
Prof. Dr. Jorge Bossi (1934-2020): father of modern
Uruguayan geology



Prof. Dr. Jorge Bossi (1934-2020): padre de la geología
moderna de Uruguay

Prof. Dr. Jorge Bossi (1934-2020): pai da geologia moderna
do Uruguai

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International.

Abstract: A synthesis of the academic and scientific activity developed by Prof. Dr. Jorge Bossi, for more than 60 years dedicated to the study of Uruguayan geology, is presented. This article is a review of his university teaching work and a tribute to his fruitful academic and scientific work on the geology of Uruguay and the region. His contributions have decisively influenced the current understanding of the tectonic evolution, stratigraphy and mineral resources of an important part of South America and southern Africa.

Keywords: regional geology, geology of Uruguay, mineral resources, Universidad de la República, Jorge Bossi.

Resumen: Se presenta una síntesis de la actividad académica y científica desarrollada por el Prof. Dr. Jorge Bossi durante más de 60 años dedicados al estudio de la geología de Uruguay. El presente trabajo es una reseña de su labor docente y un homenaje a su fecunda labor académica y científica sobre la geología de Uruguay y la región. Sus aportes han influido de forma decisiva en la actual comprensión de la evolución tectónica, la estratigrafía y los recursos minerales de una parte importante de Sudamérica y África meridional.

Palabras clave: geología regional, geología del Uruguay, recursos minerales, Universidad de la República, Jorge Bossi.

Resumo: É apresentada uma síntese da atividade acadêmica e científica desenvolvida pelo Prof. Dr. Jorge Bossi, durante mais de 60 anos dedicados ao estudo da geologia do Uruguai. Este trabalho é uma revisão de seu trabalho docente e uma homenagem ao fecundo trabalho acadêmico e científico sobre a geologia do Uruguai e da região. Suas contribuições têm influenciado decisivamente o entendimento atual da evolução tectônica, estratigrafia e recursos minerais de uma parte importante da América do Sul e do sul da África.

Palavras-chave: geologia regional, geologia do Uruguai, recursos minerais, Universidad de la República, Jorge Bossi.

1. INTRODUCTION AND MAIN ACADEMIC BACKGROUND

On May 27, 2020, the geological community received the sad news of the death, at the age of 86, of Professor Jorge Bossi, PhD, in the city of Montevideo, Uruguay. This article, based, partly, on an article recently published in *Revista de la Asociación Geológica Argentina*⁽¹⁾, aims to offer an overview of his activity and pay tribute to his fruitful academic and scientific work dedicated to the advance of geology in Uruguay. It is also worth mentioning a recent thesis by Baldovino and Rivero entitled *Biobibliografía del Profesor Jorge Bossi: el despertar de la Geología en el Uruguay*⁽²⁾, which provides valuable data of his life and work.

Jorge Luis Bossi Scorza was born on March 14, 1934 in the family home located at 1334 Micenas St. in the Atahualpa neighborhood (Montevideo). His father was Carlos Gregorio Bossi, a carpenter, and his mother Libera Clotilde Scorza, teacher and janitor of the Instituto Normal⁽²⁾. As a child he learned French with a private teacher, a language he spoke fluently. He completed his primary studies at the Bélgica School (Millán and Larrañaga St.) and his secondary studies at the Highschool number 6 "Francisco Bauzá", located at that time in Avenida Agraciada⁽²⁾. In 1957 Bossi obtained the degree of Chemical Engineer at the Chemistry Faculty of the University of the Republic (Udelar), exonerating the payment of the degree fees for his excellent grades⁽²⁾. He entered the academic career in 1955 in the Agronomy Faculty as an assistant to professors Juan Goñi and Juan Caorsi, authors of the first geological synthesis about Uruguay in 1958. To illustrate, the synthesis of the knowledge that existed at the time about the country's Precambrian covered only 13 pages⁽³⁾. In 1958, already a chemical engineer, Bossi won by competition the position of Assistant Professor of Geology in that same faculty⁽²⁾. In 1960, at only 26 years old, Bossi got, also through a competition, the position of grade 5 tenured Professor of the Chair of Geology at the Agronomy Faculty (Fig. 1). That Chair was inaugurated in 1908 by Dr. Karl Walther (1878-1948), and therefore it can be considered the foundational chair of geology in Uruguay. Bossi was a worthy continuator and brought geology to the 21st century, and we can state, without detriment to the very important contributions of other researchers, that he was the father of the modern geology of the country.



