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Research Paper

Geodiversity photographed: An exploratory and iconographic study of geoheritage in protected areas

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ABSTRACT

This paper is part of the scope of cultural geodiversity and mobilizes photography in order to understand the role it has played in the knowledge of geodiversity and in the recognition of geoheritage. To carry out this research, four books written and directed by specialists in the photographic medium were used. They allowed us to constitute a corpus of 88 photographs, 48 of which present a geodiversity now included within the limits of a protected area. They were taken between 1853 and 1999. These photographs were specifically analyzed according to three criteria: (1) the geological and geomorphological features that were the subjects of the images; (2) the location of the protected areas represented by these photographs; (3) the place and role of the photographs in the history of this medium (techniques and/or specialties). Three main results emerged from this exploratory study: The first concerned the nature of the elements photographed (typology of forms) and the “proto-geopatrimonialization” of this geodiversity (redundancy of photographs via the constitution of photographic series); the second specifically identified the links between protected areas and geodiversity via geological surveys, West Americans in particular, artistic views of abiotic nature and archaeological explorations; the third result showed the importance of geodiversity in the history of photography, and vice versa.

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1. Introduction

This proposal is part of the scope of cultural geodiversity¹ and in particular of the research first developed by Panizza and Piacente (2003) and has been enriched by numerous publications since then (i.e., the recent synthesis by Pijet-Migoń & Migoń, 2022). The latter considers geodiversity—and more specifically landforms—as elements of the landscape and as a com-

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¹ Geodiversity is understood as the variability of the abiotic world in its geological (rocks, minerals, fossils), geomorphological (landforms), pedological (soils and fossil soil layers) and hydrological (surface and groundwater) components, as well as the set of processes that generate them (Gray, 2013). The focus here is specifically on geological and geomorphological components. We note that since 2015, epistemological reflections have been conducted on the use and application of this term. Examples include the links established between geodiversity and biodiversity (i.e., Boothroyd & McHenry, 2019), climate change (i.e., Gordon, Wignall, Brazier, Crofts, & Tormey, 2022), water-related dynamics (i.e., Bollati, Pellegrini, Reynard, & Pelfini, 2017), anthropogenic landforms (i.e., Kubalíková, Kirchner, & Bajer, 2017). Neologisms related to studies applied to geodiversity and social dynamics are also used (geoconservation, geosite, geomorphosite, geotourism, etc.).

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ponent of the cultural heritage of a territory, in the same way as works of art, historical monuments and archaeological remains. The interaction between geomorphological processes and cultural assets is also included in this definition, as the geological and geomorphological context is fundamental for the conservation of these heritages over time. This study also continues the reflections carried out on the geodiversity represented (Portal & Bétard, 2019), which question the place and role of images in geography and geosciences, at the interface between art and science. Here, we propose to specifically mobilize photography and to focus on the role it has played in the knowledge of geodiversity and in the recognition of geoheritage.

For this first exploration, we have called upon four reference works on the history of photography written by art historians, specialists in the photographic medium. In other words, this inventory focuses on the geodiversity represented in the photographs identified by the specialists as being essential milestones in the history of photography. It will not be a matter of reinterpreting these images but rather of “extracting” the abiotic forms represented in them and identifying those which are located in protected areas, essential substrates for geoheritage recognition. Most of the photographs concern the “proto-geoheritage”² period when an iconographic base was constituted (19th century and beginning of the 20th). What are the photographs that represent a geodiversity elevated today into geoheritage? In what context and for what purposes were they taken? The underlying issue is, not directly developed in this paper, how these photographs are used (or not) to narrate and justify the existence of the protected areas that they are located in. We will see that the technical history of photography (e.g., shooting, development and reproducibility of photographs, transportable cameras), associated with the explorations and discovery of unknown worlds, especially of ancient peoples (archaeology), has been crucial in the recognition of geoheritage and more broadly of protected areas. The commitment of photographers to the protection of threatened natural areas has also been decisive in the history of geoheritage. Finally, it is also the question of geoheritage time scaling which is questioned, these photographs captured in this context serve as witnesses or “baseline conditions” of emblematic abiotic forms. They thus have a history associated with the photographed element (the subject), the preservation of the image itself, its inclusion (or exclusion) in a series or book, and its role in the establishment of protected areas with a strong geoheritage background. These photographs provide valuable documentation of the evolving natural and cultural heritage and contribute to our understanding and appreciation of these areas over time.

2. Material and methods

To carry out this research, four books written and directed by specialists in the photographic medium were used. They allowed us to constitute a corpus of photographs that were analyzed according to three main criteria detailed below.

2.1. Sources

In order to constitute the photographic corpus, four works were mobilized. They are all generously illustrated. Each one, in its own way, provides keys to reading the photographs and their histories. The two oldest (Beaumont, 1949; Frizot, 1994) are intended for an enlightened public. Their organization is more thematic than chronological. They provide the reader with major knowledge on the evolution of techniques and the importance of photographic specialties (nature, landscape, archaeology, astronomy, etc.) and their geographic locations (Western America, Egypt, the Moon, etc.). Often, the three technical-thematic-geographical entries are closely linked, and inscribe the photographer in an aesthetic current (e.g., pictorialist, realistic) and in a style (documentary photography, art photography, photojournalism, etc.). About thirty authors have contributed to the book edited by Frizot (1994). The books by Lowe (2019) and Jeffrey (2021)³ are popular works and are intended for inexperienced readers in the scope of history of photography. They approach the medium from two perspectives: The first highlights the developments and uses of photography chronologically, from its invention to the present day. Emblematic photographs illustrate each period. The second approaches the history of photography by photographers presented in alphabetical order. By the wide range of their publication dates (from 1949 to 2021) and by the diversity of their subject matter, these four works complement each other and allow for a diversified corpus of images; they also show geographical “redundancies” (when the same photographs are published several times) and thus point to an “iconic” iconography of geodiversity in the context of this paper.

² The term “proto-heritage” was used by A. Poiraud in a discussion. It means “before heritage is considered as such.” We have often referred to this period as “heritage premises.” The addition of the prefix “geo” specifies that this “proto-heritage” time specifically concerns the heritage recognition of geodiversity.

