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Lyell and the Spanish Geology

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ABSTRACT

Lyell visited Spain in the summer of 1830, after the publication of the first volume of *Principles of Geology*, and in the winter of 1853 coming back from his third trip to America. In his first stay he visited, among others, the Olot region (Catalonia, NE Spain) and in the second the Canary Islands. In both cases his major aim was to study these volcanic zones since volcanism constituted for Lyell the clearest evidence of the Earth interior energy, which had led to mountain building in the past. Another of his aims during his 1830 visit was to study the Pyrenees. Lyell endeavoured to show that this orogen did not result from a violent and rapid “revolution”, as proposed by Elie de Beaumont, but from processes that spanned long time periods. In the Pyrenees he also made some observations on the neogene lacustrine deposits of la Cerdanya basin, while in the southern Pyrenean foreland (i.e. Ebro basin) he paid attention to facies changes and correlations in the Eocene sequences. Lyell spent some days in Barcelona during this visit but at that time the country was in political turmoil and the main scientific institutions of the city had been closed down. Once in the Olot region, Lyell paid a visit to Bolós, pharmacist and botanist who had an interest in geology and introduced him in the volcanic zone. During his second trip in 1853, Lyell visited the Canaries and limited his personal contacts to Pedro Maffiote, professor of the Nautical School of Tenerife, who had made some interesting although never published geological observations in this island. In the Canary Islands Lyell sought to demonstrate the relationship between volcanism and coastal movement, and to confirm his theory of volcanic cone growth by accretion. Lyell’s influence in Spain was not due to his personal contacts in the country but to his books and especially the translation into Spanish by Ezquerro del Bayo of the first edition of “Elements of Geology” in 1838. Lyell’s ideas and especially his geological terminology, which was one of his most important contributions, spread in Spain thanks to this translation. Both the personality and the scientific reputation of Ezquerro del Bayo helped to promote the book that became for many years the official teaching book at the Schools of Mines in Spain and Mexico. Ezquerro del Bayo carried out the first geological map of the whole of Spain (1850) adopting in this and other publications (1850-1857) Lyell’s nomenclature, although his theoretical concepts (e.g. actualism) did not exert the same influence. It should be borne in mind that Lyell regarded his *Elements of Geology* as a descriptive Geology, a text book for students and beginners. His more elaborated theories included in *Principles of Geology* resulted in little influence in Spain, since this book was not translated into Spanish.

KEYWORDS | Lyell. History of Geology. Spanish Geology in the XIX century.

INTRODUCTION

This paper does not deal with analyzing Lyell's (Fig. 1) travels to Spain from a historical perspective. In the case of his visit to Catalunya and the Pyrenees other authors have done so more accurately and with more documentation than I have used (Aragonès, 2001, 2003, 2004, 2006; Solé-Sabarís, 1975, 1982, 1986; Ordaz 1976; Ribera-Faig, 1988). On the other hand, as far as his trip to the Canary Islands is concerned there is little information, the existing documentation is not easily accessible (Benítez, 1926; García Pérez, 1988; Lyell in Edinburgh University Library), and practically nobody has taken the trouble to study it. Wilson (1972, 1998), the author of an extensive documented biography of the British Geologist, has not yet published the part that corresponds to Lyell's travels to the Atlantic Islands, since this period is later than the "American period", the last period of Lyell's life included in Wilson's books.

The main aim of this paper is to think over how the observations made by Lyell during his stays in the Iberian Peninsula and the Canary islands affected his development as a geologist and how his thinking and guidance influenced on the subject of Geology in Spain and on Spanish geologists (Virgili, 2003).

CHARLES LYELL AND THE GEOLOGY OF SPAIN

The volcanic zones of Olot and the Canary Islands

The major aim of Lyell's trips to Spain was the study of volcanic systems, although he also made other interest-

ing observations. In the summer of 1830, once the printer proofs of *Principles* had been corrected, Lyell set off on his first trip to Spain in order to visit the volcanic region of Olot (NE Spain). Interested by Daubeny's publication (1826) he had previously studied the volcanism of the Central French Massif, which he considered miocene in age, and also the still active Vesuvius and Etna; he believed that the Olot volcanoes were intermediate in age. He knew, without doubt, the papers by Bowles (1775), Maclure (1808). Nevertheless, the new results that arose from Lyell's field work surpassed by far that of the previous authors, deciphering the volcano internal structures and describing them even with graphics in his books (Lyell, 1830-33, 1847). He recognized and showed the relationship between some of the lava flows and the fluvial terraces. This relationship enabled him to affirm that these lavas, which he considered pliocene in age despite their relationship with the terraces, resulted from different eruptions.

