

LA NATURALEZA AND THE MEXICAN GEOLOGISTS IN THE SECOND HALF OF THE NINETEENTH CENTURY

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RESUMEN

El trabajo pone en perspectiva el quehacer del grupo de naturalistas mexicanos que con el correr del siglo XIX se decantaría por las cuestiones geológicas dentro del ámbito de la Historia Natural, sin descuidar el estudio de la flora y la fauna de las distintas regiones del país para poder compararlas con los hayasgos de restos fósiles de épocas geológicas pasadas, y determinar su estratigrafía y edad en el tiempo. Aunque todavía hace falta profundizar en el estudiar de la adopción y/o aclimatación de las nuevas teorías que orientarían el interés científico y la ruta de investigación de los naturalistas mexicanos, ya es posible concluir que, a partir del análisis de los contenidos que se dieron a conocer en *La Naturaleza*, los naturalistas y hombres de ciencia mexicanos estuvieron informados y conocieron de los debates disciplinarios, los paradigmas en boga y las obras de sus pares europeos y estadounidenses; y no obstante ello, mantuvieron la prudencia de declarar su filiación a alguna teoría o modelo interpretativo sin contar con las evidencias empíricas suficientes que su experiencia y práctica científica les proporcionaba. Quizás resida en esta última cuestión la respuesta al porqué la transición del neptunismo al uniformismo haya abarcado buena parte del siglo XIX para el caso mexicano.

PALABRAS CLAVE: Geología, Historia Natural, México, La Naturaleza, siglo XIX.

ABSTRACT

The aim of this article is to put into perspective the work done by a Mexican group of naturalists over the nineteenth century. This group of scholars dedicated their studies to geological issues within the field of Natural History with special attention to the study of the flora and fauna of the regions of the country. The data obtained from these studies were useful to be compared with fossil findings of past geological epochs and to determine their stratigraphy and age. Although a deeper study about the adoption and / or acclimatization of new theories is still needed. In this paper we present an analysis of the contents published in *La Naturaleza*, and how Mexican naturalists and scientists were informed of disciplinary debates, paradigms in fashion and works of European and American peers. It also shows the objectivity and professionalism demonstrated by these scholars regarding any interpretative theory or model. Such features might have eased the transition from Neptunism to uniformitarianism present in much of the nineteenth century in the Mexican case.

KEY WORDS: Geology, Natural History, Mexico, *La Naturaleza*, Nineteenth Century.

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INTRODUCTION

In 1948, Enrique Beltrán presented for the first time an overview of the journal *La Naturaleza* (Beltrán, 1948: 145-173; Herrera, 1937) in its early days: 1868-1914. In this work Beltrán offered a social vision of the Mexican Society of Natural History (*Sociedad Mexicana de Historia Natural*, in the following presented as SMHN by its

acronym in Spanish), and the results published in *La Naturaleza*. The official journal of the Society, Beltrán also introduced the researchers who played a decisive role in the development of the Mexican science in the nineteenth century.

From the 1980s the interest of specialists in the study of the press and scientific societies of the nineteenth century increased, in part because there was the

intention to broaden the perspective of the work of the so-called “scientists” and because they wanted to study their contributions to palaeontology, mineralogy, botany, zoology and geology. In this perspective several works appeared, some general and others with a more disciplinary perspective, where a wide range of aspects of scientific institutions, scientists, and communities of interest were explored. At the same time social networks, work exchanges and scientific discoveries associated with the *Sociedad Mexicana de Historia Natural* and *La Naturaleza* were presented (Carpy Navarro, 1986; Vega and Ortega Baez, 2007; Landa Landa, 2006: 5-15).

In the present paper we offer a perspective of the work of this naturalists group. They concentrated especially in the study of the flora and fauna of the regions of the country to confront these findings with fossils of past geological epochs and be able to determine their stratigraphy and age.

ORIGIN OF THE JOURNAL

The return of the republican order in 1867 brought new life to the institutions and encouraged the reunification of Mexican intellectuals and scientists around a new idea of nation. Luz Fernanda Azuela sums up well what happened in the second half of the nineteenth century:

“Mexico experienced a great moment in the development of science: specialized societies were formed; the publications were multiplied, the first research institutions appeared and scientists changed their *amateur status* to become professionals [...] this events had also a great impact on social life visible in terms of the enthusiasm science aroused at that time that led intellectuals to aim their efforts and hope to lead the country in an inexorable movement towards perfection. The progress of science appeared to be the element that had sustained the subsequent strengthening of human reason. Hence, an intellectual movement was generated seeking to trace its own historical development, provoking at the same time the creation of the scientific Mexican historiography of the nineteenth century” (Azuela Bernal and Guevara Fefer, 1998: 79; Azuela Bernal, 1996).

