

# Friedrich Welwitsch's prolegomena of Angolan geology

## Friedrich Welwitsch: prolegómenos da geologia de Angola

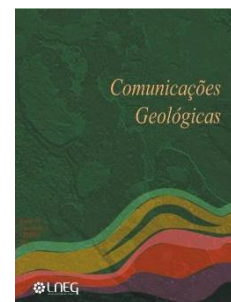
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**Abstract:** Recent work at the drill core library of LNEG at Alfragide has brought to light a small collection of rocks and fossils gathered by the Austrian physician and botanist Friedrich Welwitsch during his prolific expedition to Angola (*Iter Angolense*, 1853-1860) on behalf of the Portuguese crown. The samples were seen and mentioned by Paul Choffat, in 1889, but have remained completely forgotten ever since. Revisiting the samples, this article, which extends the evocation of 150 years of Welwitsch's passing, recalls the scientific partnership with the French naturalist Arthur Morelet, who studied mollusk faunas, and reviews the geological notes taken during the years of herborisations. Considering those notes and samples, it can be said that these pioneering elements in the study of the geology of Angola are, in essence, consistent with the recent knowledge and geological mapping of that territory.

**Keywords:** Angola, Geological collection, Geology, Phytogeography, Welwitsch.

**Resumo:** Trabalhos recentes trouxeram à luz, na Litoteca do LNEG em Alfragide, uma pequena coleção de rochas e fósseis constituída pelo médico e botânico austríaco Friedrich Welwitsch durante a prolífica expedição que, ao serviço da coroa portuguesa, efetuou a Angola: *Iter Angolense*, 1853-1860. As amostras que a integram foram vistas e referidas em 1889, por Paul Choffat, permanecendo, desde então, totalmente esquecidas. Ancorado na reavistação destas amostras, o presente artigo, que prolonga a evocação dos 150 anos sobre o passamento de Welwitsch, recorda a parceria científica com o naturalista francês Arthur Morelet, estudioso das faunas de moluscos, e passa em revista as notas de carácter geológico, tomadas durante anos de herborizações. Considerando no seu todo anotações e amostras, pode afirmar-se que estes elementos pioneiros do estudo da geologia de Angola compatibilizam, na sua essência, com os conhecimentos recentes e cartografia geológica daquele território.

**Palavras-chave:** Angola, Coleção geológica, Geologia, Fitogeografia, Welwitsch.

### 1. Introduction

After 150 years over the passing of the Austrian botanist Friedrich Martin Josef Welwitsch (1806-1872), who adopted Portugal as his second homeland, new reflections on his scientific work are propitious. This is the purpose of this article, which aims to shed some light on the lesser-known segment of his work during the African expedition *Iter Angolense* (1853-1860): the geological observations and sampling that would have accompanied his herborisations and biogeographical vision. Although little developed, Welwitsch's geological observations bear witness to pioneering steps in the knowledge of Angola's geology, as Masse and Laurent (2016) recall.

A tremendous challenge with announced failure, since over time it was assumed that his geological samples had been lost and what there was to say had already been said by others, as one of his biographers, the agronomist José Joaquim de Almeida (1862-1933) pointed out:

“If in Botany (...) nothing has been lost of his works (...) the same cannot be said of his geological observations, which have remained incomplete. Extracts from letters, a remarkable summary found in the introduction to a book by Morelet, and some geological notes which Mr. Paul Choffat published in pamphlet form, here is what remains of the work of the illustrious naturalist, from the point of view of geology” (Almeida, 1920: 130).

While the current location of his important herbaria in London, Paris, Vienna and the Universities of Lisbon, Coimbra and Porto are well known, the same is not true for the Welwitsch's geological samples. In fact, the survey conducted in some institutions proved to be not very fruitful, either because of difficulties in accessing the documentary collections or because of the lack of documents, some of which had been previously published. However, the Archives of the National Museum of Natural History and Science have a considerable number of documents from the Austrian botanist, recovered by the Portuguese government following the legal proceedings in the English courts for the possession of the collections that Welwitsch had taken to study in London, at the Kew Gardens and in the British Museum, as explained Bernardino Gomes (Gomes, 1875). Almost all concern Botany. However, we were particularly pleased to find among the enormous set of

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geological collections from the former Portuguese Overseas Territories, then gathered in the "Colonial Room" of the *Comissão dos Trabalhos Geológicos de Portugal* (Portuguese Geological Survey) in Lisbon (Brandão, 2010), currently housed in the LNEG's drill core library, at Alfragide, a small set of ten samples identified as the "Welwitsch Collection", which have remained unknown until today.

The present text aims to contribute to a better knowledge of the geological legacy of this naturalist, represented by some schemes, scattered notes, and some geological samples. It draws attention to the coincidences between his observations and the more recent geological and geomorphological knowledge of the Angolan territory, resulting from the development of stratigraphic studies and the cartography of its major geological units.

An unpublished first draft of this article served as the basis for a presentation by the authors at the conference '*Welwitschiana: Beyond Frederick Welwitsch's Collections*', held at the University of Évora in October 2022, marking the 150th anniversary of the Austrian botanist's death.

## 2. From the postponed Azorean trip to the African expedition

Welwitsch's human and scientific profile is embodied in various bio-bibliographical notes, especially those organised by Trimen (1873), Hiern (1896), Almeida (1928), Lima (1949), and Dolezal (1974). More recently, the outlines of his scientific work have been focused by Albuquerque *et al.* (2018, 2020), Albuquerque and Figueirôa (2022), and Cabral (2024). Therefore, it is only recalled here his academic background in Medicine by the University of Vienna, and the great passion for Botany, to which he devoted more than four decades of work.

His notoriety stems both from the fact that he was a continuator of the work of Félix Avelar Brotero (1744-1828), by adding new taxa to his *Flora Lusitanica* (Brotero, 1804), and by documenting, with a few thousand specimens, the flora of Angola, where he spent seven years on a mission under contract with the Portuguese government. However, his name resonates above all because of the "discovery" in the Moçâmedes region, towards the end of the *Iter Angolense*, of the enigmatic plant *Tumbo*, a name that John Dalton Hooker (1817-1911), director of the Kew Botanical Gardens, would replace with the genus *Welwitschia*, in his honour, giving the species the name *Welwitschia mirabilis*. A true "living fossil" whose origin dates to the Cretaceous Period, as its phylogenetic study would demonstrate (Jürgens *et al.*, 2021).

When he left Vienna in 1839 on a botanical journey prepared by the Association for botanical trips in Württemberg, it was not on Welwitsch's horizons to establish a new life in Portugal, as Lisbon was only a transit point to the Azores and Cape Verde islands, where he planned to herborise. The forced postponement of this journey was used for herborisations in the outskirts of the capital and in other places, which gave him knowledge of various aspects of the Portuguese flora, establishing a network of relationships that led to him giving up his tour of the islands.

At the end of 1848, he addressed the Lisbon Royal Academy of Sciences, proposing to create an herbarium of Portuguese flora, adding to the knowledge bequeathed by Brotero (1804) and his followers, that acquired over nine years of work. Once the task was finished, and with the knowledge he had acquired in a few years, his curiosity for tropical flora – a long-cherished desire –, was heightened.

At that time, the growing interest of the lead European countries in Africa and its endogenous resources with reciprocal

trade was already clear, in a process of colonisation in which the political and scientific agendas were intertwined. It was in this context of economic imperialism that Welwitsch offered the government his services as a naturalist, proposing to continue his explorations in the overseas territories, convinced of the "great convenience and necessity of a scientific exploration of those possessions" (Welwitsch's letter, 23 May 1850, *in* Lima, 1949: 39).