³ For these two works, the French editions have been used, especially for the paginations indicated in the appendix.

2.2. The corpus: Selection of photographs and analysis criteria

For each work, the photographs were selected according to the presence of an element associated with natural geodiversity (mineral, rock, landforms and associated processes) and artificial geodiversity⁴ (forms associated with archaeology, conflict-induced landforms,⁵ artistic features—land art etc.). It is the column “landform and landscape” in the Appendix. In all cases, the abiotic element is the main subject of the photograph. The place of each photograph (technical/thematic importance) in the history of the medium was listed (column “photographic purpose” in the Appendix). In some cases, quotations referring to it have been transcribed. For each photograph, a research was made to determine whether the abiotic nature represented in the image is subject to specific protection (natural park, classified site, World Heritage site, etc., see column “protected area” in the Appendix). We have chosen to retain protected areas in their natural and cultural dimensions in order to obtain the broadest representation of the geodiversity photographed; we shall see that areas with a cultural dimension (e.g., “Grand Site” in France, “National Monument” in United States) often cover a significant geodiversity. Finally, a digital resource is indicated, allowing the image to be consulted online when available. We present here only the photographs whose abiotic components are located in a protected area. However, the constitution of the corpus has made it possible to inventory all the photographs having geodiversity as a subject: Their presence in the four books participates in the enhancement of the image of geodiversity and geoheritage and thus in their recognition. They also show that their history can have several readings and will be the subject of a more specific study.

3. Results

The general corpus is made up of 88 photographs, 48 of which present a geodiversity now included within the limits of a protected area. These 48 photographs constitute the basis of the study presented here (see Appendix), but we will return to the initial corpus in the Discussion section. These 48 photographs were taken between 1853 and 1999. More than half (30) were taken in the second half of the 19th century (1853–1888). The dates of the photographs are important because many of them surround the creation of the first protected areas, often natural, in the world (Yosemite State Park in 1864, Yellowstone National Park in 1872, and European parks in the early 20th century). These 48 photographs are specifically analyzed according to three criteria: (1) the geological and geomorphological features that are the subjects of the images; (2) the location of the protected areas represented by these photographs; (3) the place and role of the photographs in the history of this medium (techniques and/or specialties). We specify that three photographs appear in duplicate and are used by two authors: the number “2” is indicated in the text and graphs when these photographs are concerned. Three main results emerge from this exploratory study: The first concerns the nature of the elements photographed (typology of forms) and the “proto-geopatrimonialization” of this geodiversity (redundancy of photographs via the constitution of photographic series); the second specifically identifies the links between protected areas and geodiversity via geological surveys, West Americans in particular, and artistic views of abiotic nature; the third result shows the importance of geodiversity in the history of photography, and vice versa.

3.1. Photographed geodiversity: Typology of forms and geoheritage “baseline conditions”

The three types of natural geodiversity most represented (Fig. 1) concern glacial heritages (e.g., cirque, valleys and *roches moutonnées*), volcanic processes and associated forms and what we have named “pinnacles” (specific forms such as arches, “towers” and fairy chimneys, sometimes called “curiosities” and often having a strong cultural dimension—myths, legends, sacred landforms etc.). All features taken together, the coastal geodiversity is of paramount importance. The combined forms of erosion (ablation) and deposition (accumulation) make up the second most prevalent landforms, on par with volcanic processes in terms of representation. However, we have chosen to differentiate the two families of coastal landforms, as dunes and cliffs do not have the same iconographic dimensions nor the same geomorphological values.

The three photographs presented twice are the fairy chimneys in *In and about the Dells of Wisconsin River: Leaping the Chasm at Stand Rock* (Henry Hamilton Bennett, 1886; Fig. 2), the *Old Faithful Geyser, Yellowstone* (William Henry Jackson, 1870; Fig. 3) and the *Eruption of the Vesuvius* (Giorgio Sommer, April 26, 1972; Fig. 4) in Frizot (1994) and Lowe (2019). Note that a third photograph of *Old Faithful Geyser* by W.H. Jackson (the first photograph of Old Faithful, 1871) appears in Beaumont (1949): Because the viewpoint is different, we did not include it in the “duplicates.”⁶

⁴ To define “artificial geodiversity” (Portal & Bétard, 2019), the terms of “anthropogenic geomorphology”, “man-made landforms” and “secondary” or “anthropogenic” geodiversity are also used in varied studies (i.e., Bianco, 2021; Kubalíková et al., 2017; Szabó, Dávid, & Lóczy, 2010).

⁵ This term refers to the landforms and patterns remaining of wars, especially the Great War (De Matos Machado et al., 2016)

⁶ These photographs appear in “bold” in the column “title of the photography” (see Appendix).

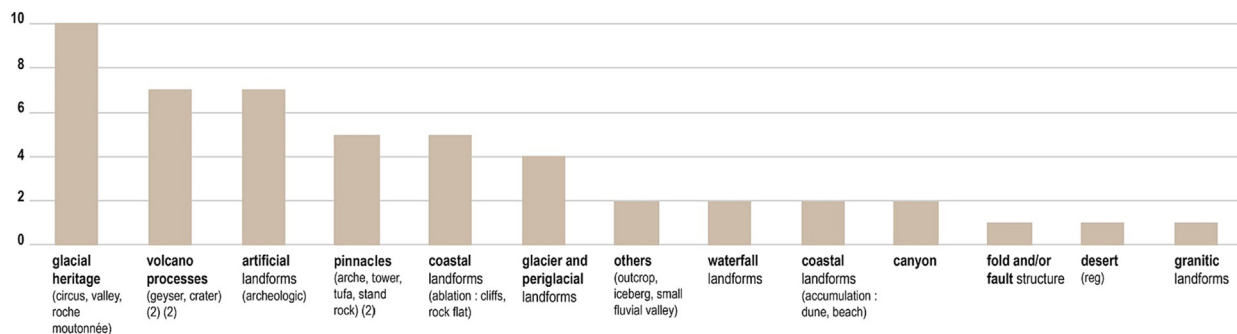


Fig. 1. Geodiversity in photographs.

