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Micropalaeontological models of foraminifera by *Reuss & Frič*, from the Natural History and Science Museum of the University of Porto

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Resumo

Em 2015, deu-se início a um grande projeto de requalificação do edifício central do Museu de História Natural e da Ciência da Universidade do Porto (MHNC-UP) que, permitindo um novo olhar sobre as coleções, levou à identificação de espécimes importantes e especiais e com valor histórico, cientifico, didático e expositivo. Com espécimes coletados por geólogos desde o final do século XIX e uma política de aquisição de peças promovida no início do século XX, a coleção de paleontologia ultrapassa os 2300 exemplares. Neste trabalho, pretendemos dar a conhecer os modelos micropaleontológicos de foraminíferos de Reuss & Frič, destacando um conjunto de 98 modelos de gesso de Paris (de um conjunto original de 100 exemplares) do final do séc. XIX. Os modelos são em parte baseados em modelos produzidos originalmente pelo cientista Francês Alcide d'Orbigny (1802–1857). Estas reproduções em 3D permitiram uma representação realista de um imaginário anatómico inacessível a muitos, e devem ser reconhecidas como uma ferramenta de ensino do passado. Mesmo hoje em dia, estes modelos ajudam na perceção destes pequenos animais e podem até mesmo ser usados no contexto de estratégias de ensino, acessível a todo o tipo de indivíduos, incluindo, por exemplo, portadores de deficiência visual. Adicionalmente, do ponto de vista artístico, estes modelos são um testemunho de arte desenvolvida como ferramenta de apoio à divulgação do conhecimento científico.

***Palavras-chave**: MHNC-UP, modelos de Foraminífero, Reuss & Frič*

Abstract

Beginning in 2015, a major redevelopment project in the central building of the Natural History and Science Museum of the University of Porto (MHNC-UP) allowed for a new insight into its heritage collections, leading to the identification of important specimens of historical, scientific and dissemination worth. With specimens collected by geologists since the end of the 19th century and a policy of acquisition promoted in the beginning of the 20th century, the paleontology collection exceeds 2300 specimens. Here we intend to shed some light on the MHNC-UP's micropalaeontological models of foraminifera by Reuss & Frič, which are part of the paleontology collection, highlighting a set of 98 plaster of Paris models (of an original 100 set), from the late 19th century. The models are similar to those made by French scientist Alcide d'Orbigny (1802–1857). These 3D scientific representations enabled a realistic representation of an anatomical imaginary otherwise inaccessible, and should be acknowledged as a teaching tool from the past. Even today, they help to better understand and visualize these small animals and are useful as an aid in teaching strategies, as for blind and visually impaired students. Furthermore, from an artistic viewpoint, these models stand as a testament of artistry developed to help a greater fulfillment of scientific knowledge.

***Key words**: MHNC-UP, foraminifera models, Reuss & Frič*

INTRODUCTION: THE NATURAL HISTORY AND SCIENCE MUSEUM OF THE UNIVERSITY OF PORTO (MHNC-UP) AND IT´S COLLECTIONS

Located in the heart of downtown Porto, the Natural History and Science Museum of the University of Porto (MHNC-UP) houses natural history and science collections of former museums associated to the Faculty of Sciences of the University of Porto, the Archeology Institute and the Polytechnic Academy of Porto, which preceded the University of Porto. Beginning in 2015, a major redevelopment project in the central building of the MHNC-UP, allowed for a new insight into the collections, leading to the identification of important specimens of historical, scientific and dissemination worth. In this context, the collection of paleontology has been the object of requalification to update past inventory, improve packaging, ensure disinfestations and cleansing, provide proper storage and foster general organization, which has allowed the rediscovery of type specimens and the identification of iconic collections.

Currently under expansion, the MHNC-UP's palaeontology collection includes fossils from different ages, as well as replicas and didactic 3D representations/models.

With specimens collected by geologists and with a policy of acquisitions promoted at the end of the 19th and beginning of the 20th century[1], the collection of paleontology now exceeds 2300 specimens. This collection expansion trend in museums is mainly reflected in extensive purchases from private collectors and professional sellers/natural history dealers. This is clear when analyzing the MHNC-UP's collections, in which a major part of specimens from foreign countries result from acquisitions from natural history *comptoirs*, such as the Swiss Comptoir Minéralogique et Géologique Suisse (Geneva, Switzerland). However, most acquisitions, adding up to almost 48% of the total paleontological collection, are from the German comptoir "Mineralien-Geschaft von Krantz" (also known as "Dr. F. Krantz Mineralien-Kontor" or simply referred to as Krantz). Founded by Adam August Krantz (1809-1872), this was one of the most important and oldest geoscience *comptoirs*, and a major supplier of Iberian institutions, such as the Portuguese Geological Survey and the Industrial Institute of Porto[2]. There are also specimens identified as being from Yvonne Willière (1905-1979), whose work, alongside her husband François Stockmans, was

[1] Simão Mateus, "Origens Da Coleção Paleontológica do Museu de História Natural e da Ciência da Universidade Do Porto," *Caderno de Resumos de Simpósio Museus, Investigação E* Educação, a 8 de abril de 2017; Simão Mateus, "A Coleção de Braquiópodes do Museu de História Natural e da Ciência da Universidade Do Porto," *Cominicações Geológicas*, 2017, 104, 1 edition.