An indicator of the interest of the Mexican society in the science during the nineteenth century was the foundation of institutions, committees and scientific societies, such as: *Sociedad Mexicana de Geografía y Estadística* (1833); *Sociedad Filoiátrica* (1841); *Sociedad Química* (1849); *Comisión del Valle de México* (1856); *Asociación Médico-Quirúrgica Larrea* (1857); *Observatorio Astronómico Nacional* (1863); *Academia Nacional de Medicina* (1864); *Comisión Científica de Pachuca* (1864); *Sociedad Médica de México* (1865); *Museo Nacional* (1866); *Hospital de San Carlos* (1866); *Sociedad Médica Hebdomadaria* (1867); *Sociedad Mexicana de Historia Natural* (1868); *Asociación Médica Pedro Escobedo*

(1868), *Sociedad Farmacéutica* (1870); *Sociedad Familiar de Medicina* (1870); *Sociedad Científica “Antonio Alzate”* (1884); *Sociedad Científica “Alejandro de Humboldt”* (1886); *Sociedad Científica “Leopoldo Río de la Loza”* (1886); *Academia de Ciencias Exactas, Físicas y Naturales* (1890). Most of the participants working on these associations attended regular meetings in which members presented papers on various topics, which were later published in their respective journals (Saldaña and Azuela Bernal, 1996: 135-171).

According to existing registers on the establishment of scientific societies, it appears that the *Sociedad Mexicana de Historia Natural* was the first operating society in Mexico dedicated exclusively to the study of the Mexican nature. One of the strategic objectives of the SMHN was to continue with the elaboration of a geological map of Mexico; such map was left unfinished by the French Scientific Comité due to the French military intervention in the country in 1862 (Maldonado-Koerdell, 1963: 246-247; Azuela Bernal, 2002: 47-67).

Other studies have also explored the social conditions on the development of the SMHN and the hard work scholars deployed through *La Naturaleza* with the intention to raise awareness and encourage the study of natural resources, and eventually to show the usefulness and application of these studies in different areas of industry, health, education and welfare of the society.

The SMNH was founded on August 29, 1868, and the publication of the first issue of *La Naturaleza* appeared on June 1, 1869. The creation of this journal was an expression of the level of maturity reached by the Mexican scientific community of the mid-nineteenth century. Community still attached to a conception of knowledge that fit fully into what was then called Science or Natural History. Among the most important promoters and founders of the journal we can mention ten well-known scholars: Jose Joaquin Arriaga (1831-1896), Antonio del Castillo (1820-1895), Francisco Cordero and Hoyos (1826-1879), Alfonso Herrera (1838-1901), Mendoza Gumesindo (1829-1883), Antonio Penafiel (1834-1922), Manuel Río de la Loza, Jesus Sánchez (1842-1911), Manuel Urbina (1843-1906) and Manuel Maria Villada (1841-1924), all illustrious men with a deep interest in the progress of science and the progress of Mexico (Herrera, 1939: 7-14). Six of them served, in different years, as president of the SMHN: Antonio del Castillo (1868, 1869), Alfonso Herrera (1872, 1882), Gumesindo Mendoza (1878), Jesus Sánchez (1879), Manuel Maria Villada (1881) and Manuel Urbina (1895) (Guevara Fefer, 2002: 39).

In the opening speech of the SMHN on September 6, 1868, the mining engineer and president of the Society Antonio del Castillo set the scientific objectives and outlined the research lines the collective should follow in order “to devote ourselves to the study of the various areas of Natural History” (*La Naturaleza*, 1870: 1). One of the priorities presented on the ceremony was to establish a journal to collect and present the contributions of the members to the natural history research of

Mexico, forming collections of objects from the three kingdoms of nature and therefore to encourage the study in all possible areas and applications.

La Naturaleza was published on and off between the years 1869 and 1914 and then the publication stopped. But after the revolutionary events had finished another group of scholars and scientists led by Enrique Beltrán restarted the activity of the journal with new impetus (Beltrán, 1948: 145-173). In this second period beginning in 1936, the journal received a new name *La Naturaleza, Periódico Científico del Museo Nacional de Historia Natural y de la Sociedad Mexicana de Historia Natural* (Table 1).

A remarkable thing to highlight is that in the first period of 45 years the *Sociedad Mexicana de Historia Natural* brought together the dedication and scientific work of a group of professionals from different areas of work including military, doctors, engineers, chemists, agronomists, veterinarians, pharmacists and artists, with different disciplinary interest. This characteristic transformed *La Naturaleza* in an obligatory reference to intellectual activities, creativity and generation of new knowledge about nature, the universe, Mexican society and scientific progress in this part of the world.