FIGURE 1

A young Jorge Bossi in the Chair of Geology of the Agronomy Faculty in 1969

Source: Bossi⁽²⁰⁾

AUTHOR NOTES

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Between 1970 and 1972 he completed his PhD in Applied Geology and Mining Prospecting at the Université de Nancy I, France, with a scholarship from the Agronomy Faculty. He received his PhD with the project *La minéralisation plombo-zincifère d'Asprières-Bouillac: Essai génétique*, under the direction of professor André Bernard. It should be noted that Bossi together with Ángel Fernández and Héctor Goso were Juan Goñi's students, professor of Mineralogy and Geochemistry at the Chemistry Faculty of the Udelar and professor of Geology at the Agronomy Faculty between 1954 and 1959. It is likely that due to Prof. Goñi's influence, the three obtained their doctorate in France and then completed a relevant activity in their respective specialties.

Jorge Bossi was the researcher of the National System of Researchers (SNI by its Spanish acronym) of Uruguay with the highest hierarchy in the area of Earth Sciences (Level III), maintaining activity practically until his last days. Likewise, he actively collaborated in the inception of the Geosciences Area of the Basic Sciences Development Program (PEDECIBA by its Spanish acronym), which he integrated as a grade 5 researcher.

2. HIS PIONEERING WORK IN URUGUAY

In his intense academic activity, Bossi and collaborators proposed in 1967 the divisions of the crystalline basement in two orogenic cycles, "Ancient and Modern"⁽⁴⁾, and recognized the relevance of the microgabbro dike swarm of Florida⁽⁵⁾, pointing to Uruguay as a "natural laboratory" for the study of the amalgamation of different lithospheric blocks, separated by transcurrent megafaults. From that moment on, he stressed the importance of the first order shear zones, relevant in the Uruguayan Precambrian, introducing an extraordinary area of deformed rocks to the international community which would then be highlighted by world-renowned specialists in various studies.

2.1 Recognition of Precambrian terranes

His restless personality allowed him to quickly adapt to new ideas and methodologies, such as the tectonic plates, using modern isotopic and geochronological techniques. He also added to his studies structural geology and large-scale shear zones and thrusts, which were useful for the recognition of tectonic terranes and their geodynamic evolution. Between 1988 and 1991, he developed the "Black Granite program" with funding from IDRC Canada, which allowed detailed mapping of the Florida mafic dike swarm. These geological maps showed that the dikes were interrupted on an approximate line between Sarandí del Yí and Piriápolis, also arching to the south (Fig. 2), which was interpreted as a large drag fold⁽⁶⁾. This led to the discovery of the Sarandí del Yí Shear Zone, with dextral kinematics, and to the definition of the Nico Pérez Terrane⁽⁷⁾, following the new tectono-stratigraphic concepts developed shortly before in North America⁽⁸⁾. He defined four tectono-stratigraphic terranes in Uruguay: *Nico Pérez*⁽⁷⁾, *Piedra Alta*⁽⁹⁾, *CuchillaDionisio*⁽¹⁰⁾ and *Tandilia*⁽¹¹⁾ (Fig. 3). The study of these terranes has radically changed the understanding of the geological evolution of Uruguay and neighboring countries in Gondwana, such as Argentina, Brazil and Namibia. In 2001-2003 he reported, with international collaboration⁽¹²⁾⁽¹³⁾, the first Archean U-Pb ages in the Complejo La China, Grupo Cebollatí and Formación Valentines, by the SHRIMP precision method on zircons. It should be noted that the Complejo La China (Paleoarchean, 3410 Ma) would be recognized as one of the oldest geological units in South America.