At the end of 1853, during a trip to the Atlantic islands, Lyell visited the Canary Islands with the purpose of analyzing the relationship between volcanic emissions and sea level variations, which he interpreted as the result of continental uplifting and down lifting. For him both phenomena were demonstrations of the internal Earth energy, which did not "run out" in some remote past as it was maintained by Werner and his adherents, but it continued in action; that is to say, volcanism was the witness which "testified in favour" of his principle of "actualism". It is important not to forget that Charles Lyell advocated learning and development, and the objective of his research was, according to his words, to demonstrate that "the causes which have acted in the geologic past are the same as those which act in the present" (Virgili, 2003).

Another objective of his trip to these Islands was to study the volcanoes's internal structure. During a former trip to Sicily (1828-29) Lyell had verified that the islands were especially favourable for this study. The steep volcano slopes and their proximity to the sea exposed them to intense erosion which resulted in deeply entrenched slope ravines. This fact allowed magnificent views of the volcanic cone internal structure. In Sicily, Lyell utilized this fact to verify that the Etna was formed by superimposed lava and solid ejections (ash and lapilli) layers. The lightness of these volcano detritic materials mixed in with the lava explained the accentuated steepness and typical volcano relief. In consequence, he formulated his theory that volcanic cones grew by accretion, as opposed to Buch's theory (1825) who maintained that this growth was caused by the uplift derived from the upward pressure exerted by melted volcanic material in the subsurface. A further reason for Lyell's visit to these islands was that La Palma was the place on which Buch had



FIGURE 1 | Charles Lyell around 1836. Drawing by J.M. Wright. National Portrait Gallery, London, (Wilson 1972).

based his hypothesis and Lyell wanted to demonstrate there Buch's misconception. As a consequence, Lyell published two articles on these studies (Lyell, 1850, 1859) and he also included the results in *Principles*, which the sixth edition contains a magnificent geological cross section of the island.

Stratigraphy of the Tertiary of La Cerdanya and the Ebro basins

When Lyell arrived at the Spanish frontier on 18 July 1830, his aim was to cross the border quickly and travel from Puigcerdà to Barcelona. However, as it is well known (Solé-Sabarís, 1975, 1982; Aragonés, 2003, 2004), some custom trouble at the border forced him to stay there during a few days. During this short time he studied the Tertiary sequences of la Cerdanya, a small neogene intramountainous fault bounded basin in the Pyrenees. He wished to compare them with the late Tertiary sequences, which he had studied in Italy and in southern England and France, and also to decipher their depositional environment. His interpretation of the lacustrine successions of la Cerdanya, by comparing them to the currently being deposited in the lakes of his natal Scotland, was absolutely correct. The poor preservation of the collected fossils did not enable him to date precisely these materials, but the result of his observations was published in an interesting paper (Lyell, 1834), which was the first one published by a British geologist on the Pyrenees (Ribera-Faig, 1988).

Once in Barcelona, Lyell visited the Tertiary marine sections of Montjuich, where he collected a number of fossils. Later, in France, he studied the Rosselló Tertiary sequences and collected better preserved and more abundant fossil fauna, which Deshayes classified in Paris. This information, as with the majority of his travels, were presented in *Principles*.

On his way from Barcelona to Olot Lyell made some observations on the Tertiary of the eastern Ebro basin (central Catalonia), but this information has not been widely known until recently (Aragonés, 2003, 2006). Wilson (1998), on examination of Lyell's field notes (which with no doubt he had access to), must have considered this fact no significant enough to be mentioned. Lyell recognized in the Ebro basin the nummulitic limestone facies, which himself had defined as Eocene in the Paris basin, and some overlying marine deposits. More interestingly he also recognized the lateral transition from continental facies at the basin margin (Montserrat conglomerates) to restricted marine facies basinward (Cardona and Súria saline formation). It is evident that his previous knowledge of the Tertiary of the Paris Basin helped him to arrive at this correct, although schematic, interpretation of the eastern Ebro basin sequences, but it is worth noting

that at that time it was a great innovation to establish the existence of these lateral facies changes.