Furthermore, in the first work report presented on January 12, 1871, the first secretary of the journal Antonio Penafiel reported on the scientific institutions and countries which were active collaborators of *La Naturaleza*, and also the societies and foreign correspondents of the SMHN. Some of these international institutions were the Smithsonian Institution in Washington, The United States Royal Academy of Sciences in Stockholm, Sweden; The Imperial Observatory of Moscow, Russia; The Royal Zoological Society of Amsterdam, Netherlands; The Royal Academy of Sciences in Berlin, Prussia; The Imperial Academy of Sciences in Vienna, Austria; The Geological Society of France; and the Geological Society of London, England [*La Naturaleza*, 1871: 1 (22), 408-409].

An example of the great international projection of *La Naturaleza* was described by the general secretary of the Zoological Society of France, Dr. Blanchard, in an

article published on May 13, 1882 in the prestigious *Revue Scientifique*. The article was later transcribed in *La Naturaleza* with the title "La Sociedad Mexicana de Historia Natural judged abroad". The text says:

"The scientific publications edited in countries of Spanish origin are rare and of little importance. So now, with great satisfaction, we draw attention to the journal *La Naturaleza* published by the *Sociedad Mexicana de Historia Natural*. This journal, almost unknown in Europe, deserves for several reasons to occupy a place of honor in our scientific libraries. Most of the papers on the journal are very interesting and to give an idea of its importance it is sufficient to say that in this publication we can find contributions from Alfredo Dugés, Eugenio Dugés, Simichrast and Jesus Sánchez to name just the leading ecologists who had published the results of their research on the Mexican fauna in this journal" (*La Naturaleza*, 1884: VI, 60).

During 45 years of existence, *La Naturaleza* was published in three series and eleven volumes. The magazine was released monthly, with a starting price of 2 reales in Mexico City and 2 ½ in the states. The efforts of its directors, the reports, abstracts and scientific articles received from different parts of Mexico, made possible the permanence of the journal among scientific publications due to the originality of its contributions in areas like zoology, botany, mineralogy, geology and paleontology of Mexico. In this period 690 papers were published: 265 on zoology, 205 on botany and 95 on mineralogy and geology, and the rest were on various topics from auxiliary sciences.

THE PARTICIPANTS AND THE GEOLOGICAL COMMUNITY

At the opening ceremony of the SMHN on September 6, 1868, Antonio del Castillo defined the contents and outlined the route to be followed by the Society in the study of the zoology, botany, mineralogy, geology and

Periods	First period 1868-1914		
Series	First Series 1868-1887	Second series 1887-1899	Third series 1910-1914
Volumes	Volume I, (1869-1870) Volume II, (1871-1873) Volume III, (1874-1876) Volume IV, (1877-1879) Volume V, (1880-1881) Volume VI (1882-1884) Volume VII (1885-1886)	Volume I, (1887-1890) Volume II, (1891-1896) Volume III, (1897-1903)	Volume I, (1910-1914)
Number of articles	68	22	5

Table 1. Periods, series, volumes, numbers and items of *La Naturaleza*, in the field of Mexican mineralogy and geology. Source: *La Naturaleza*. From 1869 to 1914.

paleontology, which were remarkable expressions of Natural History. As a mineralogist and geologist, del Castillo acknowledged the achievements and advances in both disciplines and exposed the scientific and social challenges they had:

“The scheme of the Mexican mineralogy or the catalog of the mineral species found in Mexico has already been published;¹ new species will be discovered when the research from our mineralogists researchers extends to the most remote mining states and collect complete sets of mineral districts.

But the specialised mineralogy of Mexico requires the particular description of the species that conform it, and the enumeration of which are specific to each mineral district, in other words, we still lack the mineralogical description of many of our mineral districts.

This indicates that our works should be extended to those areas, and that we have to embrace them and make them better.

From the knowledge of mineral substances that are naturally in our country derives the benefit that the society can get from it, and therefore which ones offer operating interest in increasing the public wealth” [*La Naturaleza*, 1870: 1 (1), 1-5].

When referring to geology, he said:

“In terms of geology, which deals with the history of the physics of the earth, the composition and structure of the rocks that conform its crust and the fossils found therein, and whose study is part the scope of the above areas of the Natural History, we must say, in reference to our country, which is known only to some of our miners and surrounding districts, and that the vast extent of our territory is hoping that the scholars decode the mysteries of the creation and the times to which they belong.