Note: The thirteen categories are based on the most visible features in the photograph, with an emphasis on geomorphology over geologic structure. In a number of cases, however, the photographed geodiversity could be identified in several categories. For example, the landscapes of Yosemite Valley have been referenced in the “glacial heritage” category, but the granite bedrock is also a fundamental element.

One of the first results of this exploratory study on the links between geoheritage, photography and protected areas concerns the photographed geodiversity as a temporal marker of its “state.” In other words, the images can serve as “baseline conditions” as defined by Shepard (2005) for the qualities of an ecosystem: “These conditions are the standard against which are compared projected future conditions from project alternatives. Their description and characterization are necessary for decision-makers, reviewers, and others who are unfamiliar with the project site and surrounding landscape” (p. 27). From this point of view, these photographs are a visual record of the integrity of the form at a given time. It thus constitutes a “zero point” from which a photographic value has been attributed to it and which participates in the creation of a protected area. They can serve as a temporal reference point and contribute to decisions concerning their management (e.g., degree of vulnerability). More broadly, these photographs make it possible to reconstruct the evolution of landscapes, environments and landforms from the date of the photograph to the present day (Métailié, 1997). This means that the photograph is a medium whose subject bears witness to a



Fig. 2. In and about the Dells of Wisconsin River. Leaping the Chasm at Stand Rock. Wonders and beauty of Western scenery (2), photography by H. H. Bennett in 1886 (stereographs).

Source: The Miriam and Ira D. Wallach Division of Art, Prints and Photographs: Photography Collection, New York Public Library (1865–1910). Foot of the Narrows, Dells of the Wisconsin River. Retrieved from <https://digitalcollections.nypl.org/items/510d47e1-bf76-a3d9-e040-e00a18064a99>.



Fig. 3. The Old Faithful Geyser, Yellowstone (2), photography by William Henry Jackson in 1870 (albumen silver print).
Source: The J. Paul Getty Museum, Los Angeles. Retrieved from <https://www.getty.edu/art/collection/object/104CXJ#full-artwork-details>.



Fig. 4. Naples: The eruption of the Mount Vesuvius at 3:30 p.m. on 26 April 1872, photography by Giorgio Sommer in 1872 (2) (albumen print mounted on cardboard).
Source: Städel Museum, Frankfurt am Main. Retrieved from <https://sammlung.staedelmuseum.de/en/work/naples-the-eruption-of-mount-vesuvius-on-26-april-1872>.

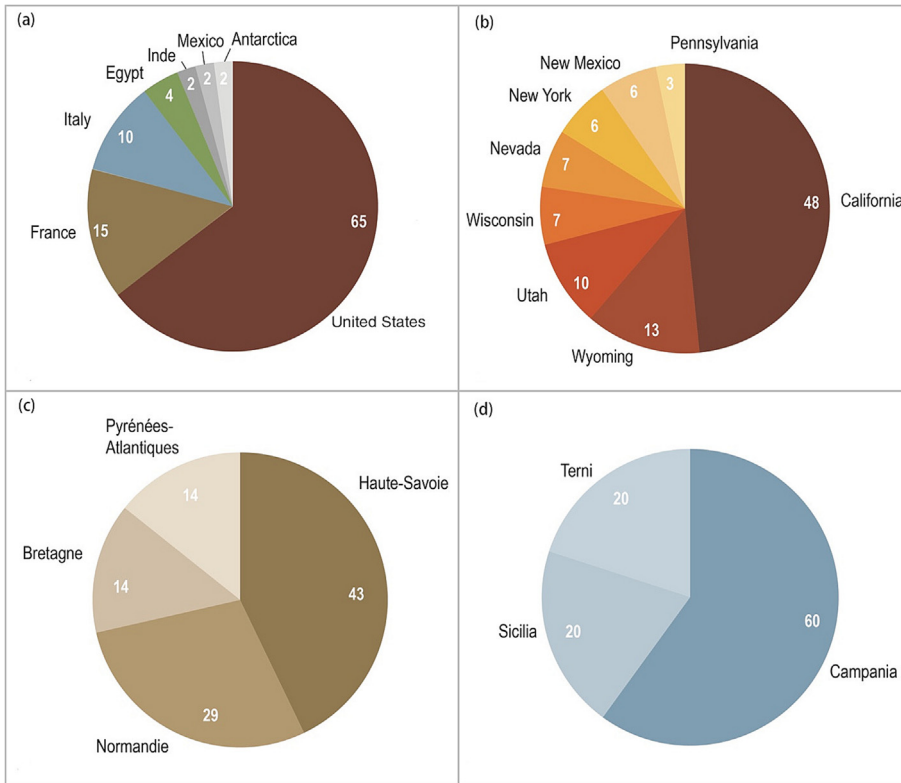


Fig. 5. This figure shows the location of protected areas identified in the corpus with a focus on main countries (a), as well as specific emphasis on the United States (b), France (c) and Italy (d).

geodiversity with a long (geological), shorter (geomorphological) and recent (anthropic) history, until it is photographed because it symbolizes “something” for the photographer. Some subjects will even be reproduced dozens of times by the same or different authors.