Without hiding that he would focus on "the most extensive study possible of the products of the vegetable kingdom", he committed himself to the formation of herbaria and seed collections, with a view to the future development of "Horticulture". At the same time, he announced his intention to attend to the study of fauna and, since plants and animals depended the climate and on the nature of the land as their substratum, he undertook to collect all the elements concerning them. This proposal would be fully accepted by the government, on the assumption of "how important it is to obtain a special knowledge of the natural productions of those territories, which can effectively contribute to the general prosperity of the Monarchy", earning the personal commitment of King Fernando II of Portugal (Trimen, 1873: 4).

The expedition to Angola was carefully prepared by requesting information and acquiring campaign materials and provision products for the specimens he intended to collect, as well as some bibliography.

Welwitsch sailed to Angola on 8th August 1853, arriving in Luanda on 30th September, after passing through the archipelagos of Madeira, Cabo Verde and São Tomé and Príncipe. It is supposedly from this last country that comes the fossil specimen represented in figure 1, which is incorporated in the Welwitsch collection of the Portuguese Geological Survey<sup>1</sup>.

He would return to Lisbon in January 1861, leaving behind him seven years of naturalistic excursions, during which he collected thousands of botanical, zoological and geological specimens. These were years of hardships and illnesses, resulting from the conditions of travel and the inclemency of the climate, circumstances that he considered to be opposed to scientific travellers in tropical Africa.

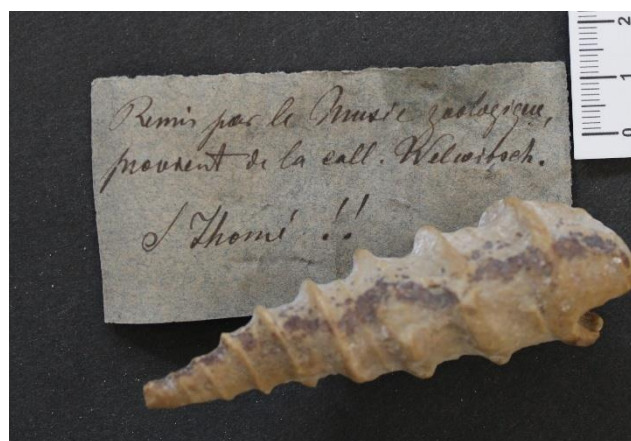


Figure 1. Fossil specimen possibly collected by Welwitsch in S. Tomé (Nerinea?). Handwritten label by Paul Choffat: "Remis par le Musée zoologique, provient de la coll. Welwitsch. S. Thomé". LNEG, Cx.1, Col. 30 – Welwitsch, 1859. Photo: Sofia Soares, 2024.

Figura 1. Fóssil possivelmente colhido por Welwitsch em S. Tomé (Nerinea?). Etiqueta manuscrita por Paul Choffat: "Remis par le Musée zoologique, provient de la coll. Welwitsch. S. Thomé". LNEG, Cx.1, Col. 30 – Welwitsch, 1859. Fotografia: Sofia Soares, 2024.

"(...) no wonder that both flora and fauna as well as the geological structure of this mysterious continent, are so far known only in fragments, and even these are restricted to the countries on the coast, while the greater part of the vast interior, and especially the highlands and mountains, remain (...) *terra incognita*" (Welwitsch, 1858 [1845]: 102).

The places Welwitsch visited during his seven years of exploring and studying the Angolan flora and fauna, as well as the itineraries he followed, have been compiled by his biographers and by researchers of his collections. The map in figure 2 locates those main places, some of which had already been visited by other 19th century explorers and travellers, gathering collections, namely of geological samples, including those preserved today in the LNEG's core library at Alfragide (see Silva and Pereira, 2014; Brandão *et al.*, 2022).



Figure 2. Map of the kingdoms of Angola and Benguela, modified. Scale [c. 1:5,100,000]. Lithography Castro, 1860. Source: National Library of Portugal, <https://purl.pt/1498>.

Figura 2. *Mappa dos reinos de Angola e Benguela*, modificado. - Escala [c. 1:5 100 000]. Lithographia. de Castro, 1860. Fonte: Biblioteca Nacional de Portugal, <https://purl.pt/1498>.

### 3. Travelling time and fieldworks

Revisiting the documentation by, and about Welwitsch, offers a good account of the journeys and fieldwork undertaken during the *Iter Angolense*, as well as on the collections sent to the metropolis from 1854 onwards. These included, besides living plants, seeds, wood, "gums", molluscs, insects and small vertebrates,

ethnographic objects, and geological samples. Those materials were mainly intended for the Nacional Museum under the "wise direction of the Academy of Sciences", and to the Botanical Garden of the University of Coimbra, which he considered "the main botanical establishment in the country" (Welwitsch's letter to the minister for the Navy and Overseas, Luanda, 22 November 1858, in Lima, 1949: 71).

Plants were, from the very first moment, the focus of his attention; he was concerned both with diversity – which at the time was transversal to contemporary studies in Natural History – and with its geographical distribution according to altitude, climate, and soils. A markedly Humboldtian vision, well evidenced in the "*Apontamentos fitogeográficos sobre a flora da provincia de Angola*", to which he attached a detailed "phytogeographical map", mentioning a total of 3,227 different plants, "belonging to 176 families or natural orders" (Welwitsch, 1858 [1845]: 113). Years later, in 1869, he published in London the *Sertum Angolense*, still now a reference work for the study of African tropical flora.

His biographers are aware of the itineraries and times of stay at the points from which Welwitsch carried out his herborisations. So, we know that after exploring the coastline around Luanda, he decided to move inland, following a line roughly perpendicular to the coast along the lower course of the river Bengo, directing exploration into the highlands. He first settled in Sange [Uíge], where he met the British missionary and explorer David Livingstone (1813-1873), who stayed there for some time, and then went on to Golungo Alto (Cuanza-Norte).

After visiting the Ambaca region, he went to settle in the Pungo Andongo (Malanje) military headquarters, where he spent some months studying the vegetation and the capabilities of the soil for future agricultural purposes. He would describe this place, also known as the Black Rocks of Pungo Andongo, as dominated by boulders of "fantastic shapes" of a reddish-grey or greyish-white colour, which protruded as inselbergs above the level of the green forest and which, during the rainy season, appeared "dressed in deep black, rising towards the blue sky like gigantic ruins of an ancient Cyclopean city" (Welwitsch, 1868: 25). Welwitsch enlightened the 'mysterious' seasonal colour change of those reliefs by the appearance of a small algae of the genus *Scytonema*, which gave them their blackish tone. From here he made excursions to the Duque de Bragança waterfalls [Kalandula Falls], to the mythical mountain ranges of the Pedras de Ginga and the salt pans of Quitage [Quitexe], south of Malange.

Welwitsch also collected in Cazengo [Ndalatando], Cuanza Norte, samples of a "micaceous iron ore" gathered almost at the surface "from which results the excellent iron for the manufacture of nails, hoes, locks or many other tools for domestic and agricultural use", made by local blacksmiths (Welwitsch, 1862: 25). From Golungo Alto he would also send several samples of "copal gum", a semi-fossil resin, much sought after on the international market for the manufacture of paints and varnishes, and some "iron pyrite crystals" resulting from the decomposition of the micaceous shales predominant in this region, which the locals used to hunt "instead of rifle bullets" (*ibid.*).

In June 1859 he headed for Moçâmedes, Cabo Negro and Baía dos Tigres, and then to Porto de Pinda [Tômbua], in Southwest Angola, whose agricultural potential the colonial administration wanted to know in detail. On his way to the inland *plateaux*, he would make the discovery that would put "his name in the annals of botanical taxonomy" (Almeida, [1928]: 138): the *Welwitschia*. From there he went to Serra da Chela and Huíla, returning to Luanda to prepare the collections for the return to Lisbon.

As neither the Nacional Museum nor the University of Coimbra had the comparative collections and bibliography needed to support the study of the specimens collected in Angola, Welwitsch was authorised to go to London in July 1863. He would take with him more than 5,000 plant specimens and 3,000 insect and other animal specimens (Mendonça, 1945), leaving most of the geological samples in Lisbon.