This identification or knowledge of those fossils is of much greater interest because it would help to complete the study of the geology of North America, which eagerly awaits the civilized world.

The geological map of our country will be a great monument erected to science, and it is therefore necessary to go collecting materials and to train the researchers who must deal with them” [*La Naturaleza*, 1870: 1 (1), 4-5].

Gradually the SMHN was establishing various committees or areas of knowledge.

“All members were divided in different groups, these groups were named sections, each member chose the section most closely related with his area of expertise. With this in mind, they estab-

lished the sections of Zoology, Botany, Geology and Paleontology, Mineralogy and Auxiliary Sciences” [*La Naturaleza*, 1871: 1, (20), 392].

Members also started with the creation of commitments, rules and values in order to set procedures and goals, organize their activities, and collectively weigh the relevance and scope of their research. These actions gave greater certainty and stability to the *corpus* of conceptual knowledge they were cultivating. The feedback they received on a daily basis paved the way to set greater goals, such as promoting more specialized courses in the disciplinary training of their students in educative institutions, the establishment of monodisciplinary societies, and even, the creation of new institutions with government support. This could perfectly fit with Kuhn’s definition of scientific community: a group of individuals sharing a common paradigm and working collectively towards achieving a work program (Kuhn, 1971).

The keynote speech of Antonio del Castillo attracted to the journal 96 specialized works related to mineralogy and geology, through them it is possible to appreciate the changes in approaches and methods adopted or innovated by Mexican scientists and the institutionalization of sciences of the Earth, with the help of government projects (Azuela Bernal, 1996).

In this sense, *El Explorador Minero* published a review at the end of the year 1876 referring to the contents and scope of work presented on the pages of *La Naturaleza*. In particular, *El Explorador Minero* referred to the geological descriptions of certain regions of Mexico “offering interest in the nature of the rocks, and geological events that have occurred, both in respect of the rocks of sedimentary origin as an igneous origin” [*El Explorador Minero*, 1876: I (9), 71]. This review made evident the scientific interest of Mexican naturalists to document the debate on the origin of rocks, geological conditions in the course of time and the cuts that have occurred to determine the corresponding geological stratigraphy and age.

El Explorador also mentions the importance of the studies on volcanic phenomena in Mexican territory, including volcano activity, the effects on the rocks and the work developed about “the country’s paleontology” -little known abroad-, the disclosure of fossils “of our geological formations from the oldest to the most modern”, all of them to be integrated to the Paleontological Catalog of Mexico in order to “discuss their correspondence with fossil faunas and floras of the old continent” [*El Explorador Minero*, 1876: I (9), 71].

Although, the group of Mexicans botanists, mineralogists, paleontologists and geologists participated intensively in various educative institutions, associations, committees, and government projects, and released the

¹ He is making reference to his works: 1863, Scheme of the Mexican mineralogy, containing the mineral species display in order by their chemical compositions and cristalization, according with the system of the professor of mining and geology in the Colegio de Minería. In *Boletín de la Sociedad Mexicana de Geografía y Estadística*, 1ª época, tomo X, México, 565-571; and, 1864, *Catálogo de las especies mineralógicas y de sus variedades que se encuentran en México, formada por Antonio del Castillo*. Imprenta A. Boix, México, 9 pp.

results of their work in magazines, newsletters, newspapers and textbooks, their initial works or professional consolidation were published in *La Naturaleza*, and many of them used the journal not only to disseminate the results of their research, but to consolidate their presence as researchers in Mexico and abroad (Uribe Salas and Cortés Zavala, 2006: 491-518; Azuela Bernal, 2005; Morelos Rodríguez, 2012: 33-252).

Some of them like Antonio del Castillo (1820-1895), Mariano Bárcena (1842-1899), Santiago Ramírez (1836-1922), Pedro López Monroy, Vicente Fernández, José C. Haro, Manuel M. Villada (1841-1924), Severo Navia, Ezequiel Ordoñez (1867-1950), Guillermo B. Puga, Alfonso Herrera (1838-1901), Manuel Río de la Loza, José Guadalupe Aguilera (1857-1941), among others, gave continuity to the systematic work of Andrés del Río during the years 1795 and 1849 at the *Real Seminario de Minería* which later was named *Escuela de Minería*. This group was, in fact, responsible of the implementation of the Mexican epistemological framework of the Mexican geology in the second half of the nineteenth century.

