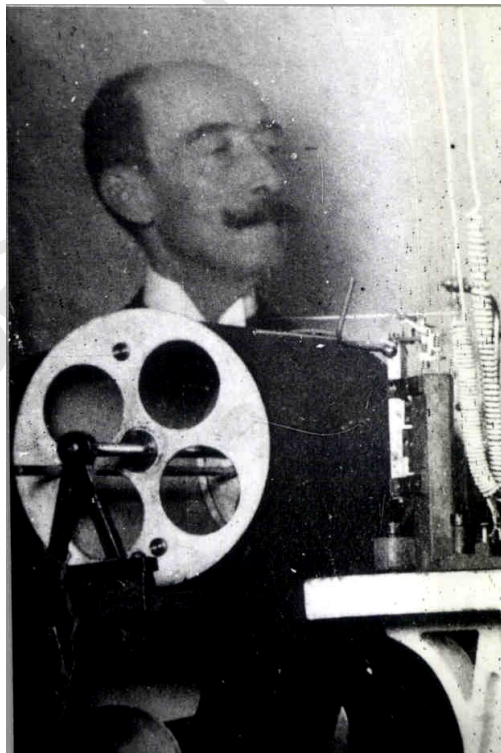


Fig 3

Bull. Seism. Soc. Am.

Vol. II, Plate 11



Conte de Montepulciano

Fig 4

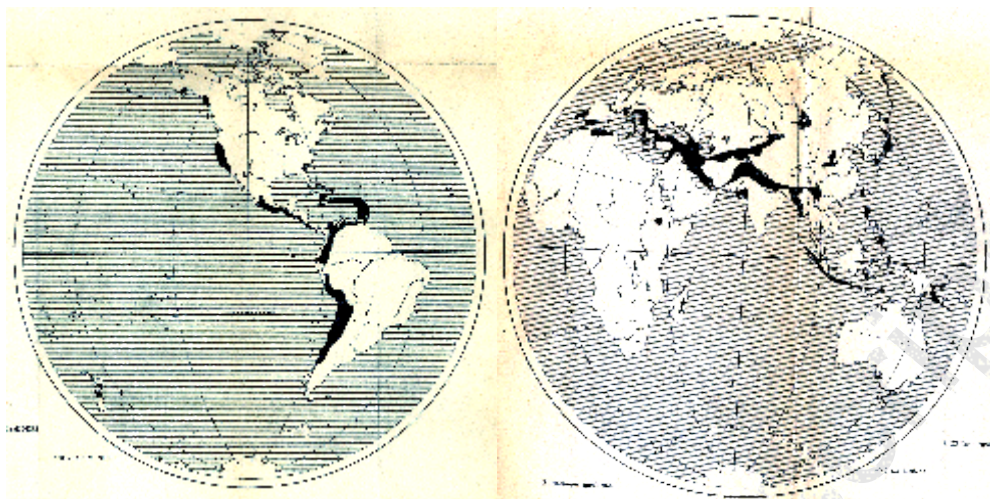


Fig 5