3.2. The origins of photographed geodiversity: American surveys, scenic and photographic series

The location of the protected areas identified in this study shows a significant representation of the United States and France as well as Italy and Egypt (Fig. 5a). In the case of the latter two countries, the consideration of archaeological sites, when they represent a remarkable geodiversity, partly explains their inclusion within the corpus (e.g., Pompei and Herculaneum Archeologic Site in 1929/WHC⁷ in 1997 in Italy and two UNESCO World Heritage sites in Egypt—Ancient Thebes with its Necropolis (designated in 1979) and Memphis and its Necropolis—the Pyramid Fields from Giza to Dahshur (designated in 1979)). These geoarchaeosites are specifically discussed in Section 3.3. In these countries, the U.S. states of California and Wyoming (Fig. 5b), the French regions of Haute-Savoie and Normandy (Fig. 5c), and the Italian Campania (Fig. 5d) are the most represented. Finally, the most frequently photographed geodiversity concerns Yosemite National Park and Yellowstone National Park in the United States, the *Site Classé*/Grand Site du Massif du Mont-Blanc in France, and to a lesser extent, Vesuvius National Park (2) in Italy, Devil’s Lake State Park (2), Niagara Falls State Park and Point Lobos State Natural Reserve in the United States (Fig. 6). Two main drivers, each distinct in their approach, have been developed to explain the origins of this photographed geodiversity. The first driver, utilitarian in nature, concerns the West American surveys carried out for the purpose of inventorying geological resources, as well as recognizing wild landscapes. The second driver, with a technical and artistic focus, is more in line with the recognition of “high places” that often possess remarkable geodiversity. Most of the photographs taken by the artists were compiled into series and occasionally exhibited, commonly referred to as “photographic missions.”

⁷ WHC refers to the sites that have been designated and created under the World Heritage Convention by UNESCO in 1972.

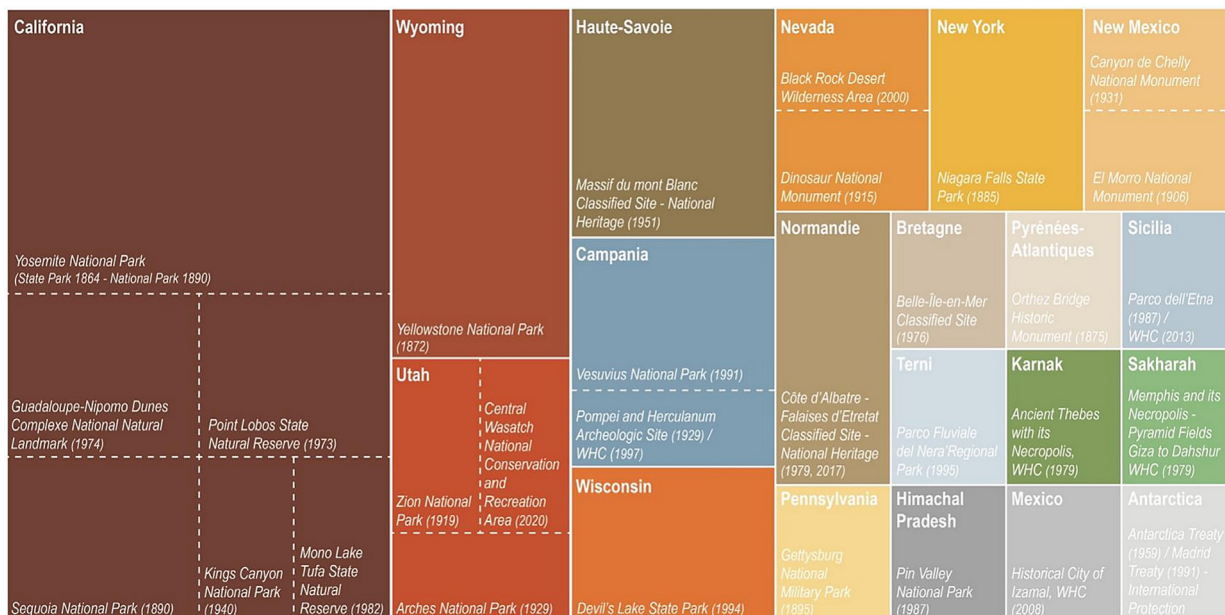


Fig. 6. Proportion of photographed geodiversity in protected areas.

3.2.1. Surveying geological resources and protecting “wild” landscapes in the American West

For the most part, the photographs of American protected areas were taken during expeditions associated with various institutional exploratory missions, notably the geological surveys conducted by the United States Geological and Geographical Survey of the Territories⁸ in the 1870s. During these missions, some well-known photographers were present and participated, not only in documenting the geological knowledge through their iconic images but also in shaping the perception of the American West. They played a significant role in crafting the image associated with the American West. This is the case of W. H. Jackson whose photograph of *Old Faithful Geyser* (Yellowstone, ca. 1870 (2); Fig. 3) was taken in this context: “His landscape photographs are some of the most important ever made and helped define the ‘West’” (Lowe, 2019, p. 73). Prior to that, W.H. Jackson had been hired by the Union Pacific Railroad to take pictures of the landscape along the railroad for publicity purposes in 1869. J. K. Hillers (who photographed *John Wesley Powell with Tau-gu* in 1872, designed as Dinosaur National Monument in 1915) was the chief photographer at the 1872 USGS expedition led by Ferdinand Vandiveer Hayden, a renowned American geologist. Photographer T. O'Sullivan was part of the first major post-Civil War western expedition, the King Survey, named after Clarence King, the chief geologist. The survey was organized by the United State Army Topographical Engineers between 1867 and 1872. A century later, the Rephotographic Survey Project (1977–1982) was launched. Its objective was to redo the photographs taken during the 1860–1870 surveys of the American West. The photographs had to be taken with the same angles of view, and as close as possible to the light conditions of the original photograph. The objective was twofold: to identify environment changes in detail after a century and to reproduce as well as better understand the practices of the early photographers of the American West. 122 photographs were reproduced in six states and were the subject of a publication (Klett et al., 1984). Klett's (1984) photograph *Arches National Park: Beneath the Great Arch, Near Monticello* (1982) was taken in this context: As photographer and geologist, he was the chief photographer of this mission.⁹ Like him, some American