[2] Pedro M. Callapez, José B., Ricardo P., Fernando B., Vanda S., Manuel S. "The Krantz Collections of Palaeontology Held at the University of Coimbra (Portugal): A Century of Teaching and Museum Activities," *Historical Biology* 27, no. 8 (2015): 1113–26, https://doi.org/10.1080/08912963.2014.939587.

mainly focused on plant fossils, pollen and acritarchs from Belgium, and was mostly published by the Association pour l'étude de la paléontologie et de la Stratigraphie Houillère (for additional information, please refer to Oldroyd[3]). Other specimens are assigned to Émile Deyrolle (1838-1917), a French naturalist and natural history dealer from Paris[4], identified as *Les fils d'Émile Deyrolle*.

MODELS & REPLICAS

Didactic models and replicas have suffered changes since they were first produced over the past centuries, from primordial techniques ("paper bodies") to contemporary 3D printing (producing solid 3D objects from a digital file). As reported by Callapez[5], the manipulation of biological specimens is still an essential practice and "(...) *it is only in this way that the student can overcome the abstraction inherent to printed images in manuals, or presented by the teacher in the course of a theoretical lesson, as well as different alternative conceptions resulting from it*", allowing for a realistic representation of an anatomic imaginary that, in some cases, would remain inaccessible in the classroom.

When referring to paleontological modeling, the most obvious are 3D skeletal reconstructions (replicas of the bones) present in many of the major natural history museums and science centres all over the world. Some reconstructions can even include soft tissue reconstitution - flesh outs - more frequently used in real-scale thematic parks (models of the animals), but also in some famous museums, such as the true-to-life animatronics model of an *Allosaurus* housed at the dinosaur exhibit of the Natural History Museum of Vienna[6].

As part of the MHNC-UP0s palaeontology collection, there are 26 replicas of both vertebrate and invertebrate animals and 98 didactic foraminifera models.

[3] David Roger Oldroyd, "The Earth inside and out: Some Major Contributions to Geology in the Twentieth Century" (England: Geological Society of London, 2002).
[4] Maria João Mogarro, "Des Objets Qui Racontent Des Histoires: Le Patrimoine Educatif Dans L'internationalisation Des Theories et Des Pratiques Pedagogiques," *La Rivista*, no. 2 (2014): 149–59.
[5] Pedro M. Callapez et al., "A Colecção Clássica de Lenoir & Forster E O Ensino de Paleontologia E Antropologia Na Faculdade de Filosofia Da Universidade de Coimbra," in *Modelação de Sistemas Geológicos: Livro de Homenagem Ao Professor Doutor Manuel Maria Godinho. Coimbra: Laboratório de Radioactividade Natural Da Universidade de Coimbra* (Coimbra: Imprensa da Universidade de Coimbra, 2011), 141–57.
[6] Mathias Harzhauser and Andreas Kroh, "WIEN:'To the Realm of Nature and Its Exploration': The Paleontological Collections of the Natural History Museum Vienna," in *Paleontological Collections of Germany, Austria and Switzerland* (Switzerland: Springer: L. A. Beck and U. Joger, 2018), 513–23.

FORAMINIFERA MODELING

Foraminifera (forams, for short) are single-celled organisms (Protists) with shells or tests (a technical term for internal shells), simple or divided into chambers, that are added during growth; they can be either planktonic or benthonic and most are very small (usually ranging in size from several millimetres to a few tens of microns) and require microscopes for clear observation. They exist today and are present in the fossil record.

The practice of foraminifera modeling was introduced by French scientist Alcide d'Orbigny (1802-1857), who sculpted, in very fine limestone, a set of one hundred (100) 3D models of foraminifera (enlarged 40-200 times), which were later replicated in plaster to be sold[7]. The first set of models is dated from the 1820s[8], and was produced following the desire for more efficient dissemination of his work, and the will to find a way to enable the observation of the specimens without having to resort to a microscope[9]. Later, a set of 100 plaster models from Paris, similar to those of d'Orbigny, was prepared in Prague by Václav Frič (1839–1916), a Czech natural history dealer, who started his business in 1862[10]. Under the guidance of Austrian Professor August Emanuel Ritter von Reuss (1811–1873) and Václav´s older brother, Antonin Frič (1832–1913)[11], the Reuss & Frič models were created and produced in 1861, with some updates in 1865[12].

