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Researchers following the Glossopteris trail: social context of the debate surrounding the continental drift theory in Argentina in the early 20th century

Chercheurs suivant la piste des Glossopteris: le contexte social du débat autour de la théorie de la dérive des continents en Argentine au début du XXe siècle

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Summary: The fossils of the plant genus *Glossopteris* were used as material evidence of the former union of the continents as proposed by the continental drift theory, since it could be found in the continents believed to have once been part of the super-continent of Gondwana. The debate about this theory in the scientific circles in the first half of the 20th century, starting at around 1915 with the publication of Alfred Wegener's "The Origin of Continents and Oceans" involved a number of scientists settled in the Southern Hemisphere, most of them trying to prove it right. One of the activities of these naturalists was the collection, identification and exchange of data concerning *Glossopteris* fossils, creating a network of communication between them. In this context, Argentina had an important role, first as one of the main sites where *Glossopteris* was found, and second as a place where scientists were concerned with the discussion of the continental drift theory. In order to better understand the role of more particularly Argentina, and more broadly, the Global South in the discussion of the continental drift theory in the first half of the 20th century, the focus of this paper was on the exchange of information concerning the *Glossopteris* fossils between scientists in Argentina. The focus in this paper was on the study about *Glossopteris* and the continental drift theory, from Federico Kurtz, Juan Keidel, and Horacio Harrington, as well as on the social contexts at the time, elucidating.

KEY-WORDS

Glossopteris
continental drift theory
scientific network
XXth century
Argentina
Global South

Résumé : Les fossiles du genre végétal *Glossopteris* ont été utilisés comme preuves d'une ancienne union des continents, telle que la proposait la théorie de la dérive des continents. Cela est dû au fait qu'ils ont été trouvés sur les continents qui auraient formé le supercontinent du Gondwana. Le débat autour de cette théorie a démarré au début du XXe siècle dans le milieu scientifique. « La Genèse des Continents et des Océans » d'Alfred Wegener, publié en 1915, est un point de repère important dans cette discussion. Cela a impliqué un certain nombre de scientifiques basés dans l'hémisphère sud, la plupart essayant de prouver que la théorie était correcte. Ces naturalistes se sont consacrés à la collecte, à l'identification et à l'échange de données sur les fossiles de *Glossopteris*, créant ainsi un réseau de communication entre eux. L'Argentine a joué un rôle important à la fois en tant qu'un des principaux sites où le *Glossopteris* a été découvert et en tant qu'un centre de discussion important sur la théorie de la dérive des continents. Dans cet article, l'accent a été mis sur l'étude de Glossopteris et la théorie de la dérive des continents, de Federico Kurtz, Juan Keidel et Horacio Harrington, ainsi que sur les contextes sociaux de l'époque, élucidant la nature sociale de la science.

MOTS-CLÉS

Glossopteris
théorie de la dérive des continents
réseau scientifique
XXe siècle
Argentine
Pays du Sud

Introduction

The idea that the relative positions of the continents are not fixed and that the continents were once connected is now a matter taken for granted. It is common knowledge that a great pan-continent, named Pangea, eventually broke apart and its fragments drifted to form the arrangement we see today. However, the continental drift theory, which proposed these ideas, resulted in a long-lasting polemic in the first half of the 20th century with complex motivations.

In 1915, the German meteorologist Alfred Lothar Wegener (1880-1930) published *Die Entstehung der Kontinente und Ozeane* ("The Origin of Continents and Oceans"), which became very well known in the scientific circles, and marked a symbolic introduction of the continental drift theory discussion among earth scientists. The theory was rejected by most of Wegener's contemporaries, gaining a minority of supporters in Europe and facing strong opposition especially in the United States (Oreskes, 1999). During this long-lasting debate, many naturalists were out searching for evidence in the southern hemisphere to support Wegener's ideas. One such evidence was the distribution of the specimens of a Permian fossil gymnosperm of the genus *Glossopteris*, found in peninsular India and throughout the southern continents. This fossil receives increasing importance in the consecutive editions of Wegener's book as a clue to his proposed former position of the continents. Today, it is accepted that the glossopterid group appeared for the first time in the fossil record around the end of the Carboniferous period, and its first representatives are believed to have existed at the time of the Late Carboniferous glaciations, since they are found in layers followed by and intercalated with glacial deposits in different regions (Goswami, 2014). They had their climax at the beginning of the Permian period and were dominant members of the "*Glossopteris* flora", disappearing from all continents during the Permo-Triassic extinction (McLoughlin, 2011).

The fossils from the *Glossopteris* flora were preserved in the coal-bearing strata distributed worldwide. At the beginning of the 19th century, the study of fossil plants was closely connected with the increase of the demand of mineral coal for the use in the industry and transportation. Therefore, the *Glossopteris* fossils were collected in the field in the explorations expeditions, and they were exchanged between mineralogists and naturalists for identification, description, and comparisons. These studies led to inferences about their puzzling distribution, which was separated by oceans, and this distribution was used to support the continental drift theory that came afterwards. These pieces of evidence represent clear testimony of the kind of exchange of data and objects between scientists connected with this theory.

This paper is part of a broader doctoral project aimed at analyzing the scientific network structure around the study and circulation of *Glossopteris* fossils and the discussion of the continental drift theory in the first half of the 20th century. It focuses on the work related to the discussion of the continental drift theory being produced in Argentina, in particular in the museums of Buenos Aires (est. 1823), La Plata (est. 1884) and Córdoba (est. 1869). In the transition between the 19th to 20th centuries, the exchange of local information between scholars, forming a global scenario, was part of their intent to convey the "unity of science" and synthesize theories of the earth (Lopes, 2011). Therefore, the productions presented here – papers, books, and letters – reveals the exchange of data and objects, as well as the connections between people and institutions that formed the network not only in Argentina, but globally.

The exchange of fossil specimens and information in the form of publications and correspondence between different countries was well expressed in the southern hemisphere (for some examples of Wegener's supporters in South America, see Cingolani, 2015), where this fossil was found, and where there was wider acceptance of the continental drift theory compared to the northern hemisphere at the time. In this research process, the archives of the Museum of La Plata and the Argentinian Museum of Natural Sciences of Buenos Aires were investigated in search of fossil entry books, correspondence, publications, and books indicating the origin of the *Glossopteris* fossils, the relationships between the scientists and their influence in the discussion. In addition, the Jagger Library, in the University of Cape Town in South Africa was also investigated for the analysis of the correspondence of the South African geologist Alexander Du Toit (1878-1948), who was a well-known proponent of the continental drift theory, and an active investigator of the correlations especially between

South America and Africa. In the process of elaborating his thesis, he maintained communication with scientists in South American countries, where he had also been traveling to study the geology at first hand, making observations in the field, and collecting specimens for later indoor analysis (Du Toit, 1927 and 1936).