In that period, *La Naturaleza* published 96 works in the field of mineralogy and geology, written by a community of 63 people: 47 of 48 of geology and mineralogy. Note that some articles were reproduced *postmortem* of the authors, such is the case of Francisco Xavier Gamboa: “Noticias sobre las minas de azogue de México”, containing comments regarding *Las Ordenanzas de Minas* (1761)”, José Mariano Muciño “Descripción del volcán de Tuxtla (1793)”; Alexander von Humboldt: “Descripción de las minas de azogue de México y el Perú hacia los años de 1801 a 1803”; Joseph Burkart: “La Guadalucazarita. Informes mineralógicos, 1872” and “Examen y clasificación de algunas especies minerales de México (1875). The publication of these works were a tribute to these researchers, and an attempt of the new generations to recover the scientific memory of their predecessors in the urgent task of promoting a professional practice in the fields of Mexican mineralogy and geology.

In any case, the new edition of the works of Gamboa and Humboldt, decidedly contributed to the study of the quicksilver mines due to the economic importance the mines represented; while the work of Muciño was more focused on the scientific interest about the behavior of the “Earth crust”; and the work of Burkart focused on nature, structure and composition of the minerals discovered in Mexico at that time.

From the 96 papers, 25 were authored by German, British, American and French geologists, among them J.W. Mallet, Cloizeaux, E. D. Cope, E.T. Cox, N. Degoutin, A. Dullfus, Ehrenberg, L. Flecher, J. Girard, M. Lumbert, J.M. Mallet, M.C. Mehu, Ernest Wittich and H. de Saussure, in some cases the papers were the result of scientific expeditions in Mexico, others were translations from the original language. It was remarkable the interest of foreign scientists in volcanology; the chemical analysis of minerals and their properties, the application of the microscopic technique in studying stones and minerals; the meteorology “which connected us

with the movement of the universe”, the hydrology and coal farms in response to the growing urban and industrial demand for water and fuel (*La Naturaleza*, 1868-1912).

Among the articles presented in *La Naturaleza*, some of them referred to the relationships and networks established to face in a better way the challenges existing in the distant year of 1869 to develop “the geological map of our country, because that map will be a great monument raised to science...” (Castillo, 1868: 5). Similar to their foreign counterparts, Mexican scientists also joined forces to produce broader and deeper knowledge of the geographical distribution, and the physical and chemical properties of mineral resources; following the example of Andrés del Río, Alexander von Humboldt and Joseph Burkart (Uribe Salas, 2012) (Tabla 2).

As it can be seen in the list of articles, there is already an anthropological concern about the origin of “the man” on the Earth, from the findings of prehistoric human remains in the Valley Mexico, such analysis would extend the debate on the origin of life and the age of the Earth among researchers. Antonio del Castillo and Mariano Bárcena were important promoters of this discussion, and were also considered as the main promoters of modern geology and biology in Mexico (Guevara Fefer, 2002; Pérez-Malvárez and Ruiz Rodríguez, 2003: 207-244). There is also presented an early conceptual synthesis of the geology of Mexico by José Guadalupe Aguilera and Ezequiel Ordoñez, already considered geologists, in the broadest sense of the term, and who with their paper symbolically prepared the generational transition between the group of Antonio del Castillo and the one led by José Guadalupe Aguilera in the late nineteenth century and first four decades of the twentieth (Aguilera and Ordoñez, 1894: 385-389; Uribe Salas and Cortés Zavala, 2006: 491-518).

SCIENTIFIC WORK AND THE CONTRIBUTIONS TO THE DEVELOPMENT OF MEXICAN MINERALOGY AND GEOLOGY

The group of Mexican mineralogists and geologists who published some of their work in *La Naturaleza*, represented only a portion of the members participating in the scientific community dedicated to the cultivation of those disciplines of natural history, but among them there were others who would exercise leadership in research in the second half of the nineteenth century. Among the principal representatives was Antonio del Castillo, Mariano Bárcena, Santiago Ramírez, Manuel M. Villada, Alfonso Herrera and Mendoza Gumesindo, founding members of the SMHN, and their disciples José Guadalupe Aguilera, Ezequiel Ordoñez, José C. Haro, Teodoro Laguerenne and Guillermo Puga, among others, these disciples would continue leading the works and projects in the transition from the nineteenth to the twentieth century.