Over the years, foraminifera models were produced in a variety of materials, such as plastic, wax, glass, sand, granite, limestone, marble, plaster and sandstone[13], and by other natural *comptoirs* or dealers, like Zittel, Pearcey, Chaffer (Flatters and Garnett), Brooks F. Ellis, Kane Scientific, Louis Kornicker, Zach Arnold, John Murray, Geoff Adams and more recently, Dr. Zheng Shouyi, a Chinese scientist responsible

[7] Marie-Thérèse Vénec-Peyré, "Beyond Frontiers and Time: The Scientific and Cultural Heritage of Alcide d'Orbigny (1802–1857)," *Marine Micropaleontology* 50, no. 1–2 (2004): 149–59.
[8] Giles C. Miller, "Micropalaeontological Models at the Natural History Museum, London," *Geological Curator* 7, no. 7 (2002): 263–74; Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi," *Landmarks in Foraminiferal Micropalaeontology: History and Development: The Micropalaeontological Society Special Publications, London, UK* (2013): 337–49.
[9] Edward Heron-Allen, "Presidential Address, 1916–17: Alcide d'Orbigny, His Life and His Work," *Journal of the Royal Microscopical Society* 37, no. 1 (1917): 1–105; Giles C. Miller, "Micropalaeontological Models at the Natural History Museum, London."
[10] Henri Reiling and Tat'jána Spunarová, "Václav Frič (1839–1916) and His Influence on Collecting Natural History," *Journal of the History of Collections* 17, no. 1 (2005): 23–43; Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."
[11] Henri Reiling and Tat'jána Spunarová, "Václav Frič (1839–1916) and His Influence on Collecting Natural History."
[12] Thom. Rupert Jones, *Catalogue of the Fossil Foraminifera in the Collection of the British Museum (Natural History) Cromwell Road, SW: By Thom. Rupert Jones* (order of the Trustees, 1882).
[13] Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."

for encouraging the creation of the world's first foramniferal sculpture park in 2009 - the Zhongshan Sanxiang Foraminiferal Sculpture Park, in Zhongshan City, China[14].

Scientific institutions would acquire foraminifera models[15] for a variety of purposes: to be used as teaching tools, to facilitate classification or simply to be part of museum displays[16]. In Miller[17], a letter dated from 1920 is mentioned; in it, French scientist/dealer Émile Deyrolle offers a quotation on a d'Orbigny foraminifera model set (and individual pricing) to scientist Heron-Allen from the Natural History Museum of London (England), standing as evidence of model trade between scholars.

THE MHNC-UP REUSS & FRIČ FORAMINIFERA MODEL SET

The MHNC-UP foraminifera collection can be divided into three sub-collections: 1) that of the Reuss & Frič models; 2) fossil foraminifera and 3) extant foraminifera specimens studied by Portuguese zoologist, and 3rd rector of the University of Porto, Augusto Nobre (1865-1946). All foraminifera are part of the palaeontology collection and account for different types of preservation supports: glass (foraminifera preserved inside test tubes), rock (fossilizations), cut (specimens prepared and mounted in laminar section) and mounted for teaching purposes (models).

The MHNC-UP's Reuss & Frič collection consists of 98 models. The original labels reveal that the complete set would have been, as expected, of 100 models in total[18]; however, no. 19 and no. 40 are missing (figure 1-4). According to the original lists for the models[19], no. 19 is identified as *" - inflata*" and no. 40 as "*Textilaria conulus*". However, the original identifications do not correspond to those attached to the MHNC-UP specimens, and it is possible that, over time, different versions produced had different specimen-number correspondences. The specimens are representative of several extinct and extant species, and presented in table 1 (last pages of this article).

Made from Plaster of Paris, the models have a glossy and yellowish look and, due to their different shapes have different sizes, with an average of 4 to 6 cm. They are supported by a long wire that is fixed to a black wooden base, to which the labels glued. According to Miller[20], based on the 1978 Frič

[14] Giles C. Miller.
[15] Giles C. Miller, "Micropalaeontological Models at the Natural History Museum, London"; Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."
[16] Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."
[17] Giles C. Miller, "Micropalaeontological Models at the Natural History Museum, London."
[18] Henri Reiling and Tat'jána Spunarová, "Václav Frič (1839–1916) and His Influence on Collecting Natural History"; Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."
[19] Thom. Rupert Jones, *Catalogue of the Fossil Foraminifera in the Collection of the British Museum (Natural History) Cromwell Road, SW: By Thom. Rupert Jones*.
[20] Giles C. Miller, "Micropalaeontological Models at the Natural History Museum, London."

catalogue, this is supposed to be the original way the models were sold. More focused on the wall structure, style of coiling[21] and chamber aperture style or foram (which is painted in black ink on each foraminifera), the models are based on specimens from localities similar to those used by d'Orbigny. Most of them represent Cretaceous foraminifera from the Maastricht area, but also include extant examples from the Philippines and India, thus completing d'Orbigny's collection[22].