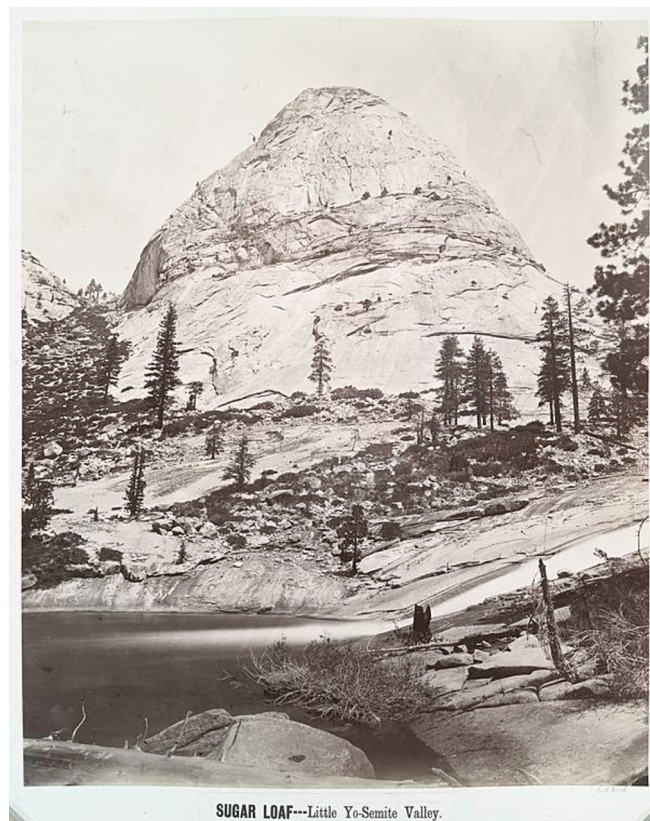
⁸ The United States Geological and Geographical Survey of the Territories was established in 1867 and became the United States Geological Survey (USGS) in 1879.

⁹ See some images on M. Klett's website: <http://www.markklettphotography.com/rephotographic-survey-project/9jluv005gj09vndrootupq486xhbst7>.

photographers were either both geologists and photographer or were strongly sensitized by their participation in West American scientific surveys. Their professional skills testify to the strong links that existed between geoscience and photography prior to the recognition of geoheritage. More broadly, the participation of photographers in international expeditions has strongly contributed to the dissemination of images of distant worlds whose geomorphological landscapes are often the subject of pictures widely distributed: H. G. Ponting, author of *The Castle Berg* (1911) was the first ever photographer invited on an Antarctic expedition (Scott Expedition “Terra Nova”). Finally, the photographers of the American West often show a commitment to the protection of wilderness. For Lowe (2019), C. E. Watkins was the “American landscape photographer whose images helped convince the U.S. Congress that Yosemite Valley should be made into a national park” (p. 6).

3.2.2. Scenic photographs, photographic series and geoheritage background

These scientific inventories linked to surveys and expeditions have also been nourished by the artistic aspects of photographs taken for aesthetic reasons. Their representations are centered on abiotic nature elements and have largely contributed to the dissemination of the image of a West American geodiversity. This is the case for C. L. Weed, the author of the first known photographs of Yosemite (*Yosemite Falls*, 1859), who photographed the landscapes and inhabitants of this region for about thirty years (1851–1880) (Hood, 1959). In addition, the *Sugar Loaf*, *Little Yosemite Valley* was taken in 1864 when Yosemite State Park was created (Frizot, 1994; Fig. 7).



SUGAR LOAF---Little Yo-Semite Valley.

Fig. 7. Sugar Loaf, Little Yosemite Valley, photography by Charles L. Weed in 1864 (albumen print).

Source: The Miriam and Ira D. Wallach Division of Art, Prints and Photographs: Photography Collection, New York Public Library (1864). Retrieved from <https://digitalcollections.nypl.org/items/510d47db-1255-a3d9-e040-e00a18064a99>.

Throughout the 20th century, photographic artists have produced series and portfolios featuring geodiversity whose values are now recognized as heritage: It is the case for E. Weston's *Oceanos' Dunes* (1936) in Guadalupe-Nipomo Dunes Complex National Natural Landmark (designated in 1974) and for R. Misrach's images (1987) taken in the Black Rock Desert Wilderness Area and that are part of "series of 'cantos'" (more than 20), " which address complex issues of environment, pollution, and the notion of "beauty" (Lowe, 2019). The Point Lobos State Natural Reserve (designated in 1973) is also a central iconographic point: The *Point Lobos Tide Pool* taken in 1957 by W. Bullock "united the natural environment with the abstract symbolism of the inner world" (Frizot, 1994); with *Driftwood and Eye* (1951), M. White also showed the importance of the interaction of images in series (Jeffrey, 2021).

The existence of photographic "series" offers indeed an important iconographic wealth. According to the definition of Gendrot (2002), a photographic series is based on "the similarity or the visible relationship between several views" (p. 361). It is thus "constituted by a set of photographs which, within the collection, can be brought together, correlated, etc. An additional meaning or information then appears in the combined view of these pictures" (Gendrot, 2002). These photographic series also include the "repeat photography" method as a tool in observing and understanding geomorphic patterns and processes (Cerney, 2010) especially in dynamic environment (i.e., glacial, fluvial) or for specific features (mass movement, erosion vegetation and land use changes (Trimble, 2008). In our corpus made up of "individual" photographs, some are part of geographical "series" made up of photographs of the same area. They have been grouped together in archives or are the subject of books published by the authors themselves. For example, the portfolios of A. Adams include photographs taken in Yosemite National Park (portfolio 3, Adams, 1960) and more widely in the national parks of the American West (portfolio 2, Adams, 1950). Some photographic series can also have a photojournalistic approach, like the case of G. Sommer's documentation of the *Eruption of Vesuvius* in 1872 (Fig. 4). The author took several shots of the erupting volcano at half-hour intervals, showing a process in action. One of the photographs is presented twice in the corpus. The redundant presence of geo-patrimonial subjects, without necessarily being photographed from the same point of view, is indicative of the photographer's interest in the subject and the importance that can be given to it. This potential value is certainly a determining factor in the creation of protected areas.