This group of 16 researchers published in the pages of *La Naturaleza* about three quarters of all articles and

Name	Article	Year, Series, Volume
Guillermo Hay, Alfonso Herrera, Manuel Rio de la Loza and Gumersindo Mendoza	Informe de la Comisión sobre las aguas potables de México	1869, 1st, 1
Jose M. Velasco and Ildelfonso Velasco	Estudio sobre una especie de falsa Jalapa de Queretaro, <i>Ipomaea triflora</i>	1870, 1st, 1
Sebastian Camacho, L. Rio de la Loza, M. Bárcena, J.P. Manzano and M. Iglesias	Dictamen aprobado por la Soc. Mex. de Hist. Nat., el 17 de abril de 1873, presentado por la comisión nombrada para dilucidar la cuestión suscitada con motivo del fraccionamiento del aerolito de la Descubridora	1873. 1, 2
Antonio del Castillo and Mariano Bárcena	Noticia de la existencia del arsénico nativo en la República Mexicana	1873. 1, 2
Mariano del Castillo and Antonio Bárcena	El Hombre del Peñón. Noticias acerca del hallazgo de restos humanos prehistóricos en el Valle de México	1874
Manuel Montañó Ramiro and Manuel M. Villada	The tequesquite	1875, 1, 3
Mariano Bárcena and J.W. Mallet	Composición química de la livingsstonita	1879, 1, 4
Jose D. Morales and Nicolas R. Arellano	Hidrología	1880, 1st, 5
Mariano Bárcena and Antonio del Castillo	Noticias acerca del hallazgo de restos humanos en el Valle de México	1886
Jose G. Aguilera, and Ezequiel Ordóñez	Breve explicación del Bosquejo Geológico de la República Mexicana	1894, 2nd, 2
Trinidad J. Paredes, Ernesto Wittich and Antonio Pastor G.	Las grutas de cristales de yeso de Naica, Chihuahua	1912, 3rd, 1

Table 2. Articles by Mexicans (coauthored) in *La Naturaleza*, 1869-1912. Source: *La Naturaleza*, 1869 -1914.

reports released in the journal. It is also noted that the largest number of papers published in the journal's first stage, which means before the creation of the *Comisión Geológica Mexicana* in 1888. This event had a significant influence in the creation of the *Instituto Geológico Nacional*. It is important to say most of the papers published correspond to Mariano Bárcena, Antonio del Castillo, Severo Nava, Manuel M. Villada and Ezequiel Ordóñez (Table 3).

Antonio del Castillo proposed on the opening speech of the SMHN a single principle of shared responsibility between the government and the scientific community to achieve the nation's progress and development of knowledge.

"Our honor and our government are interested in this task, both for the advancement of science itself and for the need to have a perfect knowledge of our mineral wealth, as it would not be fair to our noble aspiration if we let merit to other nations to come and collect the glory of the task.

In order to follow the stated purpose we prepare, arrange and classify the mineralogical, geological and paleontological collections of this

National Museum, and we hope that all the elements part of these collections, contribute largely to mitigate the difficulties that usually occur in great scientific works" [*La Naturaleza*, 1870: 1 (1), 5].

It was the establishment of a State policy with an emphasis on the consolidation of the institutions, best practices, economic activities and scientific work of greater impact to the development, progress and modernity in Mexican society. That is, a pragmatic and utilitarian view of the science.

In the teaching field, the group of Mexican mineralogists and geologists renew the contents and consolidate a new cultural practice. During this long century they moved from the study and acclimation of mineralogy to the formal teaching of the science of geology.

In the first lecture given by the eminent naturalist Andres del Rio in 1795, about *Orictognosia*, in order to broaden the knowledge of fossils by their external characteristics, *Geonosia*, for the proper understanding of the position and relationship of mineral substances in the earth, and the *art of mining*, for better extraction of mineral resources and their benefit (Del Río, 1795);

Name	Number of papers published in <i>Nature</i> published in <i>Nature</i>	Years old
Aguilera, Jose G.	1	1894
Bárcena, Mariano	23	1873-1892
Castillo, Antonio del	12	1869-1890
Castillo, Antonio del and Mariano Bárcena	3	1873-1886
Mendoza, Gumesindo	1	1869
Haro, José C.	1	1882
Hay, Guillermo	2	1869-1870
Herrera, Alfonso	1	1869
Laguerenne, Teodoro	2	1875-1898
López Monroy, Pedro	2	1869
Nava, Severo	7	1874-1880
Ordóñez, Ezequiel	5	1891-1900
Puga, Guillermo	4	1888-1892
Ramírez, Santiago	4	1870-1885
Río de la Loza, Manuel	1	1869
Vázquez de León, Miguel	1	1887
Villada, Manuel M.	7	1887-1910
Total	76	1869-1910

Table 4. Number of articles and years of publication by the group of Mexican mineralogists and geologists. Source: *La Naturaleza*, 1868 -1914.

for a “modern” teaching of geology. Del Rio demonstrated his expertise by including *Lithological Geology* as a subdivision (Bárcena, 1880: 16-18) to include the study of materials and substances that form the Earth’s crust; *Physiographic Geology* showing the physical aspects of the Earth, bio-geographical accidents, like water and air; *Historical Geology* interested in the study of the different periods of the history of Earth and its changes and transformations, and finally, *Dynamic Geology* to explore the presence of physical, chemical and natural agents that have contributed in historical time to the formation and alteration of rocks.²

The new paradigms of modern science in the field of geology were reference for planning the daily work in teaching, research and knowledge, and with it, the creation of collections and museums, libraries, collection of instruments, the design of journals and the formulation of scientific initiatives with a strong utilitarian aims to promote the development of economic activities, health, culture and education in Mexico (Bárcena, 1883; Bárcena, 1886).