#### 4. Molluscs and Geology: The partnership with Morelet

Although several occasional naturalistic contributions by travellers who ventured into Africa since the end of the 18th century are known, systematic recognition of the continent's natural resources potential only emerged in the mid-19th century, as part of the scramble for Africa. A movement in which Portugal would also participate, driven by the Marquis of Sá da Bandeira (1795-1876).

It can be said that the first notes consistent with an attempt at a geognostic description of Angola appear with Welwitsch, although confined to the areas visited by the botanist. They could have been presented as a kind of *prolegomena* to the publication of a more developed work, which didn't happen. Those observations are no more than marginal notations, despite his skills as a collector-naturalist and his long stay in Angola, as Dolezal (1974) has noted, later compiled and rewritten by others. In this context, we should highlight the fruitful collaboration with the French conchologist Arthur Morelet (1809-1892), strengthened after 1863, when Welwitsch settled in London to study herbaria, and to whom he delivered his collections of "seashells" for classification (Fig. 3).

Morelet, first came to Portugal in the Spring of 1844. With a view to contributing to the geological knowledge of the country, he undertook a journey from Lisbon to the Algarve, later recounted in novelistic style, making occasional observations on lithologies, deposit modes and the dip of strata (Morelet, 1887)<sup>ii</sup>. It was certainly on his return to Lisbon that he got to know Welwitsch, then director of the Botanical Garden, accompanying him on some excursions, who put at his disposal some materials collected in the

outskirts of the capital, which the Frenchman would publish (1845).

In Almeida's opinion ([1928]: 264) it was not surprising that Welwitsch, knowing Morelet's work and being both members of the Academy of Sciences of Lisbon, had used his "former companion of several journeys" for the classification of his Angolan malacological specimens. A request to which the Frenchman would respond by publishing a first study (Morelet, 1866).

Their correspondence indicates that Welwitsch had expressed the intention to publish his naturalistic observations in Angola, to which Morelet asks what kind of publication he had in mind? "*Doit-elle former un ensemble complet, comprenant toutes les branches de l'histoire naturelle ? N'y joindrez-vous la relation des faits qui vous sentes personnels, en un mot, de vous aventures et de vous observations sur le pays ?*" (Natural History Museum Library and Archives (NHMLA), Morelet's letter to Welwitsch, 14 May 1863. [Collection of manuscripts and correspondence relating to the flora of Angola], MSS WEL., 3FO).

He offered to translate the text into French – at the time a powerful vehicle for disseminating science – and to look for an editor. The result would be the publication of the *Mollusques terrestres et fluviatiles*, with the indication above the title, *Voyage du Dr. Friederich Welwitsch exécuté par ordre du Gouvernement Portugais dans les royaumes d'Angola et de Benguella* (Morelet, 1868), work that Morelet wanted to contextualise with elements of a geological nature.

"J'avais besoin de quelques renseignements sur la constitution géologique, ou minéralogique, des trois régions que vous avez établies. Sans entrer dans des détails qui sont étrangers à mon sujet. Il faut cependant que je donne un mot sur la nature des terrains..." (NHMLA, Morelet' letter to Welwitsch, 22 February 1866, MSS WEL., 3FO).

A request that was answered through the sending of a series of drawings, in which he describes the succession of lithologies "found from the beaches to the remote hinterland as far as I went", based only on his travel notes. "(...) although some details may not be very exact, for lack of time, I do not hesitate to affirm you its exactness in general (NHMLA, Welwitsch's letter to Morelet, London, 08 November 1866, MSS WEL., 3FO).

Punctually, he added to the lithologies some remarks concerning the geomorphology, structure and stratigraphic position of the rock units, which currently allows us to contrast his observations with more recent geological studies and cartography. However, the structural indications drawn up should be taken with caution.

On the back of the folio, the botanist expressed the difficulties he had experienced in finding the correct geological terms in Portuguese, as he had not received Cotta's recent work on rock synonymy in time – surely the work *Rocks Classified and Described: A Treatise on Lithology*, by Bernhard von Cotta, London, 1866<sup>iii</sup> –, while drawing attention to the fact that his geognostic observations were superficial as he did not have, in London, the geological samples sent from Angola. In fact, as he added, he could not even see them in Lisbon on his return in 1861, because they were still boxed up.

Morelet would not publish the sections – currently the only available of Welwitsch's drawings concerning the geology of Angola –, limiting himself to summarising (?) and framing, in the *Voyage...* the descriptions received, since, as he himself referred, his knowledge of Geology was limited.

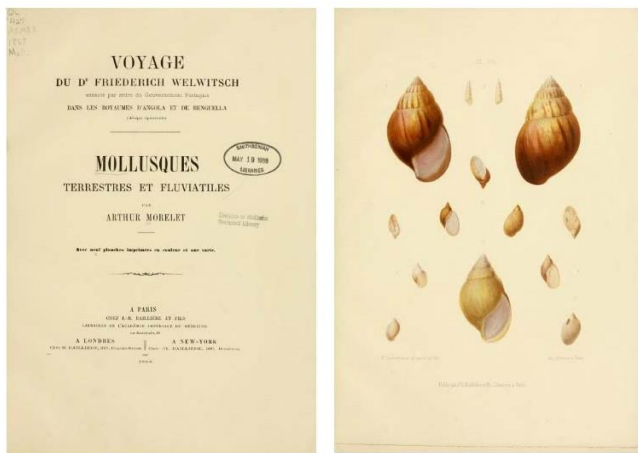


Figure 3. Cover from *Mollusques terrestres et fluviatiles*, from Morelet (1868), and plate VII from the same publication illustrating Mollusca 1. *Achantina bayoniana*, 2. *Achantina striatella* var., 3. *Limnaea bocageana*, 4. *Limnaea orophila* and 5. *Limnaea sordulenta*.

Figura 3. Capa da publicação *Mollusques terrestres et fluviatiles*, de Morelet (1868) e estampa VII do mesmo volume ilustrando os moluscos 1. *Achantina bayoniana*, 2. *Achantina striatella* var., 3. *Limnaea bocageana*, 4. *Limnaea orophila* e 5. *Limnaea sordulenta*.

The revised manuscript of the *Voyage...*, would be returned in November 1866. The botanist apologised for the marginal notes, necessary "to satisfy a public interested in the natural history of a continent known only very superficially" (NHMLA, Welwitsch's letter to Morelet, London, 8 November 1866, MSS WEL., 3FO). He added that when he returned from Africa, and read Livingstone's work, noted with satisfaction that most of the data he had collected matched with those published by the British missionary; the differences were justified with the quality or conditions of the used instruments, convinced that the ones he had used were better, concluding that the results of his work surpassed those of the various expeditions undertaken "by the English ones".

**5. The "Ideal cross sections": readings and highlights**

In January 1877, the Portuguese government appointed a commission to study the Welwitsch documents and collections that had come from London in 1870, which included the professors and naturalists of Zoology and Botany at the Polytechnic School of Lisbon (Direção Geral do Ultramar, Ordinance of 04 January 1877, *Diario de Lisboa* 8, 11 January 1877: 53). It was then that the Count of Ficalho, Francisco de Melo Breyner (1837-1903), professor and founder of the Lisbon Botanical Garden, a member

of that commission, invited Paul Choffat (1849-1919), geologist at the Geological Survey, to study the geological notes and samples gathered in Angola by the illustrious Austrian botanist. An invitation certainly justified by the fact that Choffat has already published some considerations on the palaeontology and stratigraphy of Angola (1886, 1887, and 1888 with Loriol), even though he had never set foot in Africa and the available bibliography on its geology was still scarce, not allowing for great stratigraphic and/or tectonic conjectures. The geologist limited himself to compiling and publishing the drawings and loose notes, as well as to the interpretation of Welwitsch's "ideal" cross sections, on a 209 mm x 204 mm water coloured folio, subtitled in Portuguese (Fig. 4).