Glossopteris and the Continental Drift Theory

Alfred Wegener first presented his idea of the displacement of continents in 1912 at a meeting of the German Geological Association at Frankfurt. In 1915 he further developed his ideas in his book "*Die Entstehung der Kontinente und Ozeane*". This book had then later editions in 1920, 1922, 1924, and 1929. Gaining much attention from the earth sciences experts, it was translated into English (1924), French (1924), Spanish (1924), Russian (1924), and Italian (1942). Although many before Wegener had already proposed that the continents had not always had the same configuration (for some examples see Cingolani, 2015), he presented a comprehensive thesis defending the displacement of the continents with evidence from different fields of science, such as biology, meteorology, geology, and physics. This theory generated a long-lasting debate between the specialists, which has already been historically analyzed by many (some examples are: Oreskes, 1999; Frankel, 2012; and Greene, 2015). In the "Preliminary note" of the Spanish version of Wegener's book (2009), Sánchez Ron defends that Wegener's theory challenged the hegemonic ideas of the scientific discourse of his time, which believed in the permanence and contingency of the earth's geography. Moreover, the potency of this theory was the fact that, in nature, "any hope of inevitability is nothing but a vain and unfounded illusion", and this is one of the main messages of science (Sánchez Ron, 2009: 7).

One piece of evidence used by Wegener to support his theory was the geographical distribution of the fossil gymnosperm of the genus *Glossopteris*, a name that can be found already in 1820, in the publication ("*Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt*"), by the Czech naturalist aristocrat Kaspar Maria von Sternberg (1761-1838). In this book, the origin of the *Glossopteris* classification is attributed to the French physician and botanist, Adolphe Théodore Brongniart (1801-1876). In his turn, Brongniart presents *Glossopteris* in his books, "*Sur la Classification et la Distribution des Végétaux Fossiles*" (1822), and in his "*Prodrome d'une Histoire des Végétaux Fossiles*" (1828a), where the name "Glossopteris" represents one of the genera of fossil leaves [1] defined by him in the family of the *Fougères* (ferns). These were obtained from coal mines around the world. The *Fougères* family, in its turn, was placed in the class of the vascular Cryptogams (seedless plants) (Brongniart, 1828a: 38). The *Fougères* had been previously classified by Linnaeus and Jussieu, and contained mainly living plants, as well as some fossils (Brongniart, 1828b: 97).

In the time of Brongniart and Sternberg, fossils were labeled and catalogued following the hierarchical classification, descending from classes and orders down through families and genera to species and varieties (Rudwick, 2005: 62). *Glossopteris* was initially considered an artificial, or temporary classification, since it was based exclusively in the analysis of the fossil leaves [2]. Since then, it has changed to the level of a fossil genus in itself. This definition was based on the observation of fragments of compression-impression of sterile leaves, that have a lanceolate, or tongue-shaped form, and a reticulate veination (**Fig. 1A**). These classifications were important for resolving the questions about the similarities of fossil plants observed around the world already at that time. Therefore, the naturalists could conclude if the fossil plants found in Europe were of the same group, and what was the level of similarities with the ones found in South America (Mexico and Brazil are mentioned), India, and New Holland (a historical European name for mainland Australia), as well as other places (Sternberg, 1820: 2-3).

The fossil ferns found in the coal mines in Europe were more similar to the extant tree-like ferns of tropical lands, than to the extant plants of Europe, which had been interpreted by specialists as indicating that the climate in the past had been different, and much warmer (Rudwick, 2005: 263). Already in a publication in 1804, the German mineralogist, Ernst Friedrich von Schlotheim (1764-1832) makes an analogy between the fossil ferns found by him in Germany, and the "*Farnenkräuter*" (ferns) and "*Sumpfp-flanzen*" (swamp plants) from India and Americas (at that time still called: "*West - und Ostindien*") (Schlotheim, 1804: 25).

1. The genus of fossil leaves of the Fougères family, defined by Adolphe Brongniart, were: *Glossopteris, Sphenopteris, Neuropteris, Pecopteris, Odontopteris, Pachypteris, Cyclopteris* and *Anomopteris* (Brongniart, 1828b: 141-288).

2. In the case of living plants, the classification was (and still is) based mainly on the analysis of reproductive organs, however, these were rare in fossils, or were found isolated.

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The first specimens classified as *Glossopteris* were described by Adolphe Brongniart (1828a & b), and can still be found in the paleobotanical collection of the Muséum National d'Histoire Naturelle, in Paris. Those were classified as:

Glossopteris browniana Var. *α*: *Australasica foliis minoribus subspathulatis obtusis*; identified from a fossil specimen from Hawkesbury-River coal mines, north of Port Jackson, New South Wales, Australia; received from the Oxfod University Museum, from Mr. Buckland and Mr. Lesson.

G. browniana Var. *β*: *Indica foliis majoribus lanceolatis acutiusculis*; identified from a fossil specimen from the Rana-Gunge coal mines, near Rajmahal, north of India. This species has been changed to *G. indica* (Collection Pentland).

G. angustifolia: identified from a fossil specimen from the Rana-Gunge coal mines, near Rajmahal, India, received from Mr. Voisey (Collection Voisey).

G. phillipsii: identified from a drawing of a fossil received from Mr. Phillips, and from a fossil specimen received from Mr. Murray; from the middle oolitic terrain, in sandstones and upper shales, from Gristhorpe-Cliff, near Scarborough, Yorkshire, United Kingdom.

G. nilsoniana: identified from a fossil specimen already studied before by Mr. Nilson, received from the Lund University Museum, from the Lias Formation (*grès du Lias*), in Höör, Sweden. This specimen is not considered *Glossopteris* anymore.