But it is important to remember that the members of the Mexican scientific community also wrote about different fields of natural history and made fundamental contributions in mineralogy, paleontology, meteorology and botany. We now know, for example, that Del Castillo Ramírez and Bárcena jointly published 265 scientific papers and technic reports, and 19 mapping studies (including maps, plans, geological maps, etc.) in news-

papers, newsletters, memoirs and journals at home and abroad (Morales Rodríguez, 2012: 277-305).

States of the Republic	Number of studies
General studies concerning all the country	21
Hidalgo	8
Puebla	7
Guerrero	8
Jalisco	3
Colima	1
Michoacán	7
San Luis Potosi	5
Nayarit	2
Durango	2
Estado de Mexico	8
Baja California	1
Guanajuato	6
Sonora	1
Chihuahua	3
Zacatecas	1
Veracruz	3
Oaxaca	1
Morelos	2
Mexico City	4
Querétaro	1

Table 5. Spatial distribution of mineralogical and geological papers published in *La Naturaleza*. Source: *La Naturaleza*, 1869-1914.

² Mariano Bárcena had already published in 1875 *Geología dinámica*. Study read in the *Sociedad Humboldt*. In *El Propagador Industrial*, I (10): 111-114. Here Bárcena demonstrated the pertinence of the teaching of the geology and its incorporation in the syllabus.

From observation (collection) and experimentation (identification-classification) researchers moved to comparative studies (similarities and differences) and generalization, based on the studies, theories and interpretive models previously refereed by international communities. Through the nineteenth century, men of science, the scientific and education institutions in Mexico accumulated empirical material and experience in the study of changes in the Earth's crust. Through mineralogy, paleontology, botany and geology there were advances in the knowledge of changes over historical time among different interpretive theories and models.

Jesus Sánchez accurately defined the spirit of the times when he commented on the contributions of Mariano Bárcena and Santiago Ramírez in their books *Tratado de Geología* (1885) (Bárcena, 1885) and *Litología. Introducción al estudio de las rocas* (1886) (Ramírez, 1886). From the first he said: "encapsulates and summarizes, in few words, the general principles and theories of science, the principal merit is to present the applications relating to Mexico -it is undeniable that cooperates to the scientific development of the country- and that it will be the preferred text book for the study of geology in our national educative establishments for many years" (*La Naturaleza*, 1885-1886: 7, 328). About the second, Sánchez referred to "the book's main merit of Mr. Ramírez is, to my mind, that, as he said in the Introduction, p. VIII: In determining the facts, to apply the principles, to examine theories, to discuss the results, presenting examples, we have tried to refer to our country, to serve us, and of our own studies, and to those practiced by our peers and compatriots" (Sánchez, 1887-1890: 41).

It is clear that by the late nineteenth century, Mexican geologists had documented through a collection of more than 6,000 fossils, belonging to the *Comision Geografico-Exploradora*, the correlation of the Earth layers and the elapsed time, taking into account the erosion, sedimentation, earthquakes and volcanoes that gave evidence of how geological phenomena had happened. In the work *Fauna fósil de la Sierra de Catorce, San Luis Potosí* (Del Castillo and Aguilera, 1895), written in 1895 by Antonio del Castillo and José Guadalupe Aguilera "irrefutably demonstrated by a detailed description of the fossils, Jurassic presence in Mexico" (Gómez-Caballero, 2005: 154). But it was José Guadalupe Aguilera, leader of the third generation of specialists dedicated to the study of earth science, who had the hard work of systematizing what had been written and published in the New Spain and Mexico. His works *Bosquejo Geológico de México* (1896) (Aguilera et al., 1896); *Breve explicación del Bosquejo Geológico de México* (1897) (Aguilera, 1897: 385-389); *Catálogos sistemático y geográfico de las especies mineralógicas de la República Mexicana* (1898) (Aguilera, 1898); and *Reseña del desarrollo de la Geología en México* (1905) (Aguilera, 1905: 35-117), some of these works are the scientific and epistemological bridge between the nineteenth and twentieth centuries (Rubinovich Kogan, 1991: 10-119).