What immediately stands out in these cross sections is the figuration of the relief, well cut out and reinforced by the sepia tone, although without any concern for vertical scale, nor for the horizontal scales that Choffat would later add in pencil. Morelet (1868) referred to it by writing that "30 or 40 geographical miles" from the coast, the land rose in platforms of progressive altitude, "succeeding each other in the order of geological appearance", an inference certainly drawn from the chronostratigraphic guidelines that Welwitsch had sent him. Section A, traced north of Kwanza, roughly oriented along the 9 degrees south parallel and drifting to



Figure 4. The "ideal" cross sections from Luanda to Quisonde [Quissonde] and from Benguela to Ivantala [Eiva-Nthala] lagoon. Watercolour drawing, [1866]. Historical Archive of the Museums of the University of Lisbon, F. Welwitsch fund, Cx. 3, PT-MUL-FW-01-0072.

Figura 4. Secções transversais "ideais" de Luanda a Quissonde e de Benguela à lagoa de Ivantala. Desenho aguarelado, [1866]. Arquivo Histórico dos Museus da Universidade de Lisboa, fundo F. Welwitsch. Cx. 3. PT-MUL-FW-01-0072.

10th, crosses successive geological units from Luanda to Quissonde (Malange province), over a length of c. 460 km. From the point of view of geomorphology, the Luanda cliffs (Fig. 5) stand out, perhaps exaggeratedly, as well as the vigorous relief in the region corresponding to the Serra do Alto [de Alta] Queta and the ruiniform landscape of Pungo Andongo and Pedras de Ginja, situated between 900 and 1,000 metres above sea-level.

It corresponds to a succession of lithologies that begin on the cliffs of Luanda, with Neogene deposits of compact fossiliferous sandstone, clays and marls described in some detail, and small cross sections also reproduced by Choffat, where the Austrian botanist mentions the discovery of some silicified tree trunks.

Based on his knowledge of the geological formations around Lisbon and on the notes of the Portuguese naturalist José de Anchieta (1832-1897), Choffat interpreted these formations as corresponding to the Tertiary Period; the limestones that Welwitsch had noted further north, in the mouth of the Dande River, seemed to be of Cretaceous age (*ibid.*: 38). J. C. Lang, whose report Welwitsch would certainly know, had already noted those limestones when, in July 1839, he visited the Libongos mountains at the request of the Governor of Angola to inspect local petroleum seeps. He reported them as being very dark, almost black, impregnations in the fine-grained and grey coloured limestone, which the locals explored and sold in Luanda as pitch to caulk the boats (Lang, 1886). A trip taken to look for "stone coal" in the vicinity, persuaded of the strong link between these two natural products, since many enquiries showed that "[it was] almost infallible that where there is oil there is also stone coal". However, he returned without having found it.

Welwitsch visited this "petroleum mine" in 1858, noting the existence of a bituminous sandstone, as well as the place where a mine was being opened in search of coal. There, he collected a sample of "a lamellated shale almost black, full of micaceous particles and small petrified molluscs" (Welwitsch's letter to the Minister of Navy and Overseas, Luanda, 22/11/1858, *in* Lima, 1949: 71). Choffat (1886) confirmed the presence of fossils, saying that these forms seemed to belong to indeterminable lacustrine or

brackish-water molluscs. However, as regards the stratigraphic position of these formations, he suggested that they must be from the Jurassic or Cretaceous, more recent therefore, than Welwitsch had admitted, when he attributed them to the Carboniferous (Morelet, 1868; Choffat, 1889).

To the east of these deposits, in the Icolo and Bengo regions, Welwitsch reported the occurrence of ferruginous conglomerates, "Trapp rocks" (already previously noted by Livingstone), and various types of shales, compact sandstones and Silurian grauwackes (Choffat, 1888), "laying on granite visible at some places", chronology which is not consistent with current dating. In the area of Pungo Andongo and Pedras de Ginja, it points to the occurrence of conglomerates overlaying gneisses, an interpretation coinciding with the geological history of these places according to Martins (1962). In this geologist's opinion, the ruiniform landscape which had made a strong impression on the Austrian botanist (see his sketch in Choffat, 1889, Pl. II), was due to the existence of "quartziferous gneissic bands very resistant to erosion", which resulted in a succession of very prominent hills and narrow interlocking valleys, a phenomenon spread over the entire "crystalline formation".

Cross section B, taking as its guide the 15 degrees south parallel, covers the territory east of Moçâmedes for an extension of 130 miles (c. 240 km) to the Huila plateau. As main geomorphological features, the drawing shows a kind of "staircase of planations" as it would later be called by Mariano Feio, who characterised in detail this entire sequence of reliefs, from the coast to the hinterland cratonic plateaus of the continent (main escarpment and highest mountains closer to the coast), including a simplified cross section at the same latitude (see Feio, 1964, Fig. 3).

To the south and southeast of Benguela, the relief of the Dombe Grande sedimentary plateau stands out with its truncated hills known as "mesas" (similar to those shown in figure 6), "montagnes isolées généralement tronquées en forme de plateaux et de tables, couvertes par des gros quartzites roulés" (Choffat, 1889: 43). More faraway, the important accident of the escarpment of the Serra da Chela (on average more than 1,000 m of difference



Figure 5. View of the cliffs of "S. Paulo de Luanda" according to F. Welwitsch (1854). Rep. from Choffat, 1889.

Figura 5. Vista das escarpas de S. Paulo de Luanda, segundo Welwitsch (1854). Rep. de Choffat, 1889.



Figure 6. Welwitsch's drawing showing the tabular reliefs at 16 degrees south, on the right bank of the Curoca River. Rep. from Choffat, 1889.

Figura 6. Relevos tabulares à latitude de 16° Sul, na margem direita do rio Curoca, segundo Welwitsch. Rep. de Choffat, 1889.

in level), western edge of the Humpata plateaus, “the tallest planations of southwestern Angola” (Feio, 1964: 339).

The lithological succession is close to the reported cross section A. In the more coastal band, corresponding to the Namibe basin, Welwitsch pointed out sandstone and “Trapp rocks” – certainly basalts, also mentioned in 1875 by Joachim John Monteiro (1833-1878) (Monteiro, 1875), a mining engineer who travelled in Angola in the 1850s and 1860s searching for copper ores. To the east of Moçâmedes, in the Montes Negros, he found shell-shaped marls that Choffat attributed to the Miocene; formations that, according to Anchieta (1888), extended southwards, making up the coast as far as Porto Alexandre [Tômbua] and the Curoca river. It was in this extensive flattened region partly covered with the Namibe sands that the botanist would find, in 1859, the (famous) *Welwitschia mirabilis*.

“A few miles before reaching Cabo Negro, the coast rises to 300 to 400 feet [c. 120 m], forming a continuous plateau extending across the continent for more than 6 miles, as flat as a table. This tabular elevation consists of calcareous tuffs and layers of clays covered by mobile sands and loose blocks of sandstone, covered with vegetation which though scarce is of the greatest interest” (Welwitsch's letter to W. Hooker, Luanda, 16 August 1860, in *Journal of the Linnean Society*, 5: 185).

Welwitsch correctly points out in the drawing that these carbonated beds associated with evaporites denoted by “saltwater springs”, and coarse detrital rocks with copper impregnations, lay in angular discordance on the bedrock (Precambrian soco), represented by micaceous schists. To the East, there are schists cut by granitic intrusions denoted by the occurrence of large blocks and, from the Serra da Chela escarpment, “ante-Silurian” schists, micaceous, sandy, and clayey, which Anchieta (1885) called the “primordial terrain”. The cross section ends with the granites in the region of the Ivantala lagoon, close to Huíla, after overcoming the more mountainous reliefs.