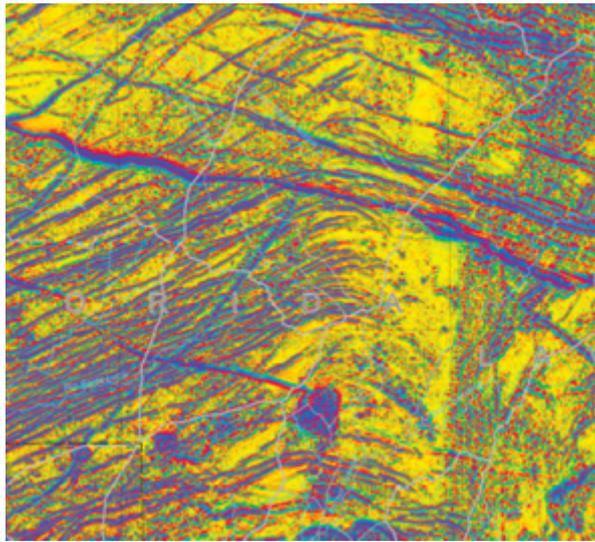


FIGURE 2

Second derivative of the anomalous magnetic field of the central-south area of Uruguay, part of the geophysical survey of DINAMIGE published in 2015⁽³²⁾. The arching of the dikes against the Sarandí del Yi Shear Zone, with north-south direction in that sector, is evident. Bossi explained this phenomenon 24 years before these surveys were available⁽⁶⁾



FIGURE 3

Bossi opened the V South American Symposium of Isotopic Geology (V SSAGI by its Spanish acronym) in Punta del Este in 2006, showing the division of Uruguay into terranes as currently proposed⁽¹⁶⁾. PAT: Piedra Alta Terrane, NPT: Nico Perez Terrane, CDT: Cuchilla Dionisio Terrane, TT: Tandilia Terrane

2.2 South American referent

His profound knowledge of the geology of his beloved Uruguay constituted a mandatory reference for South American researchers and an academic beacon that enlightened with knowledge many generations of geologists and engineers. In this sense, there are parallels with the titanic work of Fernando de Almeida in Brazil, with whom Bossi cultivated a long lasting friendship. Bossi was a generous man to communicate his ideas and proved to be an excellent field geologist, having recognized the most remote outcrops of Uruguay, often riding the legendary Toyota Bandeirante (Figs. 4 and 5).



FIGURE 4

Examining neoproterozoic sandstone outcrops from the Piedras de Aflar Formation in 2007



FIGURE 5

Jorge Bossi and Carlos Cingolani in 2009 exploring the boundaries of the Tandilia Terrane in the department of Colonia with the legendary Bandeirante of the Geology Department

He was a powerhouse of ideas, always ready to work in groups with students and colleagues, in a natural process of academic continuity. He was pleased to organize "itinerant workshops" showing unselfishly the geological characteristics of Uruguay and the new data obtained (Fig. 6). He was a true mentor, that is, a person with solid knowledge, with the ability to teach and share his ideas, igniting the flame of curiosity, with the motivation and desire to learn, what has left a deep mark on his students, colleagues and friends. The first geologists of the Udelar were formed under his direction, before the degree even existed, such as Elizalde, Cardelino, Ferrando, Sacone, Eughi, Telechea, Spoturno, Preciozzi, Morales, Carballo, Montaña, Medina, Oyhantçabal, Ford, Albanel, Ledesma, among others.



FIGURE 6

Bossi in 2005 leading a field work in marbles of the Marco de los Reyes Formation⁽²⁹⁾, within the framework of international project PROSUL

From left to right: Gabriela Martínez, Leticia Chiglino, Federico Cernuschi, Alejandro Toselli (Universidad Nacional de Tucumán, Argentina), Peter Sprechmann, Jorge Bossi, Daniel Piñeyro, Alcides Sial and Valderez Ferreira (Universidade Federal de Pernambuco, Brazil), Claudio Gaucher and Miguel Ángel Parada (Universidad de Chile).

2.3 Geology of Uruguay books and new geodynamic ideas

He edited his first book entitled *Geología del Uruguay* in 1966, which was widely cited in South America. This text was dedicated to Dr. Karl Walther, who, as aforementioned, preceded Bossi in the Chair of Geology. It should be highlighted that at that time only regional books of mandatory consultation were available in our continent: A. Windhausen from Argentina (1930), F. Ahlfeld from Bolivia (1946), D. Guimaraes from Brazil (1964), and *Geologie von Chile* by W. Zeil (1964). In the Introduction Bossi expressed that he followed the new ideas and controversies about crystalline rocks, Gondwana and continental drift⁽¹⁴⁾. He also expressed his gratitude to the students of the Udelar (although it was still 12 years before the inauguration of the Degree in Geology in the Humanities and Sciences Faculty), expressing "*from them I have learned*" and trusting that this could accelerate the progress of Uruguayan geology, which was widely fulfilled.