In France, this is the case for the Bisson brothers who are considered as the earliest mountaineering photographers, having made two successful ascents of the Mont Blanc (July 24, 1861 and August 11, 1862), from which the first photograph of the summit is derived (Auguste-Rosalie Bisson, 1861). Other known photographs, taken in the Savoyard and Swiss massifs (period 1855–1862), are also widely known, notably for the innovative technical aspects that the topographic and climatic conditions required. Although they were not trained as geoscientists or even naturalists, the photographs of the Bisson brothers contributed to the diffusion of images of glacial and periglacial environments (Chlumsky, Eskildsen, & Marbot, 1999). The aesthetic aspect of their photographs can be related to the geological and architectural reflections carried out from the middle of the 19th century on the great Alpine massifs by the British artist and art critic J. Ruskin: *Chamonix, The Mont Blanc* (1854) was taken by F. Crawley during a joint work (Frizot, 1994); Louis-Auguste Bisson had also studied architecture and took many photographs of historical monuments in Paris, Europe and Egypt in particular. Professional photographic artists have thus had a major influence in the dissemination of images now associated with geoheritage elements. A final example is illustrated by W. Hannappel's photograph of the granite cliffs of Belle-Île-en-Mer (1986) (Belle-Île-en-Mer Classified Site, designated in 1976). This image was taken as part of *La Mission photographique de la DATAR*¹⁰ (1984–1989), a vast artistic commission of photographs whose purpose was to represent the French landscape of the 1980s (Bustamante, 1989); without having strictly the same objective, this institutional commission followed the photographic exhibition—*New Topographics: Photographs of a Man-Altered Landscape*—organized in 1975 at the George Eastman House in Rochester (museum of photography) in the United States. This exhibition of documentary photographs focused on contemporary American urban landscapes, a number of which showed altered geodiversity (Adams et al., 1975). Two of the ten photographers exhibited (L. Baltz and F. Gohlke) also participated in the DATAR Photographic Mission, demonstrating the link between the two approaches. In both cases, abiotic aspects are decisive in the composition and in the objective of the photographs. These two photographic events show that the insertion of geodiversity in a common history of photography and geoheritage extends beyond the limits of protected areas. This inclusion is influenced by the photographic technique, styles, and the dissemination of images, which depend on the modalities of circulation and publication of the images.

¹⁰ DATAR: French office for Spatial Planning and Regional Action (French acronym for "Délégation à l'Aménagement du Territoire et à l'Action Régionale"), from 1963 to 2014.

3.3. Crossed histories of photography and geoheritage: Techniques, photographic genres and circulation of images (the example of geoarchaeosites)

The authors of the books have selected the photographs to illustrate a theme because they consider that they are representative of either the work of a photographer or, for chronological books, an era (e.g., chapter *Around the world: Explorers, travelers, and tourists* written by F. Heilbrun in Frizot, 1994). In all cases, technical are a common thread in the books: Whatever the subject of the image is, the shooting techniques are always either indicated or detailed when it is a major innovation (e.g., the first daguerreotype). The identification of the techniques used for the 48 photographs that constitute the corpus adds an additional richness to these images and further links photography and geoheritage (see column “photographic purpose” in Appendix). These techniques are part of the great history of photography, we will not explain them in detail here. However, by being emblematic of certain innovations, some photographs have allowed the diffusion of geoheritage subjects that interest us.¹¹ This is the case for *In and about the Dells of Wisconsin River: Leaping the Chasm at Stand Rock. Wonders and Beauty of Western Scenery* (2) made by H. H. Bennett in 1886, and which results from a “synthesis” between the use of gelatino-silver-bromide in 1880 and the capture of movement by hand-held camera in 1876 (Fig. 2)¹². This photograph was used by Frizot (1994) and Lowe (2019) to illustrate the theme of movement involving shots that followed each other at regular intervals and which was a major innovation. This photo is not commented for its geoheritage aspects. We can just note that E. Muybridge, one of the inventors of chronophotography, is also the author of *Tutokanula, Valley of the Yosemite, the Great Chief, “El Capitan”* (1872); the picture is not illustrating the movement in photography (Frizot, 1994)! The same year, the “snapshot” photography was used by G. Sommer for the *Eruption of the Vesuvius* (1872; Fig. 4). The invention of the night flash exposure, hand-held camera, and especially aerial photography has allowed taking geoheritage pictures according to new focal lengths.

The conditions of access to geodiversity also led photographers to show adaptability and innovation since the shots were taken outdoors and no longer in a studio, implying a chaotic topography and an often difficult climatic environment. In the 19th century, some photographers (e.g., C.E. Watkins, V. Sella, C.L. Weed, Bisson brothers) used very large plates (“mammoth,” 20 in. × 44 in. to 50 in. × 60 in.) that were heavy and cumbersome in order to improve the sharpness of the photographs. During the ascent of the Mont Blanc in 1862, Auguste-Rosalie Bisson appealed to 25 porters to transport the photographic equipment. Similarly, for the experiments of W. H. Jackson and the Western American landscapes: “If large prints were required, large negatives had to be made, and as the expanse of western scenery demanded big pictures, field photographers were obliged to take big cameras (...). Working with the oversize camera was exacting. His first exposure, of Lake San Cristobal, Colorado, cost him three days' work. Three times he climbed the mountains. On the first day, the wind blew too strongly; on the second day, the silver bath leaked; on the third day, “everything worked lovely and secured a fine negative on first attempt” (Beaumont, 1949, p. 100).

Just before photography, the invention of stereoscopic views allowed for the illusion of relief from two flat images (e.g., Fig. 2). A. J. Russell (Monument Rock, mouth of Echo Canyon, 1867; Fig. 8) was also given rise to a stereoscopic rendering. Over 400 stereoview glass plate negatives have been taken by the photographer during his mission for the Union Pacific Railroad¹³ and were used, among other, to stage Western American landscapes. Finally, the use of the Poitevin process (photoengraving, photolithography) made it possible, along with other inventions, to rapidly multiply photographic images at a lower cost. This has increased their diffusion by their printing in different newspapers and magazines and covering well-defined photographic genres. Concerning the photographs associated with geodiversity and the creation of protected areas, we have seen that the photographs are part of scientific and documentary photography (e.g., surveys of the American West), especially in the 19th century. In this context, we will focus on the photography of archaeological sites whose presence in the corpus must be explained.