Although fragmentary, these drawings and notes show that while Welwitsch gave priority to the observation of altitude and climate, collecting many elements, he also paid attention to geology, as a determinant of relief and soil type; however, altitude, influencing both temperature and precipitation was, for the Austrian botanist, the main vector structuring the variety and geographical distribution of plants. It is on the basis of its variation that he delimits and characterises the three phytogeographic zones into which he considers Angolan territory to be divided: the *Região litoral* (coastal lowlands), comprising land from the coast inland rising successively up to 1,000 ft (c. 300 m) comprising beaches, barren hills and flat areas covered with tough grasses and thorny plants; the *Região montanhosa* (mountainous region), extending up to c. 250 km inland, rising to 2,300 ft (c. 700 m), where forests

dominate and the *Região alto-plana* (inland plateaus), more inland and elevated, above 3,000 feet, extending, as he said, “far beyond the end of his holdings”, characterised by the great diversity of the flora (Welwitsch, (1858 [1945]: 108) (Fig. 7). These regions had a vegetation occupation he summarised as follows: “aridity and scarcity of vegetation characterise the first; in the second, the freshness and luxuriance of the individuals; in the third, the variety and elegance of the species predominate” (*ibid.*: 110).

As Brian Huntley (2019) states, Welwitsch's interpretation of the relationships between physiography, geology and vegetation established “a strong ecological tradition” in Angolan biodiversity research. On the one hand, his altimetric zonation is also roughly coincident with the major geological units represented in the Geological Map of West-Africa, drawn by the German-Austrian geologist Oskar Lenz (1848-1925), and published in 1882 (Ghota, Germany, Justus Perthes) after his travels undertaken in the years 1874-1877 and 1879-1881; on the other hand, it is also similar to the one adopted by Choffat and Lorient (1888), although in both cases the objective was not the characterisation of the vegetation cover.

The occasional coincidences are quite evident when one compares Welwitsch's notes with more recent works, namely the in-depth study by Antunes (1964) or when the cross sections are adjusted to more recent geological maps, namely the sheets 1 and 3 of the 1:1,000,000 geological map of Angola, published in 1983 by the former Portuguese Instituto de Investigação Científica Tropical (Institute for Tropical Scientific Research). This can be noted despite the detail of those maps and the fact that the Welwitsch's drawings represent generic sections without specific points of observation, in which the toponym referred or

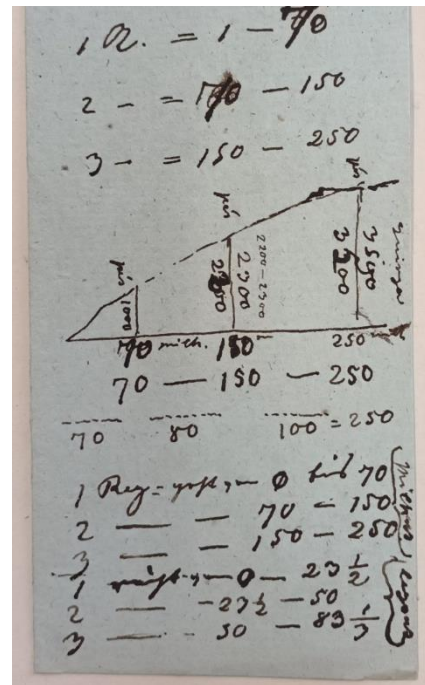


Figure 7. Schematic cross section attached to the Welwitsch's handwritten report (1858), showing the extent and altimetry of the “phytogeographic regions”. Separate note attached to the “Phytogeographical notes”, chap. 903. Courtesy of Lisbon Academy of Sciences.

Figura 7. Corte transversal esquemático anexo ao relatório manuscrito de Welwitsch (1858), mostrando a extensão e altimetria das “regiões fitogeográficas”. Nota avulsa anexa aos “Apontamentos fitogeográficos”, cap. 903. Cortesia da Academia das Ciências de Lisboa.

has either fallen into disuse or may correspond either to a locality or a district (Fig. 8).

## 6. The geological samples from the ‘*Iter Angolense*’

By reading Welwitsch’s epistolary, it can be seen that several shipments of natural products were sent to the metropolis, including geological samples. The herbaria, the mainstay of the African expedition, were always an exception, as Welwitsch always wanted to keep them with him, so that, on his return journey to Lisbon, he could watch over the specimens personally, "or perish with them if that was [his] fate" (Letter to the Secretary of the Academy of Sciences, G.-Alto, 15 January 1859, in Almeida, [1928]: 157).

In August 1855, a small collection of rocks “whose decomposition influences the formation of the soil of the cultivated land” was sent from Golungo Alto to the attention of the Governor of the Province, together with some "useful plants", seeds, resins, and small animals (Welwitsch, 1855); in July 1857, several botanical collections and animals preserved in "spirit of wine" were also sent out, as well as "an instructive collection" of geological samples from Pungo Andongo and from the Kwanza riverbed (Welwitsch, 1857 [1945]: 79).

Despite the admitted fears of sending his collections by steamer to the metropolis, Welwitsch would still send, in January 1859, six more cases with natural history and ethnographic objects (Welwitsch’s letter to the Minister for the Navy and Overseas, Luanda, 14 January 1859, in Lima, 1949: 75-77). Two of those destined to the National Museum contained geological samples from the Angolan coast and inland districts, "both of rocks and soils, as well as of the petrifacts found in them", bituminous shale

from the Libongo hills and samples of magnetic iron and copper from Balunda [Bailundo]. All specimens carried "explanatory labels", except for the petrifacts from the gypsum-lime layers to the southwest of Luanda, all from the Praia da Zamba [Samba] Grande site.

Among the products sent, there were also several samples of copal, a fossil resin whose genesis placed it in a limbo zone between being a mere product of biological origin or the result of the geological evolution of a raw material of vegetable origin, like fossil coal: a parallel evoked by Welwitsch himself. Drawing attention to the misconception that copal was harvested directly from trees, he explained that it was dug up from sands, marl, and clays at varying depths of up to three metres or found in loose fragments washed up by streams and brought to the surface of the ground by rain (Welwitsch, 1866 [1845]: 418).

“The most important question is to ascertain whether the copal gum exported from Angola for so many years (...) is still produced by trees, or whether it must be considered (like amber) a fossil resin that was produced in earlier geological periods, or from trees that no longer exist today, of which very few fossils remain can be found” (*ibid.*: 425).

As he did not discover "even one living tree with resin similar to copal gum" (*ibid.*, p. 434), he was convinced that this natural product was a fossilised resin, which seems to be in line with the results of recent radiocarbon dating of West African copal, namely that from Angola, as having been formed between  $5840 \pm 35$  and  $2830 \pm 80$  years (Solórzano-Kraemer *et al.*, 2020), and can therefore be considered as probably middle to late Holocene in age.



Figure 8. Extract from the geological map of Angola 1:1,000,000, Sheet 1 - Luanda, and Welwitsch’s “ideal cross section”. (LNICT, 1982)

Figura 8. Extrato da Carta geológica de Angola, LNICT, 1:1 000 000, 1981, Folha 1 - Luanda, e “perfil ideal” segundo Welwitsch.

## 7. Lost and found: a discussion

Despite the scientific and political relevance of Welwitsch's mission and his notoriety, which required him particular care with the delivery of his collections, the fact is that the whereabouts of the aforementioned series of geological samples remains unknown, and their loss was assumed over time (Brandão *et al.*, 2015). There are, however, a few samples from the last fieldworks in Moçâmedes region, by 1859, which recent inventory and repackaging works of the African collections currently housed in the LNEG's Core Library, have brought back to light.

It can be argued that those collections arrived in Lisbon at a complicated time, a consequence of the transfer of the National Museum housed at the Royal Academy of Sciences to the Polytechnic School of Lisbon, ordered by the Charter of 10 March 1858. Certainly, a complex and perhaps lengthy process, during which many specimens have been lost or lost their labels, depriving them of their identity and scientific value, as had already happened in 1836, when the Royal Museum of Ajuda was transferred to the Academy of Sciences (Almeida, 1868).