Although by the end of the 60s plate tectonics was just beginning to be accepted, when dealing with the subject of Gondwana Bossi expressed in his classic book of 1966 "*that the evolution of the Paleozoic has been as it was proposed by Wegener*" and reproduced this author's original maps⁽¹⁴⁾. He mentioned numerous aspects in support of this model, and he did not fail to cite the presence of the fossil reptile *Mesosaurus*, emblematic for the Permian Gondwana and recorded in the Mangrullo Formation of Uruguay. Even in 1967 he organized symposia on various aspects of continental drift⁽²⁾, when not many geoscientists yet agreed with Wegener's model. Bossi remembered listening with admiration to the emblematic Tuzo Wilson presiding over a meeting ("*which he opened with a hit of a pick*") and expressing his ideas of opening and closing oceans that would later have a wide impact on the scientific community (Wilson Cycle). Together, they also undertook field work in the northeast of Brazil, within the framework of the Symposium on Continental Drift.

The second and most extensive book of *Geología del Uruguay* was published in 1991, although the manuscript dated from 1988. Even though the text presented very substantial advances throughout the stratigraphic column⁽¹⁵⁾, in the words of Bossi "*it was already outdated at the time of publication*", mainly due to the discovery of the Nico Pérez Terrane⁽⁷⁾ and the revolution that meant the application of tectonostratigraphy in Uruguay. In 2014, already almost 80 years old, Bossi was encouraged to a new

challenge such as the edition of the third book of *Geología del Uruguay*, specifically Volume 1 on the Predevonian. This book reflected the important advances in knowledge derived from tectonostratigraphy, U-Pb dating and other isotopic methods⁽¹⁶⁾.

2.4 Geological maps of Uruguay and mineral resources

As a natural consequence of the advance of knowledge and new studies of the geology of the country, Bossi and collaborators published the *Carta Geológica del Uruguay* with three editions, in 1975, 1998 and 2001 — the last two were published digitally, which was pioneering in the region. These geological charts have served as the basis for all kinds of geological, mining, groundwater, geotechnical, environmental and soil studies, representing a substantial advance for Uruguay. Particularly, the cartography of two orogenic cycles (ancient and modern)⁽¹⁷⁾, the definition of the Cuchilla Dionisio Terrane⁽¹⁰⁾ and the discovery and cartography of Archaean units in the Nico Pérez Terrane⁽¹⁸⁾ are highlighted.



FIGURE 7

Bossi explains to students of the Degree in Geology (Science Faculty) the characteristics of an outcrop of valentinesite⁽¹⁹⁾ in Cerro de los Morochos, during a field trip of the course “Geology of Uruguay” in 2010. He participated as a guest lecturer in the course between 2010 and 2014

Applied geology was always a devotion for Bossi, looking for ways to contribute to the economic and social advance of his homeland. Mineral resources and mining occupied a privileged place in his applied research. He described in 1963 the important iron deposit of Valentines⁽¹⁹⁾(Fig. 7), recognizing it as of sedimentary origin (banded iron formation or BIF), which was previously unknown for rocks of high metamorphic grade and that justified the introduction of the term “valentinesite” to designate these rocks⁽²⁰⁾⁽²¹⁾. He dedicated the publication of three books named *Recursos Minerales del Uruguay* (1969, 1978 and 2000) to this line of research related to mineral deposits, as well as innumerable publications in journals and national and international events. Particularly, the book *Recursos Minerales del Uruguay* of 1978, written more than 40 years ago, is still extraordinarily valid, both in the exposed basic concepts of economic geology and regarding the Uruguayan deposits and their projection towards the future. In the most recent edition, he deals rigorously with the origin and potential of Uruguayan mineral waters⁽²²⁾, constituting a mandatory reference on the subject. Likewise, his book series of *Rocas ígneas básicas del Uruguay* presents systematic chapters on “contributions to economic geology” and “contributions to agronomy”. Among other scientific contributions, the detailed description of the cretaceous basalts, including their petrology, geochemistry and age, stands out⁽²³⁾.