Lyell's interest on the subject of Sedimentology has not been emphasized adequately. To realize this interest it is only necessary to leaf through his books and find magnificent examples of sedimentary structures; current generated crossed and parallel lamination, water drops, etc. The examples presented of the flysch of Bayonne sedimentary formation (Basque Country) in the *Principles* are extraordinary, although he wrongly supposed that they were deposited in a coastal environment.

The Pyrenees

Although Lyell's major aim during his first visit to Spain (1830) was to study the Olot volcanic region, he was also interested in the Pyrenees and more precisely in the age of the orogenic movements that resulted in them. Elie de Beaumont (1830) had just published a paper (*Recherches sur quelques-unes des révolutions de la surface du Globe*) where, in agreement with the theories of



FIGURE 2 | Francesc Bolòs (Olot, 1773-1844) in the uniform of first assistant of the Army Pharmacy. Portrait of Panyo. Collection Bolòs family. A typical character of the illustration who suffered all the contradictions and problems of the Spanish intellectuals. He was born into a wealthy family which for more than 300 years owned the most important pharmacy of Olot, a town of 10,000 inhabitants near the Pyrenees with an important leather and textile industry. While studying in Barcelona he established contact with Pierre André Pourret, a French naturalist in exile because of the French Revolution. They collaborated in botanical research and collected an important herbarium. Bolòs also studied the volcanoes that surrounded Olot and acted as guide to foreign specialists such as Maclure and Lyell.

catastrophism, he maintained that mountains had been formed during three short but intense orogenic periods: *the Jurassic revolution, the Cretaceous revolution and the Tertiary revolution* (in particular the Pyrenees were formed in the Cretaceous revolution). Evidently, Lyell could not agree with this idea but thought that the orogenies were produced over long time periods and as a result of different tectonic pulses.

The journey he made from Puigcerdà to Pau, passing la Maladeta and Mount Perdut, allowed him to make some interesting geological observations which were collected in his field notes (Aragonés, 2004). He identified different, successive major Paleozoic to Tertiary unconformities, which allowed him to refute the existence of the sudden and violent “revolutions” proposed by Elie de Beaumont.

These observations were probably not very important from the point of view of tectonics, but they have great significance for one of the fundamental paradigms of Geology as a science, which is the temporal dimension of the geological phenomena. That is to say, time as the fourth dimension that geologists can reconstruct using the three spatial dimensions. It is true that Hutton was the first who proposed the concept of “deep time”, but it was Lyell who showed us how to convert it into history; the Earth history. A history not to be found in ancient myths or sacred religious texts, because it is written in the Earth crust, in the rocks that make it up and the fossils they bear.

CHARLES LYELL AND THE SPANISH GEOLOGISTS

Personal Contacts

Throughout his travels Lyell was interested in getting to know the universities and museums of the cities he visited, but this was not possible on his both trips to Spain. During his first visit, Barcelona was a city devastated by the Napoleonic wars, internal fighting and the repression from the central government. The university (Els Estudis Generals) had been closed down and “exiled” to Cervera in 1717 by order of Felipe V, as punishment for the Catalans’ support to the Austrian pretender during the War of Succession. Barcelona still had not a museum of Geology or Natural History as did Madrid, London or Paris. Both the Martorell and the Seminari geological museums would not be founded until nearly 50 years later. The Academy of Arts and Sciences of Barcelona founded in 1770 had also been closed down in 1824.

Once discarded any official contact with the scientific institutions in Barcelona, Lyell was constrained to contact

personally with local naturalists; with Yáñez in Barcelona, who had published some geological notes on Catalonia and accompanied him on his visit to the Tertiary of Montjuich; with father Boada who guided him in Montserrat; and, as it is well known (Aragonés, 2001, 2003, 2006; Ordaz, 1985; Sole Sabaris, 1975, 1982, 1986; Virgili, 2003), with the Pharmacist Bolòs (Fig. 2) who helped him in his introduction to the Olot volcanic zone. Without entering into controversies as what they could have shown him or what he could have taught them, it is clear that these people would have no relevance in the future of Geology in Spain, and therefore it was not through them that the renewal of paradigms and the new vocabulary that Lyell proposed arrived to the Spanish scientists.