It should be remembered that Welwitsch had informed Morelet that in 1861, before he left for London as a government delegate to the Universal Exhibition of 1862, he had not been able to see the geological samples from Angola because they were still boxed up. As the place is not mentioned, we do not know where the boxes would be: if they were kept somewhere in the Academy of Sciences or if they were already in some space of the Polytechnic School, awaiting their incorporation into the collections of the National Museum.

Through a letter sent on 14th March 1859 by M. d'Oliveira Lima, head of the *Secção do Ultramar* (Overseas Department) to the Secretary of the Academy of Sciences (Arquivo Histórico MUNHAC, Div. 60), it is known that five boxes had been delivered there, which certainly correspond to the shipment sent from Luanda in January of that year (Welwitsch's letter to the Minister of Navy and Overseas, Luanda 14 Janeiro 1859, *in* Lima (1949). However, the subsequent course of the respective content is unknown, a doubt which the report on the work of the Academy, read at the formal session of 10th March 1861, does not allow to be dispelled:

“In the last two years, the Academy received some precious natural history collections (...) on the assumption that the National Museum was still under its superintendence. From Dr. Frederico Welwitsch (...) the Academy received a copious collection of natural history objects, mainly destined to illustrate the geology and mineralogy of our province of Angola, which by order of the government was for many years travelled in risky excursions...” (*Diário do Governo* no, 59, 14th March 1861: 730).

When preparing the materials destined for the London International Exhibition of 1862 and for the Lisbon Medical-Surgical School, Welwitsch selected, among other objects, samples of iron, micaceous iron, pyrites and copal from Golungo Alto (Welwitsch, 1862), possibly taken from the afore mentioned boxes. Thus, if those consignments remained at the Academia das Ciências, and had not been transferred to the Escola Politécnica, their incorporation into the study collections of the Aula Maynense<sup>IV</sup> may be presumed, their identity being lost over time. In fact, neither in the catalogue of the "*Secção Mineralógica*" of the reinstated Nacional Museum, drawn up by the naturalist Xavier de Almeida (1868), nor in the "*Notas sobre as colecções*" published in 1915-16 by Jacinto Pedro Gomes (1844-1916), who

succeeded him in 1883, are there any references to the Austrian botanist's materials. Finally, what remains are the samples seen by Choffat and referred to in this article, which were later incorporated in the collections of the Portuguese Geological Survey, although paradoxically they are not mentioned in the general list of its colonial collections drawn up in 1921, kept in the LNEG Historical Archive (AHLNEGCG13.04.99). Although no references have been found, the possibility that this small collection was later displayed in the 'Colonial Room' of the Geological Survey (Brandão, 2010) should not be ruled out.

A small set of 10 pieces, mostly fossils, almost all with loose labels written in French, surely added by Choffat, and a small, printed label with the indication "Welwitsch", still exists, currently incorporated into the geological collections housed at the LNEG's *Litoteca* (drill core repository). Some of those samples keep the original label in German.

The petrous materials can be summarised as a lumachel from Cabo Negro, whose table, by the lettering, indicates the possibility of having been exposed in the museum of the Geological Commission, five samples of very fine-grained gneiss from the region to the east of Moçâmedes, and bituminous schists from Libongo (Fig. 9). The lumachel sample, correctly attributed by Choffat to the Miocene, possibly corresponds to the Flamingos Formation (1: 1,000,000 Geological map of Angola, LNICT, 1982) which also includes other lithologies such as sandstones and calcarenites.

Choffat and Loriol (1888) mention that the Libongo samples came from London with "recent shells", which would have happened following the end of the legal dispute over the Welwitsch collections and documents. This could be – or not – a misunderstanding that, for lack of evidence, has no clear solution.

The fossils seen by Choffat resulted from Welwitsch's last explorations along the coast from Benguela to Moçâmedes between June and October 1859, and are from the Cenozoic deposits of the Cabo Negro region and, a little further east, the



Figure 9. A - Lumachel (*Muschelbreccie*) from Cabo Negro; B - Set of gneiss samples representative of the basement, Moçâmedes region; C - Samples of the micaceous oil schist collected at a depth of 80 feet (c. 25 m), October 1858. LNEG- core library, Alfragide, Col. Welwitsch, 1859, Cx.1 - Coleção 30. Photos: Sofia Soares, 2024.

Figura 9. A - Lumachel (*Muschelbreccie*) do Cabo Negro; B - Amostras de gneisses representativas do soco, região de Moçâmedes; C - Xistos micáceos betuminosos, recolhidos à profundidade de 80 pés (c. 25 m), outubro de 1858. Litoteca do LNEG, Alfragide, Col. Welwitsch, 1859, Cx.1 - Coleção 30. Fotografias: Sofia Soares, 2024.

Montes Negros (Fig. 10). These sedimentary series are mentioned in Morelet's text (1868) as being Triassic (Muschelkalk), an indication also patent in one of the labels. Choffat, places them in the Neogene, considering the indications of Oscar Lenz's map, that the Tertiary of the Angolan coast extended to the north of Dombe Grande, and the descriptions of José de Anchieta (1885), which stated that the Tertiary formations of Benguela, like those of Luanda, extended southward to from the coast of Moçâmedes.

Considering the date of the collections, and Welwitsch's short stay in Lisbon between his return from Angola and his departure for London to deal with the Portuguese representation at the 1862 Exhibition, it can be assumed that these few samples were not unpacked, going to London in 1863 with the herbaria. They would then be returned with the remaining materials, being at the disposal of the Count of Ficalho. So, as no documentation has been found to prove this, it was not possible to determine the contours of the collection that the Count of Ficalho placed at Choffat's disposal, who, for his part, may have focused on the fossils as key elements

for the stratigraphic precisions adopted in the works he published on the geology of Africa from 1888 onwards.

The fossil specimens gathered by Welwitsch in this region, as well as their patina, indicate that they were collected in Pleistocene sands of raised beaches, which cover old abrasion platforms of the high coast, of abrupt cliffs (Huntley, 2019). The small collection comprises three internal casts of *Turritella* sp., five specimens of *Bullia callosa* (W. Wood, 1828), a *Trona stercoraria* (Linnaeus, 1758) and a *Aspa marginata* (Gmelin, 1791), all coming from Cabo Negro, one specimen of *Stramonita haemastoma* (Linnaeus, 1767) from serra de Montes Negros, a right valve of *Senilia senilis* (Linnaeus, 1758) without location, but according to Choffat, possibly from Moçâmedes or Cabo Negro, and one specimen of *Mathildia* cf. *quadricarinata* (Brocchi, 1814) from Montes Negros.

## 8. Final remarks

Bernardino Gomes, indefatigable friend and advocate of Welwitsch's prestige and aptitude as a naturalist, wrote that in 1850 Viscount Sá da Bandeira, "a minister concerned with all things relating to the overseas provinces", had used his influence to get the government to order an expedition for the scientific exploration of Portuguese West Africa, for which Friedrich Welwitsch would be nominated. The royal decree of appointment made explicit, unequivocally, the dual function of this mission: "to obtain the most extensive knowledge possible of the natural products of the same Provinces" - in the broadest sense, it should be understood - and "to use this knowledge for the development of the wealth and well-being of their inhabitants; and of the relations with the Metropolis". Therefore, a combination of Science and Politics.

Although the Austrian gave greater emphasis to the phytogeography as Bernardino Gomes said, geological issues were not alien to him at a time when, it should be remembered, Portugal was taking the first steps towards the establishment of a permanent entity for the geognostic recognition of the country, which resulted in the creation of the first Geological Survey within the Academy of Sciences (1848), refunded a decade later, under other conditions.