FIGURE 8

Field trip to the Department of Florida in 2009 to analyze the thrust fault that determine the geology of the Piedra Alta Terrane⁽¹⁰⁾



FIGURE 9

Science and Technology Week at INIA, 2013, where teachers from CURE Treinta y Tres (Gonzalo Blanco, Sandra Carro and Carlos Rossini, in the photo) participated, as well as teachers from the Agronomy Faculty (Raquel Caggiano, Antonella Celio and Sebastián Mármol, in the photo). The “didactic box” can be seen on the left

Bossi perfectly understood the feedback between basic science and applied science. The advance of basic geology allowed the discovery of new mineral resources and more efficient prospecting of groundwater. In a documentary on iron ore produced in 2014 by PEDECIBA⁽²⁴⁾ Bossi stated categorically: *"To get an idea of Uruguay's potential mineral resources, there is no other way than through Geology."* Moreover, and

complementing the abovementioned statement, detailed studies with applied objectives, generally better funded than basic studies, constitute "*an example of the impact that the availability of adequate resources has on obtaining significant advances in geological knowledge*"⁽²⁵⁾.

It is worth noting his efforts as proponent and co-responsible, since 2013, for establishing the degree of Mining Technologist at the Centro Universitario Regional Este (CURE) in the city of Treinta y Tres, as well as a research group based there with a focus on geology and mineral resources. The installation of modern laboratories and the establishment of a nucleus of full-time, dedicated geologists were achieved. This was one of his objectives in recent years, which he embraced with enthusiasm and dedication (Fig. 10), validating the process of decentralization of the University of the Republic with locations outside the capital city.



FIGURE 10

Prof. Bossi was a tireless promoter of geology in the CURE and the decentralization of the Udelar in general. Here, he is participating in 2014 of a meeting at INIA Treinta y Tres to adjust details for the construction of the local premises of the CURE, together with —among others— rector Prof. Roberto Markarian (left) and the president of the Coordinating Commission of the Inland, Prof. Gregory Randall (third from the right)

2.5 Other activities and academic recognitions

He was an undergraduate and postgraduate professor at universities in Brazil and Argentina, and at the Chemistry and Engineering faculties of Udelar; an international consultant; he served on countless academic committees; he was an organizer and chaired various national and international academic events, as well as developing an intense professional consulting activity.

He directed and supported with great enthusiasm the CSIC research and development project entitled: *Yaguari Formation: an extense unit in the northeast of the country*. The team of this project was integrated by the professors of the Geology Disciplinary Group (Agronomy Faculty) R. Caggiano, S. Mármol, M. Francia, S. Rivas, I. Dalera, M. Appratto, V. Takata and A. Celio, obtaining information that allowed publishing two geological charts at a scale of 1/100,000 and that will allow several more to be drawn.

Due to his academic conditions, he assumed the deanship at the Agronomy Faculty of Udelar on eight occasions and was appointed Professor Emeritus. In 2014 Bossi received the Morosoli Award for his work in the Agricultural category (Agricultural Research and Development). In 2015, the Agronomy Faculty recognized his long career and academic contributions and generated a space that bears his name (Figs. 11-12). In the Space Prof. Jorge Bossi what survived from the beginnings of geology in Uruguay is preserved. The first collections of rocks used here as reference material can be found in this Space, so various samples of the geological units recognized by Bossi and collaborators are cataloged.



FIGURE 11

Emotional arrival of Professor Bossi to the recognition event by the Agronomy Faculty and the Geology Disciplinary Group, naming a sector of the Faculty as Space Professor Jorge Bossi, in 2015. He was accompanied by family, friends, professors and non-teaching officials, as well as close acquaintances



FIGURE 12

Professors and collaborators who accompanied Bossi during the last period of his life
From left to right (affiliation: Agronomy Faculty unless indicated): Antonella Celio, Claudio Gaucher (Science Faculty), Raquel Caggiano, Gonzalo Blanco (CURE), Jorge Bossi, Carmen Oliveira, Olga Franco and Sebastián Mármol

3. HUMAN AND TEACHING QUALITIES

Bossi was an endearing person who possessed special empathy and sensitivity towards other human beings. He had formed his family in 1959 with Estela Filippi in Montevideo, which was his permanent residence, and they have two daughters: Mónica and Marcela.

His academic training and his human qualities led him to stoically endure the ingratitude of life, joining other research groups abroad between 1974 and 1985, when he was removed from his position by university interveners during the military regime. In this period, he devoted significant efforts to professional consulting activity, as well as teaching.