In any case, either this stay in Spain or perhaps the success of the publication of three volumes of the *Principles of Geology* (1830-1833) had a certain repercussion in the media and on 7th June 1836 a Madrid newspaper, *El Español*, published an article (New considerations on the geological constitution of Europe) that attempted to summarize the new vision of Geology brought about by the British geologist.

When in 1853 Lyell returned to Spain during his trip to the Atlantic islands, the situation was quite different. The Queen Isabel II had started a two year “progressist” period with a liberal Constitution. In Catalonia, since 1837 the University had been re-established in Barcelona. A certain, although unequal, industrial and economic development had also started in the country. The discovery of lead and silver deposits in Hiendelaencina, of mercury in Almadén, lead in Linares, copper in Río Tinto and iron in the Basque country had awakened an interest in Geology. The long time developed but not very successful exploration for thick workable coal seams, which were necessary for the textile industry and for the railways that were beginning to function in the Peninsula, also had an influence. In 1849 the Comisión del Mapa Geológico de Madrid y General del Reino was founded. Although since 1777 there had been a mining school in Almadén, in 1835 the Escuela de Minas was established in Madrid and at the same time Geology courses begun to be held at the Academy of Science in Barcelona.

It is difficult to know to what degree Charles Lyell was able to perceive these changes when, at the beginning of 1854, he arrived at the Canary Islands. He was just returning from a three month trip to the Atlantic islands, Madeira in particular, where he studied the structure of the volcanoes and the sea level variations evidenced there by ancient elevated beaches. He also studied both the present day and the ancient fossilized flora and fauna in order to confirm the observations on the endemic nature of island species, which his friend and colleague Charles

Darwin had made on the Galapagos Islands a few years before. Although he still did not agree completely with the evolutionary principles of Darwin, he would come to agree a couple of years later. Thus, by that time he wanted to verify in the field the arguments on which these evolutionary principles were based.

The rural areas of the interior of the Canary Islands were poor and under developed, but in the cities there was a cultured and prosperous society and the ports had an important commercial activity, since they were an almost obligatory port of call for ships on their way from Europe to Africa or America. Lyell found neither universities nor geological museums, but at the Nautical School of Tenerife he visited the professor of sciences, Pedro Maffiotte (Fig. 3) who was as good a naturalist as he was a host. He accompanied Lyell on his trips to Teide, helped him in the collection of fossils and provided numerous items of geological information. The correspondence and exchange of data between both men about ancient elevated beaches, sequences of Miocene and Quaternary materials, formation of calcareous crusts and dunes, and evidently volcanic deposits, lasted until 1866. In 1858 Lyell wrote to his friend communicating the possibility of publishing a book about the Canary Islands and Madeira, a project which unfortunately did not come to fruition. Pedro Maffiotte was certainly, of all the people Lyell met during his travels in Spain, the person with whom he maintained the



FIGURE 3 | Pedro Maffiotte (Tenerife, 1816-1870). Professor of science at the Nautical School of Tenerife, and of mathematics at the School of Fine Arts. Amateur naturalist and one of the main animators of the cultural life of the city. He supervised the expansion of the harbour of Puerto de la Cruz. As he knew the island very well, he used to guide the visiting scientists. Charles Lyell was a good friend of him and they corresponded regularly (Benítez, 1926, Edinburgh Library).

longest and most intense scientific contact, as the conserved correspondence (Benítez, 1926; Lyell in Edinburgh University Library) demonstrates. The volumes of *The Principles of Geology* signed by Lyell, which can be found in the Museum of Natural Sciences in Santa Cruz in Tenerife, are probably those which the author sent to Maffiotte, who sent a letter to thank Lyell on 4th July 1854. These could be the first book copies to arrive in Spain. But, although Maffiotte certainly read them with great interest, it was not him who introduced Lyell's teaching to our country.

Translation and influence of "The Elements of Geology"

Despite all of this close personal contact, the person who introduced Lyell's work and ideas into Spain was not Maffiotte, but Ezquerro del Bayo (Fig. 4), a Spanish geologist who Lyell probably never met. But he was the person who translated one of his fundamental books: *Elements of Geology* (Lyell, 1830-1833). The first English edition of this book, which was translated by Ezquerro (Fig. 5), was published in 1838 (Ordaz, 1976) and it included all the more descriptive and systematic aspects of *The Principles*, leaving to one side the theoretical formulations about the geological processes and Earth history. *Elements of Geology* was especially intended for students and was easier to read and understand than the *The Principles*. Charles Darwin, who Lyell had asked to critically read his book, thought it was "a marvel of clarity and concision". It was an extraordinary success, and it was adopted as the official text in universities and mining schools throughout the world and numerous editions were published. The second edition (1841) was notably extended; the third, fourth and fifth were titled *A Manual of Elementary Geology*; and the sixth (1865), the last in the author's life, regained its original title.