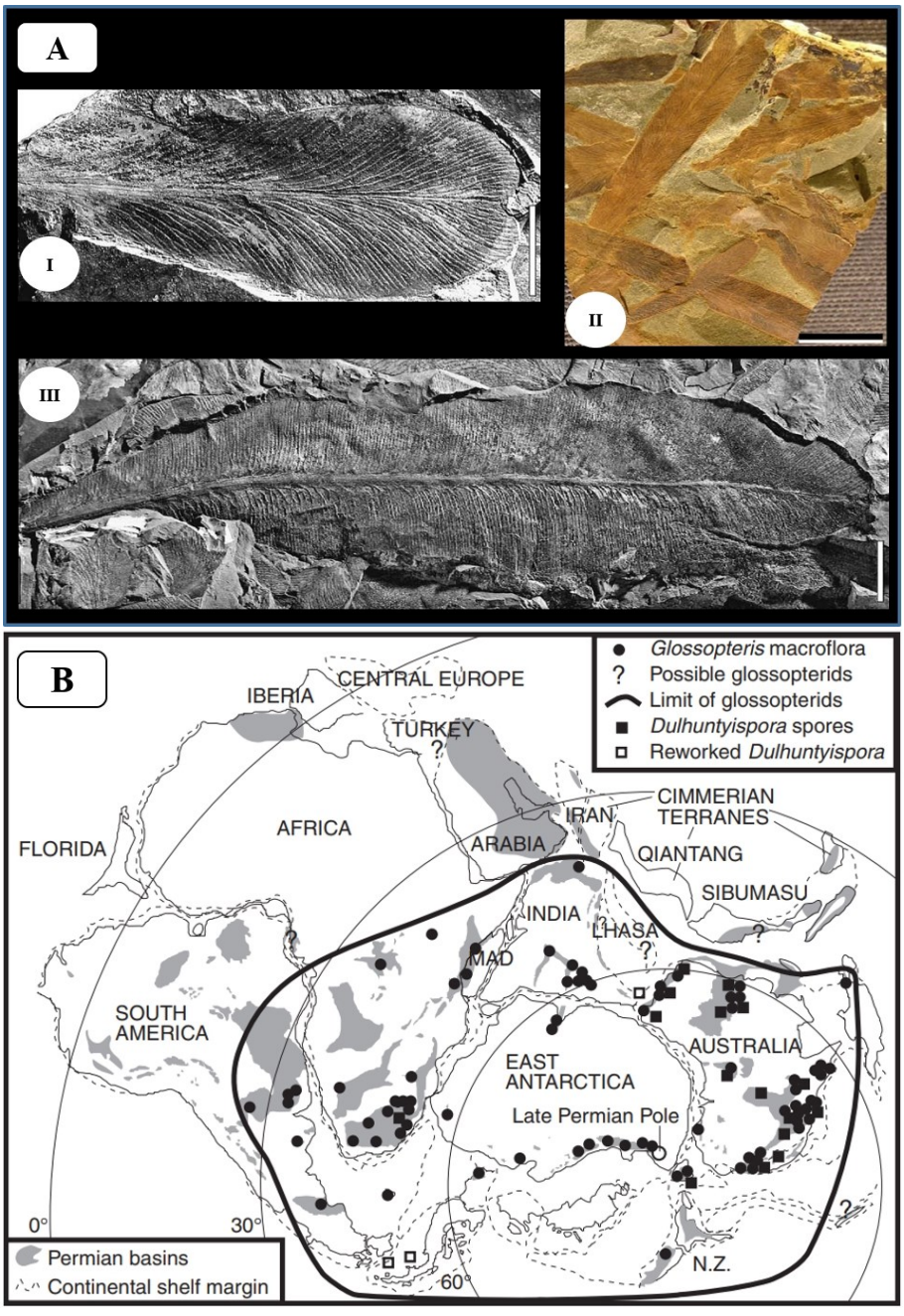


Fig 1. A. Some examples of Glossopteris leaves. I and III: Scale bar = 10 mm.; II: Scale bar = 1 cm. Modified from Prevec et al., 2009 (I and III), and Prevec et al., 2010 (II). B. Distribution of the Permian Glossopteris flora in Gondwana. Modified from McLoughlin, 2001.

In 1905 the British paleobotanist Edward A. Newell Arber (1870-1918) included the genus *Glossopteris* in the class Filicales, in the group of Pteridophyta (vascular Cryptogams). The places where Arber (1905) confirmed the existence of the genus were: India, Persia, Australia, Tasmania, South Africa, Rhodesia, German and Portuguese East Africa, Argentina, Russia and China. He also mentions the names of important collections containing Glossopteris, present in the British Museum in 1905 (p. lxxi-lxxiv) (**Table 1**).

By 1905, *Glossopteris* had been reported from economically explored Carboniferous-Permian coal reserves in all the southern hemisphere continents and India (**Fig. 1B**), which, already in the late 19th century, were proposed to have been united together in the supercontinent of "Gondwana" [3]. The name Gondwana was later

3. First proposed as "Gondwána-Land" by Suess (1885).

Collection	Collector	Other repositories	Provenance	Year of receipt at the British Museum	Reference
Hunter	Rev. R. Hunter	Geological Society of London	Nagpur, India	1897	Hislop & Hunter, 1855; Bunbury, 1861
Odinheimer	Odinheimer		New South Wales, Australia	1858	
Nicol	William Nicol			1867	Nicol, 1831, 1833, and 1835
Royle	Royle		India		Royle, 1833
Strzelecki and Morris	Count Strzelecki; J. Morris	Geological Society of London	New South Wales, Australia	1859 and 1883	Strzelecki, 1845; Morris, 1845
Nathaniel Plant	Nathaniel Plant		Brazil		Plant, 1869; Carruthers, 1869
David Draper	David Draper		Transvaal, Orange River Colony and Natal, South Africa	1890 and 1893	Draper, 1897; Seward, 1897
F. H. Hatch	F. H. Hatch		South Africa	1898	Hatch, 1898; Seward, 1898
A. J. C. Molyneux	A. J. C. Molyneux		Rhodesia (Zimbabwe)	1901	Molyneux, 1903; Arber, 1903
Sankey	Lieut. R. H. Sankey		Nagpur, India	1880	Sankey, 1854
Claussen	P. Claussen		Brazil	1841	
Stephens	T. Stephens		Tasmania	1898	
H. D. Hoskold	H. D. Hoskold		Argentina	1890	
Keene	W. Keene		New South Wales, Australia	1905	Keene, 1862, 1864
Livingstone			South or Central Africa	1884	
Sutherland			Cape Colony, South Africa	1880	Sutherland, 1855
C. W. Wilmot			India	1883	
Capt. Sir. E. Home			New South Wales, Australia	1853, 1859, 1860	
W. L. R. Gipps			New South Wales, Australia	1875	
Sir C. Purdon Clarke			New South Wales, Australia	1889	
W. H. Shrubsole			New South Wales, Australia	1892	
H. F. Collins			New South Wales, Australia	1903	
R. L. Jack			Queensland, Australia	1879	
G. Sweet			Tasmania, Australia	1900	
Prof. T. R. Jones			Cape Colony, South Africa	1884	
D. D. Eraser			Cape Colony, South Africa	1893	
Rev. G. Smith			Natal, South Africa	1876	
The Natal Government			Natal, South Africa	1897	
J. Mawson			Brazil	1894	

Table 1. Collections of fossils containing *Glossopteris*, kept in the British Museum, According to Arber (1905).

adopted by Wegener (1915-1929) in his different proposition for the former union of the southern continents. In his idea, the continents formed a single landmass that has since broken apart, and they continue to move in relation to each other. This was different from the initial idea of "Gondwána-Land", that was believed to be the former union of the static southern continents by land-bridges, which had since sunk. Two strong arguments about the former existence of Gondwana were the widespread occurrence of Carboniferous/Permian glaciations and the *Glossopteris*. Thus, we have a fossil plant genus (*Glossopteris*) described for the first time in the 1820s, which is then being used in different and sometimes competing scientific and technical contexts: as index of coal deposits, as evidence of former continental connections, as evidence of continental drift.