In the main corpus, 7 photographs with a geoarchaeological dimension have been included. These mainly concern the remains of Egyptian, Mayan, Amerindian and Roman civilizations, the traces of ancient colonizations (Spanish in the American Southwest) and the excavations carried out in Herculaneum and Pompeii. The geoheritage represented in these photographed geoarchaeological sites can be understood in two ways.

The first is based on the definition of geoarchaeosites as “archaeological sites located within a geomorphosite¹⁴” (Fouache & Rasse, 2009). These are units of place that are particularly favorable to the understanding of ancient society-environment interactions on the scale of Quaternary or historical times (Piau, Betard, & Dugast, 2021). These sites bear witness to relationships between ancient human societies and their abiotic environment. For example, the rocks are used as building materials for ages, being subject to erosion processes like any natural landform. The photograph of the *Pyramids of*

¹¹ These techniques can fall into three categories: (1) the type of camera and the medium of the photograph (negative, positive, type of paper etc.), (2) the shooting, and (3) the development. Some techniques imply advanced knowledge in chemistry.

¹² It's called “snapshot photography,” that is to say without pause, contrary to the first snapshots which required several minutes and the immobility of the subject, in studio. These images implied that the support of the photograph was very sensitive to “print” the image as quickly as possible (gelatin-silver process plates) and the use of compact cameras.

¹³ See the Central Pacific Railroad Photographic History Museum online: http://cprr.org/Museum/Russell_Catalog.html.

¹⁴ Geomorphosites are landforms that have acquired scientific, cultural, historical, aesthetic and/or socio-economic value because of their perception or use by man” (Reynard & Panizza, 2005).



Fig. 8. Monument Rock, foot of Echo Canyon, Utah, Andrew J. Russell (ca. 1867), and George Wharton James, 1923 (Folder 5C. Albumen print).

Source: W. H. Holmes collection of photographs of Utah, Colorado, Idaho, Wyoming Territories and Mexico. Retrieved from <https://collections.library.yale.edu/catalog/2011325>.

Sakharah Seen from the North-east (1858) by F. Frith (Egypt, Sakharah) shows that the Saharan sand progressively covers the pyramids, which degrade like ruinous natural landforms. As natural mountains, especially in flat spaces, these pyramids take on symbolic and sacred aspects. The constructed rocks can also be sculpted (*Entrance of the Hypostyle Hall*, 1854, J. B. Greene, Karnak and the Kabul pyramid hut at Izamal; *Maya sculpture*, 1861,¹⁵ Mexico) or engraved. They can then be inscribed in a wider geomorphological context as for the petroglyphs of Inscription Rock, component of the larger protected area El Morro National Monument (*Historic Spanish Record of the Conquest. South Side of Inscription Rock*, 1873, T. O'Sullivan). On another scale, the photograph of *Ancient Ruins in the Cañon de Chelle, New Mexico. In a Niche Fifty Feet Above Present Cañon Bed* (1873), also taken by T. O'Sullivan, shows Anasazi troglodytes in a nationally recognized geopatrimonial context. These relationships between ancient civilizations and geomorphological environments also encompass the documentation of disasters such as volcanic eruptions. For instance, the photograph *Excavations of Herculaneum* (1869) by G. Sommer is a significant contribution to the geoarcheosite of Vesuvius-Pompeii-Herculaneum. Finally, a particular interest can be taken in hydraulic legacies, some of which are still in operation: This is the case for the *Marble Falls* (ca. 1860) in the Regional Park Marmore Waterfalls in Italy. This photograph is part of the collection of Fratelli Alinari (Alinari brothers). These are “man-made waterfalls, built by ancient Romans at 271 BC for tried [sic] to

¹⁵ The author of the photograph is unknown, but a similar image taken by Désirée Charney in 1881 can be seen on the Bibliothèque Nationale de France (France National Library) website (photograph on glass plate of the Société de Géographie [French Geographical Society]).

solve the problem of the Velino River and Valnerina wetlands and, at the same time, to use the water resource both for the agriculture and as a source of power. With a total height of 165 m, it is one of the highest man-made waterfalls in Italy and worldwide” (Poponessi, Aleffi, Sabovljevic, & Venanzoni, 2020, p. 34). These sites also have the particularity of containing an important ecological wealth.

The second way of reading the photographed geoarchaeological sites is in line with the history of photography, which has a direct link with archaeology. This is closely connected to the need for documentation of research, particularly in Egyptology, which has implied the development of documentary photography whose images have to be reproducible. The calotype technique was thus widely developed in the years 1830–1840: It offered the first possibility of duplicating images for science. It also allowed for their diffusion to a “general public” turned towards the “exotic” and antiquisite history sought after in the 19th century (*Le voyage d’Egypte*, photographed by C. Bustanet in Frizot in 1994). If the pictures list the archaeological vestiges, they would also show, in part, the associated geomorphological landscapes.

4. Discussion and perspectives

The results of the analysis of this corpus of 48 photographs have been partially discussed previously. They offer numerous research perspectives, some of which will be proposed and debated below.

4.1. Expanding the corpus

This first exploration of the links between photography, geoheritage and protected areas shows that there are multiple research opportunities: The existing corpus can certainly be increased by adding photographs from other works on the history of photography. It can also be refined by constituting corpuses via different collections (e.g., geographical societies, geological surveys, series and all the digital collections). As mentioned before, the initial corpus from which this article is extracted consists of 88 photographs. Among these, some are taken from the work of Montier, Louvel, Méaux, and Ortel (2008), *Photography and Literature*, which was mobilized to thematically complete the initial corpus. The inscription of photography in literary works is in fact important in the framework of the diffusion of images and thus of their national and international knowledge. The previous analysis exclusively focuses on works of photographic history, so we did not mobilize it. However, five photographs represented abiotic nature are used by Montier et al. (2008): Four photographs taken by the Bisson brothers illustrate their alpine explorations between 1860 and 1868; a photograph of W. H. Sanford’s *Stand Rocks* is from the collection of poems, *Pictures and Poems of the Pike’s Peak Region*, written by Whitney (1891). More broadly, these books and portfolios articulate photographs to each other according to what the author wishes to show. They thus constitute photographic series whose importance in the history of photographic representations of emblematic protected areas is highlighted in this study (e.g., A. Adams and the Yosemite National Park Park). The association of photographs with texts is a field of research to explore in various literature (travel guides, travel stories, novel, fiction, comics etc.). Beyond the geoheritage aspects, the photographic series also have a major significance in environmental history (e.g., the photographs of the Farm Security Administration/Office of War Information Photograph Collection, which were taken between 1935 and 1944, the document of the *Dust Bowl*; Masutti, 2004).