Elements has two quite different parts; the first describes and classifies rocks as sedimentary, volcanic, plutonic, and metamorphic, which was a complete novelty as it was Lyell who introduced the concept of metamorphism. In those times some geologists still maintained Werner's proposals about the "aquatic" (sedimentary) origin of basalts and granites. The second part of the book is a geological history which also represented a new vision with respect to other manuals and opinions of the time. As a consequence of recognition of metamorphism processes, Lyell denounced the error of considering any crystalline rocks as remains of the primordial crust of the Earth. Obviously, the chronostratigraphic nomenclature used in this book is not exactly the one we use today, as the Precambrian, Ordovician and Silurian still had not been defined. Until the third edition (1851) he did not use the names Carboniferous, Permian, Triassic or Jurassic,



FIGURE 4 | Joaquín Ezquerro del Bayo (Ferrol, 1793-Tudela, 1859). One of the most important and influential geologists of his age, who modernized and systematized Geology and the exploitation of mineral resources in Spain. Ezquerro was a liberal man educated at the School of Mines of Freiberg and became Professor in the School of Madrid and Inspector of Mines. He also was a fellow founder of the “Real Academia de Ciencias Exactas Físicas y Naturales” (Royal Academy of the Exact Physic and Natural Sciences). He completed more than seventy works of investigation and of applied geology and mineralogy, for instance “Ensayo de una descripción general de la estructura geológica del terreno de España” (1850-7). In 1850 he published in Stuttgart “Geognostische Übersichtskarte von Spanien (1: 5,000,000)”, the first complete geologic map of the country.

but on the other hand he used the terms Eocene, Miocene and Pliocene, which he had defined in the Paris Basin, to divide the Tertiary. The Paleocene and Oligocene were characterized later. Another novelty is represented by the attempt to date the volcanic rocks in accordance with the rocks they cross-cut or cover.

To sum up this was the first modern treatise on geology which was accessible to the lay public and the fact that it was widely distributed and accepted represented an important renovation of the geological paradigms in the middle of the 19th century. Spain was not left out of this renovation thanks to the fact that Joaquín Ezquerro de Bayo translated *Elements of Geology* in 1847 and the book was adopted by universities and schools of engineering not only in Spain but also in the prestigious School of Mines in Mexico. In consequence Lyell’s petrographic and stratigraphic nomenclature was widely and rapidly used in our country. It should also be noted that Ezquerro was also a prestigious and influential person (Ayala-Carcedo, 1993). He was the author of the first geological map of the whole of Spain, i.e. the Geognostische Übersichtskarte von Spanien (1850), and Ensayo de una descripción general de la estructura geológica del terreno de España (1850-1857). Through this work Ezquerro exerted a great influence on the work of the future Commission for the Geological Map of Spain.

It is obvious that prior to Ezquerro’s translation, Lyell’s work was known in Spain through both the English edition and the French translation of the first edition (Lyell, 1839) as well as the existence of several copies of the latter edition is documented in libraries and private collections, which in some cases belonged to ex-students of engineering schools. This allows us to suppose that Ezquerro could have used this French translation to a greater or lesser degree to produce his translation into Spanish. This would explain why he translated the first edition (the only edition that had been translated into French) and not the second, which had already been published and contained much more information about Spain than the first. However, this does not lessen the merit which Ezquerro deserves as the person who introduced in Spain the geological nomenclature and terminology proposed by Lyell.