The discovery of these and other fossils in Africa, India and Australia was used as an argument by the Austrian Eduard Suess (1831-1914), when proposing his "Gondwána-Land" already in 1888 [4] (South America was added in 1909). Suess' Gondwana-Land became the former union of: South America, Africa, Syria, Arabia, Madagascar, India and Ceylon (now Sri Lanka) (Suess, English version, 1909: 500). The term "Gondwana" [5] was probably borrowed from the publications of the Geological Survey of India (GSI) [6], that resulted from their expeditions in search of coal (between 1850-90), in which the term "Gondwana Series" (later named "Gondwana System") was already used to designate the coal-bearing formations from the Late Paleozoic of the Satpura basin, in India. *Glossopteris* fossils were often found associated with coal and glacial deposits in these formations (Leviton & Aldrich, 2004).

The members of the GSI had already noted similarities between certain formations in India and South Africa. Two of them, Henry B. Medlicott (1829-1905), together with William T. Blanford (1834-1893), had already suggested in 1879 the former union of India, Australia and South Africa in the Permian and Triassic periods (Leviton & Aldrich, 2004). The term "*Glossopteris* flora" was presented by the Austrian geologist Melchior Neumayr (1845-1890) (Neumayr, 1887 *apud* Arber, 1905: xviii) to describe the flora of the Permian-Carboniferous of the Southern Hemisphere and India. This concept was a renaming of the previous "Gondwana flora", used to refer more generally to the fossil flora of the Gondwana strata in the coalfields of India, and from the similar strata that had already been found on other continents, such Australia, South America, and Africa (p.e. in Suess, 1909: 663). *Glossopteris* got more significance with time. In the same book ("*Erdgeschichte*"), Neumayr also published a paleogeographical map of the world, where he presented his idea of former land connections between South America, Africa, and India, based on the ideas of the British geologists of the GSI. Others, such as Ernst Haeckel (1838-1919) and Philip L. Sclater (1829-1913) also suggested former connections, the most famous being "Lemuria", between Africa, Madagascar and India (De Camp, 1970: 52-54). Their proposed land connection was based mainly on the correlations already made by the geologists of the GSI with fossils (especially *Glossopteris*), and on the distribution of extant mammals, such as lemurs, between Africa and India.

Therefore, *Glossopteris* fossils were an important evidence of the former union of the continents before the elaboration of the continental drift theory. However, back then, most of the plant fossil specialists studying them supported the theory proposed by Suess of the former land bridge connections (Oreskes, 1999: 11), or simply did not fully commit themselves to any point of view for explaining their distribution. Wegener, when commenting on this positioning, accused these scientists of being narrow-minded, and having insufficiently considered other areas of science, such as physics, in order to understand the inconsistency of the land bridges theory (Wegener, [1929] 2009: 200). He also expressed his intention to reconcile the contradictory theories existent at the time, and to reunite the divergent lines of thinking in Earth Sciences (Oreskes, 1999: 55).

Initial studies of *Glossopteris* in Argentina

The European studies about similarities of the fossil plants of the *Glossopteris* flora from coal deposits from different countries in the southern hemisphere and India included explorations made in Argentina. The studies about *Glossopteris* fossils in this country were also part of the base for the development of Wegener's theory. One of the important fossil-bearing coal deposits found there was in the locality of Retamito, in the province of San Juan (Correa & Césari, 2019). The plant fossils

4. This was published in Suess' books, "*Das Antlitz der Erde*" (Vol. I: 1883 and 1885; Vol. II: 1888; Vol. III: 1901; Vol. IV: 1909). In the second part of his Vol. I (from 1885), Suess had already presented "Gondwána-Land" as being a connection of Africa with Madagascar and India by land-bridges. Australia was included in 1888. These books were at that time mandatory references for those studying mountains, continents, and oceans (Lopes, 2011).

5. This term is the Sanskrit for forested land of the "*Gonds*", who were a Dravidian people, native to India's central region (Medlicott & Blanford, 1893: 149).

6. This is the new name of the former Geological Survey of the Coal Formation of India, created in 1840 by the British East India Company, mainly for the exploration of minerals, such as coal, in the colonies of the then called "East Indies" colonies, of which India and South Africa were parts.

found there were collected and sent for their identification to the *Academia Nacional de Ciencias de Córdoba* (National Academy of Sciences of Cordoba, est. 1869) [7], which housed the German botanist Friedrich Kurtz (1854-1921) and the German geologist Wilhelm Bodenbender (1857-1941).

Kurtz had received his doctoral degree in Natural Sciences in 1879 in Berlin, with specialty in botany. In Argentina he entered the National Academy of Sciences of Cordoba. According to Harms (1920), he came to Argentina after two frustrated working positions in Germany, due to disagreements with his superiors – first when working in the Berlin Botanical Garden, then in the Mineralogical Museum of Berlin University –. Thus Kurtz left Europe, and was proposed a job in 1884 as a professor of botany in Córdoba, Argentina. Over the years he undertook exploration travels and created a large herbarium of local plants classified by himself. His interest in fossil plants led him to the discovery of the Permian Gondwana strata in the locality of Bajo de Véliz, which was considered evidence of the presence in South America of the strata formerly described by the GSI in India. Located in the Argentinian province of San Luis, Bajo de Véliz is one of the main fossil deposits in Argentina, assigned today to the Late Carboniferous (286 million years). This region acquired notoriety due to the significant occurrence of mega- and microfloral fossils from Gondwana (Mange, 2015). About this subject, Kurtz maintained communications with other well-known specialists, such the British botanist Edward A. Newell Arber (1870-1918), with whom he also exchanged fossil specimens, drawings and texts (Harms, 1920). Therefore, he could compare and make inferences about the distribution of these fossils. In Kurtz' words:

> *"Fossil floras of a composition similar to that of the Bajo de Véliz are known from the Cape of Good Hope (Ecka-Kimberley-beds), from cisgangetic India (Karharbári-beds), from New Holland (Newcastle-beds, Bacchus -Marsh-sandstone) and Tasmania (Mersey-coalfield). Of all these floras, the most closely affiliated with the ancient vegetation of Bajo de Véliz is that of the Indian layers called "Karharbári-beds" of the lower Gondwana "* (Kurtz, 1895: 133, my translation). [8]

Kurtz alleged his work would contain "all the series of fossil plants from Argentina since the Permo-Carboniferous until the Early Jurassic" ([Kurtz]Hosseus, 1921: 133). The specimens investigated by him came from the Argentinian provinces of San Luis, La Rioja, Mendoza, and San Juan and were collected by many different naturalists. Many scientists from other countries, such as India, Australia, Tasmania, and Germany, helped him in different ways, showing how Kurtz's work is a good example of the collective and mobile character of this kind of research, in which many people, institutions and regions are involved.

In his "*Contribuciones á la Palaeophytología Argentina*" (Contributions to Argentinian Paleophytology, 1895), he refers to the existence of Gondwana strata in Argentina, and mentions the finding of *Gangamopteris* in Bajo de Véliz by Francisco Moreno (1852-1919). This fossil plant is very similar to *Glossopteris*, and today there is still a controversy about whether these two genera should be considered different (Adendorff, 2005: 4). However, they still are, and both are part of the *Glossopteris* flora. The actual *Glossopteris* genus in Argentina was considered to have been first identified by Kurtz, and published by Bodenbender in 1895 (Arber, 1905: lxx-lxxi). White (1908: 347) also claims that this was the first *Glossopteris* specimen identified in South America and also in his report, cites the work of Kurtz in Argentina to emphasize the correlations with his studied regions in Brazil, mostly about Rio Grande do Sul and Santa Catarina states. In this regard, D. White (1908: 349) affirmed:

> *"The stratigraphical relations of the plant-bearing terrains, so far as ascertained in Argentina, are discussed much more fully in an article entitled 'Devono y Gondwana en la República Argentina' published in 1897 by Bodenbender* (...) *In this, as in Bodenbender's former papers, the plants were named on the authority of professor Kurtz*".

The similarities between strata from Argentina and from the other countries of the former Gondwana were further complemented by the work of another German scientist, Juan (Hans) Keidel (1877-1954). He arrived in Argentina in 1906, and worked until 1922 at the Argentinian Geological Survey (*Servicio Geológico Argentino*), in the General Direction of Mines, Geology and Hydrology, in the Ministry of Agriculture (Ramos, 2013). There, he had an active role in one of the first petroleum explorations in Argentina (Riccardi, 2015), He was professor of Geology at the Universities of Buenos Aires and La Plata until 1942. During this time, he published a seminal work on the *Sierra de la Venta-*

7. This was created as a scientific and educational institution supported by the government, to form professors of natural and exact sciences (Babini, 1949).

8. Floras fósiles de una composición semejante á la del Bajo de Velis se conocen del Cabo de Buena Esperanza (Ecka-Kimberley-beds), de la India cisgangetica (Karharbári-beds), de la Nueva Holanda (Nowcastle -beds, Bacchus-Marsh-sandstone) y de Tasmania (Merscy-coalfield). De todas estas floras, al mas afiliada á la antigua vegetación del Bajo de Velis es la de las capas índicas llamadas « Karharbári-beds » del Gondwána inferior".

na in Buenos Aires, comparing its composition and structure with the Cape Mountains in South Africa, and finding many similarities between these regions (Keidel, 1916 *apud* Ramos, 2013). This work was mentioned in Wegener's book as one important basic reference for the development of his theory. He was well inserted in the international circle of geologists that were discussing the genesis of continents and oceans, as is revealed by his correspondence with Suess (in 1906) about Gondwana (Ramos, 2013), and by his relationship with the influential South African geologist Alexander L. Du Toit (1878-1948), who was the leading expert on the Karroo System in South Africa, and a strong supporter of the continental drift theory. The two scientists exchanged data, especially about the "Gondwanides", a term coined by Keidel to designate the "mountain system uplifted by the late Paleozoic deformation in several parts of central and southern Argentina" (Ramos, 2007). He also described the distribution of Permian glacial deposits in Argentina (Farro, 2015).

Keidel and Du Toit were important proponents of the former union of South America and Africa. In their respective famous publications (Keidel, 1916; Du Toit, 1927; 1937) they discussed the many similarities between the two continents, and in so doing, used the data on the distribution of fossil plants, such as *Glossopteris*. This can be seen for example in a passage from the doctoral thesis of one of Keidel's pupils, the Argentinian geologist Horacio Harrington (1910-1973), in which he cites Keidel's conclusions on the correlation of Argentina with South Brazil and South Africa when considering their fossil floras:

> "*On the other hand Keidel has admitted that there is in Argentina undoubted associations of the* Glossopteris *flora with some Lycopodiales; but he has expressly noted that it is a 'mixture' perfectly comparable to that which exists in the South of Brazil and in South Africa*" [9] (Harrington, 1933, translated by myself).

In his career, Harrington worked in partnership with his mentor Keidel. He was a Professor at the University of Buenos Aires, first president and founder of the Argentinian Geological Association in 1945, first director of the Institute of Geology and of the Department of Geological Sciences of the University of Buenos Aires in 1947 and 1951. Moreover, he was director of the Overseas Division of the Tenneco Co., in Houston, Texas, in 1957 (Riccardi, 2008). With his focus being Structural Geology, he had a solid knowledge of Paleontology and Stratigraphy. One of his most important works was his doctoral thesis, in which he presented a study of the Sierras Australes [10] in Argentina (Harrington, 1933). In his paleontological research identified the elements of the *Glossopteris* flora in this region and compared with the strata from southern Brazil, Uruguay, India, South Africa, Australia, and Antarctica. In his thesis, Harrington cites Arber (1905) and White (1908) as a basis for the classifications of the *Glossopteris* specimens found, as well as Du Toit, when concerning the correlations with the Cape Mountains in South Africa.

According to Ramos (2007), neither Harrington nor Keidel were entirely convinced of the continental drift theory before 1926, but following the symposium on continental drift sponsored by the American Association of Petroleum Geologists (AAPG) that year, both became active supporters of Wegener's theory. Both of them were in close contact with the ideas and publications of Du Toit about the comparison of strata from South Africa and South America (1927), and Harrington and Du Toit exchanged correspondence about their work to compare the stratigraphy of Argentina and South Africa.