In 1903 Aguilera lead the creation of the *Sociedad Geológica Mexicana*. Once the Society was established, he created the *Bulletin of the Sociedad Geológica Mexicana* as its official communication organ (Uribe Salas, 2012). In this bulletin José G. Aguilera wrote a long dissertation on the development of geology in Mexico. His final words were:

"That the members of the Society [*Sociedad Geológica Mexicana*], in their eagerness to scientific progress of the country, when traveling the country, correct existing errors, explore regions that remain unknown, study in detail the currently incompletely described and studied regions to discover and present anything new, and constitute about geology solid foundation, so that, within a short time, the Mexican Geological literature will be increased a hundredfold" (Aguilera, 1905: 117).

It is necessary further study on the adoption and/or acclimatization of new theories that would guide the scientific interest and research path of the Mexican naturalists, but it is possible to conclude that, based on the analysis of the contents that were presented in *La Naturaleza*, Mexican naturalists and scientists knew and were aware of disciplinary debates, paradigms in fashion and works of European and American peers, and nevertheless, remained objective to any interpretive theory or model. Such features might have eased the transition from Neptunism to uniformitarianism present in much of the nineteenth century in the Mexican case, when in Europe the 1830s would be the breaking point with the appearance of the book by Charles Lyell.

CONCLUSIONS

In a global perspective of the period: 1868-1914, the cycles of *La Naturaleza* were shortened: the first period lasted 19 years, considered to be the most productive, the second 12 and the third 4 years. *La Naturaleza* concentrated in its first stage (series, 1868-1887) 68 items, the second stage (series, 1887-1899) 22 items, and in the third phase (series, 1910-1914) 5 items.

The most productive stage of *La Naturaleza* was the period from the years 1869 to 1887, which coincides with the intellectual maturity of its original promoters. The subsequent years were less promising, contrary to an upward trend and consolidation, as could be expected; it is precisely during the Diaz regime that scientific activity in Mexico reaches higher development. This may have several explanations or hypotheses. It is not, of course, a crisis at inner Mexican scientific community, or the loss of direction in the work and scientific-cultural practice of men of science in the country. Rather should be considered for other components to understand and explain the gradual loss of consensus that experienced both the SMHN and *La Naturaleza*, to continue to represent the scientific interests of a community that had by then reached a level of maturity in their areas of interest.

Therefore I propose three hypothesis: 1) the establishment of the *Sociedad Científica "Antonio Alzate"* (SCAA) in 1884, took the space until then in the hands of the SMHN. The members and promoter of the SMHN and *La Naturaleza*, Antonio del Castillo (1820-1895) and Mariano Bárcena (1842-1899), had fulfilled its production cycle in front of the SMHN, others had left the office because they reached retirement age, or had died. The strong group of mineralogists and geologists came to serve on commissions and government institutions, like the cases of the *Comisión Geológica Mexicana*, 1888, and the *Instituto Geológico Nacional*, 1891, this is the case of Antonio del Castillo, José Guadalupe Aguilera and Ezequiel Ordóñez. 2) In those years the disciplines part of the research at the SMHN reached a degree of autonomy, and their members promoted the incorporation of companies and their own monodisciplinary bodies of scientific dissemination. Such is the case of the *Sociedad Geológica Mexicana* (1905) and its dissemination organ called *Boletín de la Sociedad Geológica Mexicana*. Such bulletin between 1905 and 1912 was responsible of the scientific publication on the Earth sciences in Mexico, representing a reduction in human resources, scientific material and prestige to *La Naturaleza*. 3) The paradigm of Natural History, as a part to gather scientific knowledge and practice in the Age of Enlightenment, had come to an end in Mexico. The biology and geology, two paramount bastions, would reach in the last quarter of the nineteenth century epistemological autonomy, the first separating from botany and the second from mineralogy. Moreover, the Mexican government had them reserved for institutional tasks of greater significance to lead Mexico's development and contribute to the welfare of the country's population. By this time the interest on fuel fossil (oil), is considered a matter of great importance for the State, and Ezequiel Ordóñez would become one of the most prestigious geologists in the field of scientific study on the oil of Mexico.

These considerations bring up the generational change in the development of science, the Mexican state's role in the design of science policy from the last quarter of the nineteenth century, leading and promoting certain scientific disciplines and practices, as well as the disciplinary autonomy and generational change in the work of institutions of education, where the scientific work began to develop more strongly and consistently. This is the case of the establishment of the *Instituto Geológico Nacional* and the *Sociedad Mexicana de Geología*, both under the leadership of José G. Aguilera.

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