In any case the translated book, *Elements of Geology*, represented only a part of Lyell’s geological vision, and

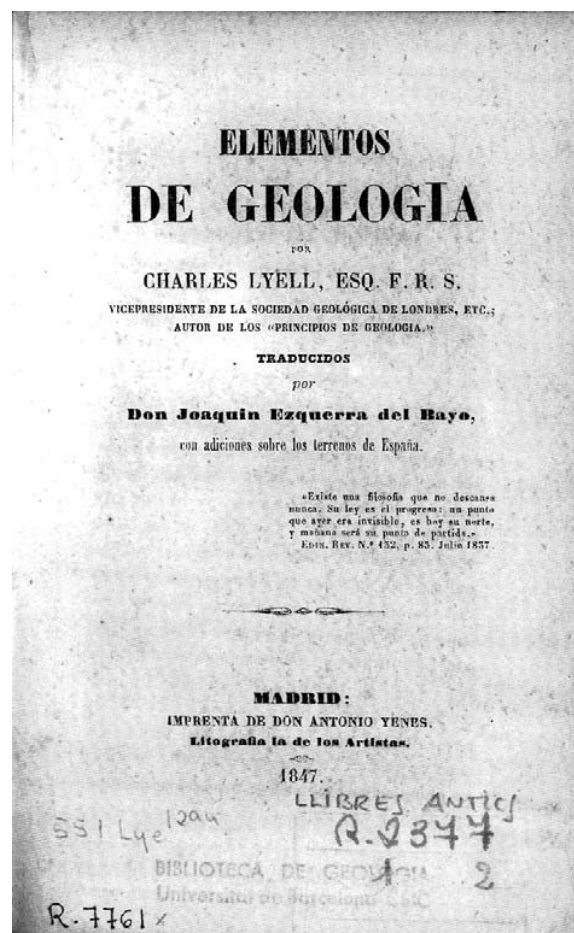


FIGURE 5 | Cover of the book “Elementos de Geología” translated into Spanish by J. Ezquerro del Bayo in 1847.

not the fundamental part that was the concept of actualism, as an “attempt to explain the changes that have been produced on the Earth in the past by processes which we can see operating today”. This aspect that could be called “doctrinal” or “theoretical” was the subject of the other book “*Principles of Geology*” which was less widely distributed in our country. It was never translated into Spanish, as it was into French and German. As has already been mentioned, the first copy that probably arrived was that which Lyell sent to Pedro Maffiotte in 1854. The purchase of a copy by the library of the Seminari of Barcelona in 1876 is also documented (Aragonès, 2004) and both the original in English and the French translation have been found in a number of libraries including the Universities of Barcelona and Madrid. Nevertheless, most of the Spanish geologists of that time had been trained at the school of Freiburg, where Lyell’s influence had not managed to eliminate the Werner’s ideas of “catastrophism” and “neptunism”. Thus, for many years they would continue talking of “Diluvial period” and “orogenic paroxysms”.

CONCLUDING REMARKS

Charles Lyell visited Spain, as he did in a large extent Europe and North America, looking for proofs and examples to support his principle of “actualism”, which he understood as the permanence and rationality of Nature laws in the Earth, in analogous way to that established by Newton for celestial bodies. When he came to our country he marvelled at the outcrop variety and quality but he was indignant at the social and political situation and wrote (Lyell–Horner, 1881): “*Spain is a magnificent country for geology*”, “*although it does very little in literature and nothing in science, due to the exterminating actions of the Inquisition against independent thinkers and scientists*” (Inquisition was active until 1834). In any case, despite the fact that most of his statements were right, it should be emphasized that the Spanish geologists were not completely isolated from the rest of Europe. Most of them followed with interest what happened and how progressed Geology in Europe and their thoughts were not confined by political borders. Some of them went abroad as political exiles during times of rampant repression, while others went to foreign centres with official grants during periods of political calm and freedom. This was especially frequent in the case of the geologists, as mining was very important for the Spanish economy, due to both the new deposits which were being discovered and exploited in the Iberian Peninsula and those which were surveyed and explored in the American possessions. For this reason, the Spanish governments of the time, regardless of their political colour, protected geological and mining studies. One of the best examples

of this “combination of exiles and study trips” was Ezquerro del Bayo (Ayala-Carcedo, 1993), the translator into Spanish of “*Elements of Geology*”. The spreading of this work amongst Spanish geologists triggered the influence of the thinking and, especially, of the vocabulary of Charles Lyell in our country, while there is no trace that the personal contacts he might have had with various naturalists attained similar efficacy. This seems to prove that more often than not “words fly away” while, on the other hand, written words, books, are left to bear witness for the people and their thoughts.

ACKNOWLEDGEMENTS

In this volume as homage to Francesc Calvet, the final reflection resulting from this paper allows us to think that, although with his death we lost a great, extraordinary friend and colleague, his writing and his work will remain with us and we will always find there both his leading thought and stimulating teaching.

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