Those who trained or worked with Bossi recognize him as a constant support, almost a father, who guided scientifically, but also supported materially the successful completion of theses, projects and geological charts. He was an extraordinary teacher, with the ability to transmit the most complex concepts in an understandable way. He also taught by example, demanding from the students, but also providing them with all the necessary tools and knowledge. He was a highly respected person and cherished by the non-teaching officials of the Agronomy Faculty, especially Olga Franco, and the technician Carmen Oliveira, who also

shared an extensive period with Bossi and supported him constantly. In the fieldwork he was just as anyone (Figs. 4, 5, 6, 7 and 8), offering to open farm gates even in old age, not hiding behind any privilege of age or academic position, which, on the other hand, he had well deserved. He always quoted the fine words of his tutor and professor at the University of Nancy, André Bernard: "*Geology enters through the feet.*"

Bossi loved teaching Geology (Fig. 7), his contributions to the formation of so many generations are invaluable. His students remember him for his high demand, which taught them to be university students ("*you learned or you learned*"), and his "quizzes" (evaluations at the end of the practical course) are remembered by the numerous students who had the privilege of having him as a teacher.

The creativity he possessed for the teaching of science was very important. A clear example was the creation, together with the technician Carmen Oliveira, supported by the Disciplinary Group of Geology, of the didactic box for educational centers in 2010, financed by PEDECIBA. This box, which combined a geological map of Uruguay with samples of the most widespread rocks in the country (Fig. 9), has been used successfully by teachers of Orchard, in schools and other educational instances, such as the Week of Science and Technology.

In his daily work he was a methodical person with a great will. Every day he attended work and stayed long hours at his desk, even after being appointed Professor Emeritus, when he had no obligation to keep a schedule. Because geology was not his work, it was his passion and his life, a continuous learning and a journey of discovery. He constantly had pen and paper at hand, where he wrote his notes, and his collaborators helped transferring them to a computer. Even during his last months of life he wrote chapters of the second volume of the book *Geología del Uruguay* and outlined several projects of importance for the country, which were left as "homework" for his collaborators.

4. FINAL THOUGHTS

Bossi always stood out for his authority based on example and the admiration he inspired in everyone. He clearly showed the direction forward, he was a "locomotive" that with his energy and enthusiasm impelled all those around him to advance in the knowledge of the *terra incognita* that was —and in a certain way still is— the geology of Uruguay. However, he listened carefully to those who worked with him and did not hesitate to change directions if he got convinced. Moreover, he declared obsolete concepts created by himself in the past, such as the division into only two cycles of the Predevonian⁽²⁾ or the Lavallega Group⁽¹⁴⁾, which grouped units of low metamorphic grade, but of very different ages⁽²⁶⁾⁽²⁷⁾, from Archean⁽¹²⁾, through Mesoproterozoic⁽²⁸⁾⁽²⁹⁾ and Ediacaran-Cambrian⁽³⁰⁾⁽³¹⁾ as was demonstrated later.

He was member of the Sociedade Brasileira de Geología (1963), of the Societé de Geologie Appliqueé aux gites minéraux (1972), of the Sociedad Uruguaya de Geología since 1980, and of the Asociación Geológica Argentina since 1987, which also distinguished him as a corresponding member in 1999. In addition, he was an honorary member of the Sociedad Uruguaya de Geología since 2004.

At the IV Argentine Congress of the History of Geology, Museum of La Plata, in 2016, Bossi described in his work, according to his criteria, the stages that could be recognized in the one hundred and eight years of development of scientific geological knowledge in Uruguay⁽²⁵⁾. He stressed that the Agronomy Faculty was the only institution that maintained geological activity throughout the period, although with different intensity, and was the initial engine of geological studies in Uruguay, since it always had a working group in basic geology from its creation in 1908.

All this was achieved largely thanks to his effort and dedication. For this reason, Jorge Bossi will be recognized as a pioneer of modern geology in Uruguay, who dedicated his life to the country and the study of geological science, leaving an example of noble and fruitful academic life, deserving international recognition. He was a distinguished scientist and a true patriot, always caring to improve the socioeconomic conditions

of the country from his position as a geologist and university professor. His example will inspire and impel the new generations for many years to come to face the coming scientific challenges and to persevere in the study of the Geology of Uruguay.

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