Du Toit was considered a very important field geologists, due to his numerous travels around the world (Oreskes, 1999), and he was also the leading expert on the Karroo formation in South Africa, which was a very important geological piece of evidence in the study of Gondwana. The Karroo was correlated – ever since Suess, and later Wegener – with equivalent sequences in India, Australia and South America. Du Toit was responsible for putting Africa in a central position in the Gondwanan paleocontinent (Frankel, 2012). In his several field expeditions he collected many fossils, and among them was *Glossopteris*. In the early 20th century, coal explorations and studies were just beginning in South Africa, and ever since it has remained the main source of energy in that country. Therefore, the study of *Glossopteris* was significant among geologists and paleobotanists in the country. In 1923 Du Toit received a grant from the Carnegie Institution of Washington to travel to South America. During this trip, he spent five months doing field expeditions to Argentina, Brazil and Uruguay. There he collected and identified many *Glossopteris* fossils. The results of these identifica-

9. "*Por otra parte Keidel ha admitido que existen en la Argentina indudables asociaciones de la flora de* Glossopteris *con algunas Lycopodiales; pero ha hecho notar expresamente que se trata de una 'mezcla' perfectamente comparable a la que existe en el Sud de Brasil y en Sud de Africa*".

10. Also called "Sierras de la Ventana". It is a group of mountains located in the the southeastern section of Buenos Aires province. Its geological structure was defined by Keidel (1916) and Harrington (1933).

tions were published in his work "*A Geological Comparison of South America with South Africa" (1927). His aim was to gather information about the Gondwana deposits of South America "to discover any evidence favorable or adverse to the 'displacement hypothesis*" (Du Toit, 1927: 2).

In his journey to prove Wegener's theory right, Du Toit maintained communication with some Argentinian scientists other than Harrington and Keidel, as can be seen in the introduction of his book from 1927:

> "*Among the numerous other persons to whom I have been particularly indebted are* (...) *Drs. Pablo Groeber, Roberto Beder, Juan Rassmuss, Anselmo Windhausen, Ricardo Wichmann, and Hausen, of the Geological Survey of Argentina, Dr. Juan Keidel, formerly director of that survey, Dr. H. Schiller, of the Museum of La Plata, Dr. C. Hosseus, of the University of Córdoba*" (Du Toit, 1927: 5).

Du Toit's archive in the Jagger Library of the University of Cape Town, South Africa, keeps six letters dated from November 1937 to November 1939 between Du Toit and Harrington, which reveal the exchange of ideas and arguments based on their own field discoveries, classifications and dating of stratigraphical sequences. This was the base for the correlations between the two continents, as has already been pointed out by Cingolani (2008). In the first letter (of November 30th 1937), Harrington cites his findings of *Glossopteris* fossils from the Bonete beds, in what is now known as the *Sierras Australes*, in Buenos Aires province (Pagani, 2000). The next three letters (May 13th 1938; March 14th 1939; and July 19th 1939) are copies of letters from Du Toit to Harrington. These show that Du Toit seemed to have a better communication with Harrington than with Keidel. He asked his questions to Keidel through Harrington. For example, in one of the letters (in March 14th of 1939), Du Toit expresses annoyance with Keidel related to the subject of his published paper, in which he revises another previous publication by Du Toit about his travel to Argentina:

> "*I have not had time to go through Keidel's long paper with care but am a bit puzzled to know whether he is no longer pressing a close relation between South Africa and Argentina or not. It looks as though he admits a general relationship, but not a detailed one stratigraphically or closer one geographically. If such is correct, then I must differ* (...) *I still see no alternative to the view that South Africa and South Amercia were formerly closer together."* Adding, *"Keidel has mentioned the finding of marine fossils in the Sierras of Tandil. Have you seen them and can you give any opinion on their age? That region I have always regarded as a key one in our paleogeographical reconstructions*".

In a subsequent letter (July 19th of 1939) he asked for some data about Keidel's dating of Olavarría [11] strata:

> "*I am specially interested because I was thinking of setting down some of the evidence having a bearing on the supposed correlation of the Gondwanides of the Cape & the Sierras of B. Aires. Keidel has curiously seemed to have abandoned his original views & now argues that the foldings on the opposite sides of the Atlantic differ somewhat in age. All the evidence he has now submitted agrees in toto with that out here, & I think that it may be worth while reviewing the problem in the light of the new information, largely as the result of Keidel's work, published in the Rundschau & elsewhere*".

In this passage, Du Toit questions Keidel's change of opinion concerning the correlation between the Gondwanides and the Buenos Aires Mountains. These mountain belts were the main subject of their correlations between South America and South Africa. In his reply (September 17th 1939), Harrington writes: "*As a result of my investigations I am afraid that my ideas have undergone rather important changes and I do not any longer agree with many of Keidel's views, past and present*".

He also summarized his own observations on the geology of the Olavarria region, characterized the sedimentation processes, the fossils found and their probable ages, morphological structures of the different rocks, and his ideas on the correlation of these sequences, as well as their ages and the probable phenomena that occurred to form them. When doing so, he used terms connected to the continental displacement phenomena:

> "*Strong tectonic movements have taken place along the major bedding planes which separate the different lithological horizons of the La Tinta beds.* (...) *They (the movements) are not overthrusts, as Schiller*

11. A region of the Buenos Aires province in Argentina belonging to the mountains of the Tandilia System.

believed, nor clean-cut-thrusts developed from nearly horizontal reverse faults. On the contrary they belong to the 'décollement' type of movements, sesu lato. The different lithological groups have glided differentially one over the other (...)"

And he also sent drawings (**Fig. 2**) to illustrate his ideas on the cause of the observed disposition of the strata investigated. In the last letter from Du Toit, he underlined the importance of fossil findings for the dating of sequences, and for their subsequent correlations:

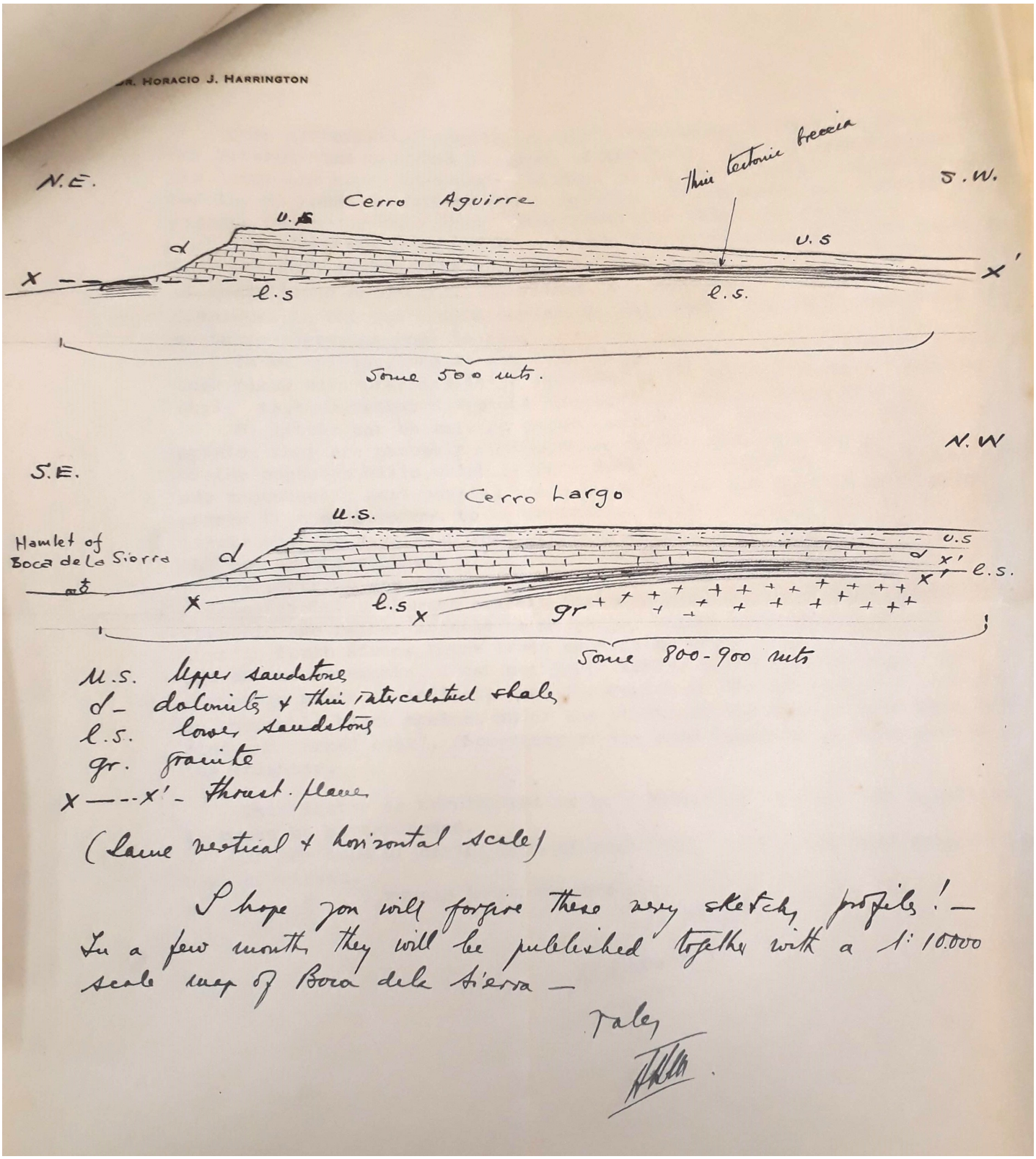
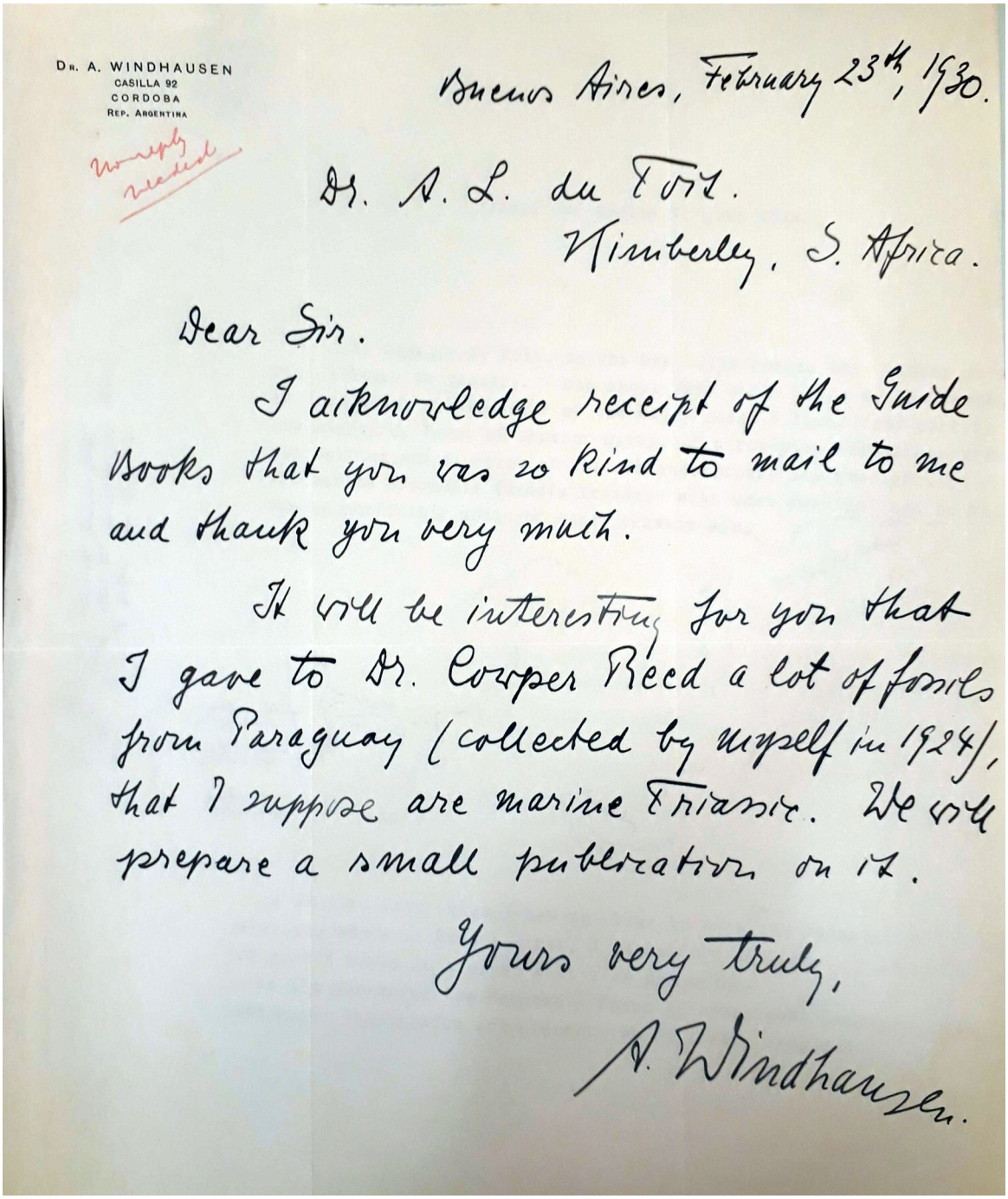


Fig. 2. Sketch drawing made by Harrington, sent with a letter to Du Toit on September 17th, 1939, to illustrate the sedimentary structure of Cerro Aguirre and Cerro Largo, and tectonic movements that happened. Photo taken in March, 2019 in the Jagger Library at the University of Cape Town, South Africa.