Angola's current geological knowledge is today substantially different from that invoked in the previous paragraphs, at the time of the works of the Austrian botanist, the naturalists Monteiro and Anchieta, and the syntheses of Choffat. Nevertheless, one can find many coincidences between Welwitsch's pioneering observations and the available geological cartography produced by the former *Laboratório de Investigação Científica Tropical* (LNICT). It should be added that, with the collaboration of LNEG, a new geological cartography of Angola has been developed within the framework of the National Geology Plan (PLANAGEO). It aims to meet the major challenges inherent to the sustainable development of Angola.

Welwitsch's observations, schemes and geological samples are unique testimonies of the *Iter Angolense*, one of the first Portuguese scientific missions in lands of Africa. Therefore, as a final balance of his contribution to the knowledge of Angola's geology, and despite the temporal distance from this expedition up to date, we recognise the relevance and timeliness of the commentary of the editor of the Lisbon weekly newspaper *Arquivo Universal* who, at the time when the expedition was rapidly ending, wrote:

"Dr. Welwitsch (...) applied himself wholeheartedly to the study of flora, and only in passing gave his attention to the other



Figure 10. Some specimens from Welwitsch's collection. A - *Turritella* sp., Cabo Negro. B - *Bullia callosa* (W. Wood, 1828), Sande, Cabo Negro. C - *Trona stercoraria* (Linnaeus, 1758) and *Aspa marginata* (Gmelin, 1791). Sande, Cabo Negro. D - *Stramonita haemastoma* (Linnaeus, 1767). "Serra de Montes Negros, at 500 feet [c. 150 m] 500 feet above the Sal River". E - *Senilia senilis* (Linnaeus, 1758). Without label, F - *Mathildia* cf. *quadricarinata* (Brocchi, 1814). [Choffat] "A peau de distance du sommet de Montes Negros". LNEG core library, Alfragide, Coleção Welwitsch, 1859, Cx.1 - Coleção 30. Photos: Sofia Soares, 2024.

Figura 10. Alguns espécimes da coleção Welwitsch, depositados na Litoteca de Alfragide do LNEG. Fotografias: Sofia Soares, 2024. A - *Turritella* sp., Cabo Negro. B - *Bullia callosa* (W. Wood, 1828), Sande, Cabo Negro. C - *Trona stercoraria* (Linnaeus, 1758) e *Aspa marginata* (Gmelin, 1791). Sande, Cabo Negro. D - *Stramonita haemastoma* (Linnaeus, 1767). "Serra de Montes Negros, at 500 feet [c. 150 m] 500 feet above the Sal River". E - *Senilia senilis* (Linnaeus, 1758). Without label, F - *Mathildia* cf. *quadricarinata* (Brocchi, 1814). [Choffat] "A peau de distance du sommet de Montes Negros". Litoteca do LNEG, Alfragide, Col. Welwitsch, 1859, Cx.1 - Coleção 30. Fotografias: Sofia Soares, 2024.

branches of natural history (...) But if the other studies of this naturalist do not have the same perfection as his botanical investigations, they must be considered as very useful works for the knowledge of a region that is still so much ignored (Carvalho, 1859: 28).”

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## References

- Albuquerque, S., Figueirôa, S., 2022. A complementary note to Welwitsch's map of travellers in Africa. *Earth Sciences History*, **41**(1): 128-132. <https://doi.org/10.17704/1944-6187-41.1.128>.
- Albuquerque, S., Figueirôa, S., Felismino, D., 2018. Depicting the invisible: Welwitsch's map of travellers in Africa. *Earth Sciences History*, **37**(1): 109-129. <https://doi.org/10.17704/1944-6178-37.1.109>.
- Albuquerque, S., Figueirôa, S., Felismino, D., 2020. The forgotten library of the botanist Friedrich Welwitsch (1806-1872). *e-JPH*, **18**(2): 83-112. <https://doi.org/10.26300/0tps-4458>.
- Almeida, F. X., 1868. *Notícia das colecções da Secção Mineralógica do Museu Nacional de Lisboa*. Typographia Lisbonense, Lisboa, 125.
- Almeida, J. J., 1928. O Dr. Frederico Welwitsch e sua obra em Angola: estudo crítico biográfico. *Boletim da Agência Geral das Colónias*, **1**(2): 13-34.
- Almeida, J. J., 1920. Observações gerais sobre a agrologia, climatologia e etnografia de Angola. *Anais do Instituto Superior de Agronomia*, **1**: 123-152.
- Anchieta, J., 1885. Traços Geológicos da Africa Occidental Portuguesa. *Boletim Sociedade Geografia Lisboa*, **5**(9): 525-529.
- Antunes, M. T., 1964. O Neocretácico e o Cenozóico do litoral de Angola. Junta de Investigações do Ultramar, Lisboa, 247.
- Brandão, J. M., 2010. O Museu de Geologia Colonial das Comissões Geológicas de Portugal: contexto e memória. *Revista Brasileira de História da Ciência*, **3**(2): 184-199.
- Brandão J. M., Póvoas, L., Lopes, C., 2015. Geologia colonial: o protagonismo do museu da “Politécnica de Lisboa”. *MIDAS* [Online], **5**. <https://doi.org/10.4000/midas.804>.
- Brandão, J. M., Soares, S. M., Brito, S., 2022. Remanescências do Império Português em África. As amostras geológicas de Capelo e Ivens revisitadas (1884-1885). *Comunicações Geológicas*, **108**(1): 35-43. <https://doi.org/10.34637/MWC4-W324>.
- Breure, A. H., Audibert, C., Ablett, J. D., 2018. *Pierre Marie Arthur Morelet (1809-1892) and his contributions to malacology*. Netherlands Malacological Society, Leiden, 544.
- Brotero, F. A., 1804. *Flora Lusitânica*. 2 vols. Typographia Regia, Lisboa, 607 + 557.
- Cabral, J. P. S., 2024. Friederich Welwitsch e a história natural de Portugal e de Angola. *História da Ciência e Ensino*, **29**: 131-156. <http://dx.doi.org/10.23925/2178-2911.2024v29p131-156>.
- Carvalho, A. P., 1859. Viagem do Dr. Frederico Welwitsch ao sertão de Angola. *Arquivo Universal*, **2**(2): 27-28.
- Choffat, P., 1889. Dr. Welwitsch - Quelques notes sur la géologie d'Angola coordonnées et annotées par P. Choffat. *Comunicações da Comissão dos Trabalhos Geológicos*, **2**(1): 27-44.
- Choffat, P., 1886. Sobre os terrenos sedimentares das províncias de Africa e considerações sobre a geologia d'este continente. *Jornal do Commercio*, **9926**, December 31.
- Choffat, P., 1887. Notice préliminaire sur les fossiles recueillis par M. Lourenço Malheiro, dans la province d'Angola. *Bulletin de la Société Géologique de France*, **15**: 154-157.
- Choffat, P., Lorient, P., 1888. Matériaux pour l'étude stratigraphique et paléontologique de la province d'Angola. *Memoires Société de Physique et d'Histoire Naturelle de Genève*, **30**(2).
- Dolezal, H., 1974. *Friedrich Welwitsch: vida e obra*. Junta de Investigações Científicas do Ultramar, Lisboa, 249.
- Edwards, P. I., 1972. Friedrich Welwitsch, 1806-72: his manuscripts and correspondence in the Departments of Botany and Zoology, British Museum (Natural History), the Linnean Society of London and the Royal Botanic Gardens, Kew. *Biological Journal of the Linnean Society*, **4**: 291-303. <https://doi.org/10.1111/j.1095-8312.1972.tb00696.x>.
- Feio, M., 1964. A evolução da escadaria de aplanções do sudoeste de Angola. *Garcia de Orta: Revista da Junta de Investigações do Ultramar*, **12**(2): 323-354.
- Gomes, B. A., 1875. *As collecções da expedição científica africana ordenada pelo Governo de Portugal em 1851 e o direito a ellas perante os tribunales em Londres*. Imprensa Nacional, Lisboa, 37.
- Gomes, J. P., 1915-1916. Notas sobre a disposição das colecções. *Comunicações da Comissão do Serviço Geológico*, **11**: 138-144.
- Hiern, W. P., 1896. *Catalogue of the African plants collected by Dr. Friedrich Welwitsch in 1853-61. Dicotyledons, part I*. British Museum (Natural History), London, 336.
- Huntley, B. J., 2019. Angola, um perfil: fisiografia, clima e padrões de biodiversidade. In: Huntley, B. J., Russo, V., Lages, F., Ferrand N. (Eds.), *Biodiversity of Angola. Science & Conservation: A Modern Synthesis*. Springer Open, 39-73. <https://doi.org/10.1007/978-3-030-03083-4>.
- Jürgens, N., Oncken, I., Oldeland, J., Gunter, F., Rudolph, B., 2021. Welwitschia: Phylogeography of a living fossil, diversified within a desert refuge. *Scientific reports*, **11**: 2385. <https://doi.org/10.1038/s41598-021-81150-6>.
- Laboratório Nacional de Investigação Científica Tropical – LNICT. 1982. Geologia de Angola, 1:1,000,000, sheet 1, Junta de Invest. Cient. do Ultramar, Lisbon, Portugal.
- Lang, J. C., 1886. O petróleo do Dande / 1839 / Relação da Comissão em que foi o Dr. J. C. Lang para o districto do Dande examinar as fontes de petróleo. *Boletim da Sociedade de Geografia de Lisboa*, **4**: 240-249.
- Lenz, O., 1882. Geologische Karte von West-Afrika, nach seinem dem Jahren 1874-1877 und 1879-1881, Unternemen Reisen. *Petermann's Mitteilugen Bd XXVIII*, Heft 2.
- Lima, A. P., 1949. *Correspondência oficial de Welwitsch: Coligida e comentada por Américo Pires de Lima*. Agência Geral das Colónias, Lisboa, 101.
- Martins, J. A., 1962. Notas sobre a Geologia de Angola. Geologia da área de Pungo-Andongo (Angola). *Boletim dos Serviços de Geologia e Minas*, **6**: 5-13.
- Masse, P., Laurent, O., 2016. Geological exploration of Angola from Sumbe to Nabibe: A review at the frontier between geology, natural resources and the history of geology. *Comptes Rendus Geoscience*, **148**: 80-88.
- Mendonça, A., (Comp.) 1945. *Colecção de escritos doutrinários, florísticos e fitogeográficos de Frederico Welwitsch concernentes principalmente à flora de Angola*. Agência Geral das Colónias, Lisboa, 441.
- Monteiro, J. J., 1875. *Angola and the River Congo*, v. II. MacMillan and Co., London, 340.
- Morelet, A., 1845. *Description des mollusques terrestres et fluviatiles du Portugal*. Paris: J.-B. Baillière, Paris, 116. <https://doi.org/10.5962/bhl.title.12994>.
- Morelet, A., 1866. Coquilles nouvelles recueillies par le Dr. Friedrich Welwitsch dans l'Afrique équinoxiale. *Journal de Conchyliologie*, **4**: 153-163.
- Morelet, A., 1868. *Voyage du Dr. Friederich Welwitsch exécuté par ordre du Gouvernement Portugais dans les royaumes d'Angola et de Benguella (Afrique équinoxiale). Mollusques terrestres et fluviatiles*. J.-B. Baillière et Fils, Paris, 102. <https://doi.org/10.5962/bhl.title.12986>.
- Morelet, A., 1887. *Une aventure en Portugal*. Calmann Lévy Éditeur, Paris, 301.
- Silva, R., Pereira, P., 2014. Redescoberta dos equinodermes fósseis das colecções históricas ultramarinas do LNEG. *Comunicações Geológicas*, **101**(III): 1379-1382.
- Solórzano-Kraemer, M., Delclòs, X., Engel, M. S., Peñalver, E., 2020. *A revised definition for copal and its significance for palaeontological and Anthropocene biodiversity-loss studies*. Nature research, Scientific Reports. <https://doi.org/10.1038/s41598-020-76808-6>.
- Trimen, H., 1873. Friedrich Welwitsch. *Journal of Botany*, **11**(2): 1-11.