4.2. Exploring the links between art, science and geodiversity/geoheritage studies

Some of the studied photographs were produced during institutional commissions (surveys, photographic missions, etc.). It constitutes a very favorable frameworks to the inventory of knowledge and the production of scientific and documentary photographs. However, the evolution of commissions towards artistic photography taken by artist-photographers and no longer by scientist-photographers, offers a new look at photographed geodiversity, going beyond the framework of protected areas (e.g., Giusti, 2014; Sellier, 2020). If this artistic dimension was voluntarily left aside during this first study, the abiotic nature and what it represents would constitute a support and an unavoidable artistic material. On the 88 images of the initial corpus, 3 photographs taken since the end of the 1960s concern works going from photomontage to earth works. In the plastic arts, if photography plays the role of highlighting and disseminating the existence of the work, it is also essential to its conservation. Many in *situ* or site-specific creations are ephemeral, just like a museum exhibition. Photography is then a memorial tool which testifies to the existence of the work (Tiberghien, 2005). The aesthetic aspect of the protected areas also strongly contributed to their creation (Larrère, 2018) and the geodiversity was strongly

mobilized—and still is—in this context. The Ansel Adams Gallery in Yosemite is a very illustrative example: It was opened in 1902 in Yosemite Valley, and exhibits—and sells—emblematic images of the photographer, participating in the narrative of Yosemite National Park. Finally, the study of the photographic approach to geodiversity can be developed, particularly in connection with geotourism and geo-interpretation aspects. This can be done in a number of ways, both temporally (i.e., geohistorical study of postcards and their dissemination) and spatially—i.e., analyzing the photographic productions of geoparks (Meira, da Silva, do Nascimento, & Orús, 2021), and assessing geoheritage landscapes and landforms (Nakarmi et al., 2023). While the aspects developed by repeat photography method essentially serve fundamental knowledge, they are also widely used in contexts of environmental awareness, particularly in protected natural areas. In all those cases, photography is an essential medium for connecting points of view and transmitting knowledge (i.e., Smrekar, Zorn, & Komac, 2016).

4.3. Linking the past and the present: Contemporary studies in protected areas

Managers of protected areas use the photographic medium in many ways. One of the first of them is the use of pictures via websites; others can be, for example, the constitution of archives available online, the organizing of photographic contests¹⁶ and continuing of certain practices initiated earlier. The photographic observatories of landscapes often implemented by French nature parks seem to be inspired by the Rephotographic Survey Project conducted in the United States in the late 1970s. The approach is based in particular on the constitution of photographic series over time in order to capture the permanence and evolution of landscapes. The photographs are taken by professional and artist photographers.

Technically, the development of digital photography and associated tools has allowed for an almost unlimited distribution of old photographs (large-scale digitization of archive collections). A specific study should be carried out on the role of the photography conveyed by the websites of the protected areas and the *in situ* enhancement of the geodiversity in the contemporary protected areas. Among other things, it would be necessary to see if photographs that are emblematic of the history of the medium (19th century) are still present in contemporary accounts of protected areas and how they are used. This research would answer the underlying question stated in the Introduction section: How do abiotic forms contribute to the creation of protected areas, especially in a proto-heritage period? How are ancient photographs used today (if at all), and with what discourse? The increasing presence of amateur (vernacular) photographs constitutes a field of study in itself. Finally, these photographic studies have to be integrated in the reflections already engaged on photography itself and on its uses in the scientific fields connected to geodiversity and geoheritage (e.g., visual anthropology—Collier and Collier (1986); geography—Marshall (2009); geology—Wickliff (1997); cultural studies—Erlil and Nünning (2008).

5. Conclusions

This proposal is an exploration carried out within the framework of a more consequent research. It is the first part of a long-term study on geodiversity, geoheritage and photography. Future developments will mobilize expended corpuses in order to nourish this research with a geohistorical dimension¹⁷ on the knowledge of geodiversity and the recognition of geoheritage. Among other things, it participates in the questioning of the process of patrimonialization of abiotic nature and shows that the history of photography, and that of geoheritage are very closely connected. By specifically mobilizing the photography medium, the results of this first research and the perspectives that follow show that the field of study is very vast and that it feeds both the thoughts on geoheritage in general and on their cultural aspects in particular. Finally, photography has added to the reflections on the temporal scales of geoheritage: The first concerns the element photographed, e.g., the subject of the image (“baseline condition” of an abiotic element whose history is part of geo-morpho-logical and anthropic time); the second is linked to the photographic object itself in its historical and technical developments associated with its production, conservation and dissemination; the third temporal aspect relates more broadly to the place of the image in the creation of protected areas. In all cases, photography is an archive, a multifaceted memory of the natural and cultural history of geodiversity and geoheritage.

Ethical statement

Ethical approval is not applicable, because this article does not contain any studies with human or animal subjects.

CRedit authorship contribution statement

Claire Portal: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

¹⁶ For 16 years, the Italian National Parks of Stelvio, Gran Paradiso, Abruzzo, Lazio e Molise and the French National Park of La Vanoise have organized the competition “Fotografare il Parco” open to professional and amateur photographers.

¹⁷ A geohistorical approach is “showing the permanencies, inertia or trajectories imposed by spatial configurations, to make a narrative of them, to show the meaning of which the present time is the end” (Jacob-Rousseau, 2009, p. 211).

Declaration of Competing Interest

The author, Claire Portal, is a Guest Editor of Virtual Special Issue: Time Scaling Issues in Geoheritage Studies, and was not involved in the editorial review or the decision to publish this article. The author declares that there is no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

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