"Most interesting was your survey detailed account of the stratigraphy of the Sierras Bayas & the Spiriferina *discovered there. Your argument seems quite sound that those beds must be of pre-tillite age, which in turn suggest that the glacials must be at earliest of Lower Permian age. Whether such limestones & shales may prove the equivalent of our Witteberg is remains uncertain, though not impossible: once more fossils from both countries could settle this point."*

In their correspondence, they mentioned some other Argentina-based scientist, such as Cowper Reed, Pablo Groeber, Augusto Tapia, Walther Schiller and the Scottish geologist working in Uruguay, John D. Falconer, with whom Du Toit also kept correspondence concerning the correlations of Uruguayan terrains with Gondwana. Tapia personally accompanied Du Toit in his travel to Argentina in 1923 (Ramos, 2007).

In a letter from the German-Argentinian Anselmo Windhausen (1882-1932) to Du Toit (**Fig. 3**), one can see mention of an exchange of information ("guide book"), as well as fossils from Paraguay between the two scientists and the British geologist Cowper Reed (1869-1946). In this way they exchanged their specific and local scientific expertise.



Dr. A. WINDHAUSEN
CASILLA 92
CORDOBA
Rep. Argentina

Buenos Aires, February 23th, 1930.

Dr. A. L. du Toit.
Kimberley, S. Africa.

Dear Sir.

I aiknowledge receipt of the Guide Books that you was so kind to mail to me and thank you very much.

It will be interesting for you that I gave to Dr. Cowper Reed a lot of fossils from Paraguay (collected by myself in 1924), that I suppose are marine Triasic. We will prepare a small publication on it.

Yours very truly,
A. Windhausen.

Fig. 3. Letter from Windhausen to Du Toit, on February, 1930. Photo taken in March, 2019 in the Du Toit's archive in the Jagger Library at the University of Cape Town, South Africa.

Conclusion

The interesting case of the debate involving Wegener's continental drift theory showed that its rejection was associated with a threat that this theory represented to previously deeply held methodological beliefs and scientific practices at the time (Oreskes, 1999). This controversy went on for decades since the first publication of Wegener's book (1915) until the rise of paleomagnetism in 1950 and plate tectonics around 1960, which helped to present an explanatory mechanism for the movements of the continents (Frankel, 2012; Cingolani, 2015). With the focus on the work done, more particularly in Argentina and more broadly in the "Global South" (see Gray & Gill, 2016) at the end of the 19th and beginning of the 20th century, related to the discussion of the continental drift theory – which was initiated in Europe –, this study was directed to one of the main pieces of evidence, the *Glossopteris* fossils, taking as a compass the study and exchange of these fossils, since this was one of the main pieces of evidence used by specialists to validate the theory of continental drift. The idea is to reflect on the social aspect of science-making, to reveal the relationship between the supposed objective scientific undertaking, with the social context in which it is inserted. This was done through the analysis of the study of *Glossopteris* fossils and the social connections it encompassed.

The study of fossils of previously living organisms involves extra information on the sedimentary horizons in which they are found, this represents important information for the comparison of terranes from different continents. Therefore, the study of *Glossopteris* was a part of the methodology of experimentation used to prove the ancient connection of the now separated continents. The cases of exchange of *Glossopteris* fossils and all the information about this subject, as of other kinds of scientific exchanges in Argentina, were on many occasions determined by the very relationships that were developed between European researchers living in Latin America, and by the characteristics of the natural environments investigated (Lopes, 2000). Sciences such as Geology and Paleontology, are intrinsically global, and the different and distant regional data need to be connected to form an integrated picture. The scientific production is based on field work, and the communication between different scientists worldwide. Paleontology has united people, and strengthened the bonds between museums of natural history and universities in different countries in Latin America and in the world, as shown before (Lopes, 2000; Lopes & Podgorny, 2001; Podgorny, 2008; 2009).

The dynamics of science is based especially on the circulation of objects and of know-how, and knowledge is described universally precisely because it circulates (Nyhart, 2016). Therefore, the analysis of the circulation of objects and of the context they are inserted in is pertinent. It was precisely because of this international exchange of fossils and data, that Wegener and the others discussing continental drift could claim *Glossopteris* as important evidence for the theory. The exchange of data can be measured by the citations that appear in a publication, and their exchanged correspondence. This also reflects who was reading who, and often, a level of personal relationship and esteem.

As stated by Frankel (2012: 264): "*Drift is better observed and studied in the Southern Hemisphere. There are several very clear fragments of Gondwanaland and they each preserve better evidence of their Palaeozoic relations than anything in Laurasia*". The most important characteristics used as evidence were paleontological data and the presence of Paleozoic tillites, which represented the Permo-Carboniferous glaciation in Gondwana. Among specialists in Argentina, Keidel and Harrington were actively engaged in the discussion of the continental drift theory and were trying to prove it right with their own collected evidence, generating a scientific network in Argentina and the world. Kurtz's work with the fossil plants of the coal deposits in Argentina was mentioned by scientists worldwide, and it served as basis for further research and seminal publications in the field, especially when the subject was related to the comparisons of the Gondwanan territories. The communications, specially between Harrington and Du Toit, were very important for drawing conclusions in the transformation and development of the initial Wegener's theory, focusing on the correlation of South America and South Africa.

The role of these Argentinian scientists in the broader discussion of the continental drift theory can be appreciated when analyzing the circulations of their ideas in the scientific circles involved in this matter. This is observed in the network formed by scientists connected

worldwide by citations in their publications, as well as in their communications between each other through letters, in which they exchanged their ideas and the outcomes of their researches, each one contributing with his own insight of the aspects of the globe, tracing together the outlines of an image of the world and how it functions. Even though the research here initiated shows that it was still only a small group of people involved in the debate on the continental drift theory, it also helps to put in evidence the role of Global South countries, more specifically of Argentina. This work will continue with the investigations of this network connected by the exchange of *Glossopteris* specimens and information focusing especially on the countries of the Global South in the first half of the 20th century.

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