- Welwitsch, F., 1855 [1945]. Relação das colecções de objectos de História Natural feitas até agora nos distritos de Golungo-Alto, Cazengo e parte do de Ambaca. In: A. Mendonça (Comp.), *Colectânea de escritos doutrinários, florísticos e fitogeográficos de Frederico Welwitsch concernentes principalmente à flora de Angola*. Agência Geral das Colónias. Agência Geral das Colónias, 57-59.
- Welwitsch, F., 1857 [1945]. Informação do Dr Welwitsch, sobre os seus trabalhos, ao Governador Geral de Angola. In: Mendonça, A. (Comp.), *Colectânea de escritos doutrinários, florísticos e fitogeográficos de Frederico Welwitsch concernentes principalmente à flora de Angola*. Agência Geral das Colónias. Agência Geral das Colónias, 77-81.
- Welwitsch, F., 1858 [1945]. Apontamentos fito-geográficos sobre a flora da provincia de Angola na África Equinocial, servindo de relatório preliminar acerca da exploração botânica da mesma provincia, executada por ordem de Sua Majestade Fidelíssima pelo Doutor Frederico Welwitsch. In: Mendonça, A. (Comp.), *Colectânea de escritos doutrinários, florísticos e fitogeográficos de Frederico Welwitsch concernentes principalmente à flora de Angola*. Agência Geral das Colónias. Agência Geral das Colónias, 101-168.
- Welwitsch, F., 1862. *Synopse explicativa das amostras de madeiras e drogas medicinaes e de outros objectos mormente ethnographicos colligidos na provincia de Angola, enviados à exposição internacional de Londres, em 1862, incluindo os que foram offercidos ao Gabinete Pharmacologico da escola Medico-Cirurgica de Lisboa*. Imprensa Nacional, Lisboa, 56.
- Welwitsch, F., 1866 [1945]. Observações acerca da origem e distribuição geográfica da goma copal em Angola, África trópico-ocidental, pelo Dr. Fred. Welwitsch, (lido em 15 de Fevereiro de 1866). In: Mendonça, A. (Comp.), *Colectânea de escritos doutrinários, florísticos e fitogeográficos de Frederico Welwitsch concernentes principalmente à flora de Angola*. Agência Geral das Colónias, 413-436.
- Welwitsch, F., 1868. The Pedras Negras of Pungo Andongo in Angola. *Journal of Travel and Natural History*, 1: 22-36.
- Welwitsch, F., 1869. Sertum Angolense: Sive stirpium quarundam novarum vel minus cognitarum in itinere per Angolam et Benguellam observatarum descriptio iconibus illustrata. *Transactions of the Linnean Society of London*, 27(1): 1-94.

<sup>i</sup> The possibility that the original label has been lost and that this specimen came from Angola should be admitted. It seems to be a Cretaceous “*Nerinea*”.

<sup>ii</sup> The Frenchman (1887: 53) mentions having published his observations in the “*Bulletin de la Société de géologie*”; however, as already mentioned by Breure *et al.* (2018: 15), it has not been found.

<sup>iii</sup> Bernard Cotta's name appears on the list of authors presented by Albuquerque *et al.* (2020), concerning Welwitsch's personal library in London. However, the title of the book is not given.

<sup>iv</sup> Created by Fr Joseph Mayne (1723-1792) within the Academy of Sciences, it was aimed at teaching ‘Theological Natural History’, with the main objective of highlighting the ‘Natural wonders of Creation’ through the study of the three kingdoms of nature (cf. <https://www.acad-ciencias.pt/museu/apresentacao-museu/>).