Foraminifera models are still a witness to the techniques developed for their production and the value given to the understanding of the natural world, in this particular case, about different anatomies and varieties.

[21] Giles C. Miller.
[22] Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."

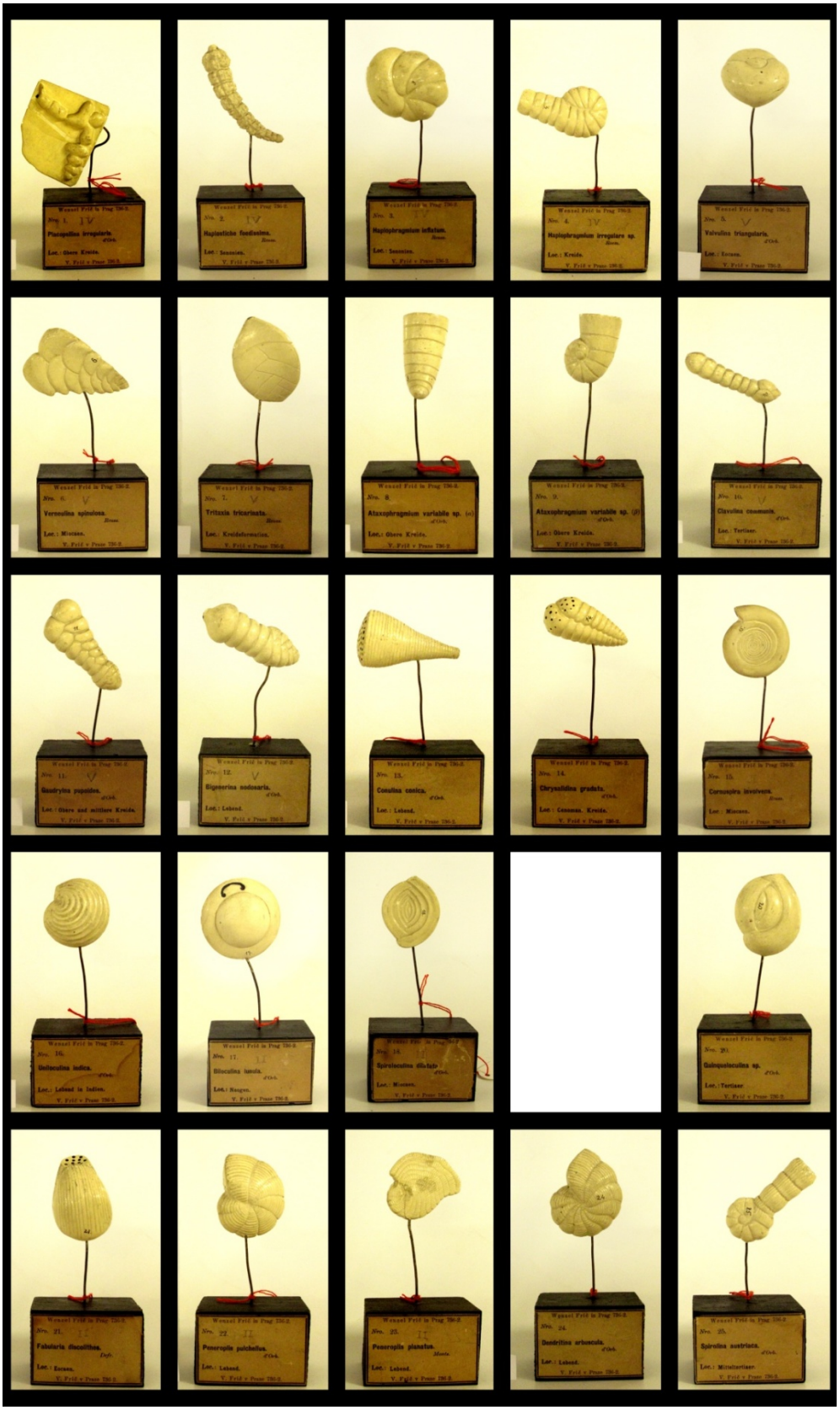

Figure 1: The Reuss & Frič foraminifera model set from the MHNC-UP (specimen nº. 1 to 25), in the original order (from left to right). Please refer to the wooden base of the models for scale, 6 x 4 cm..

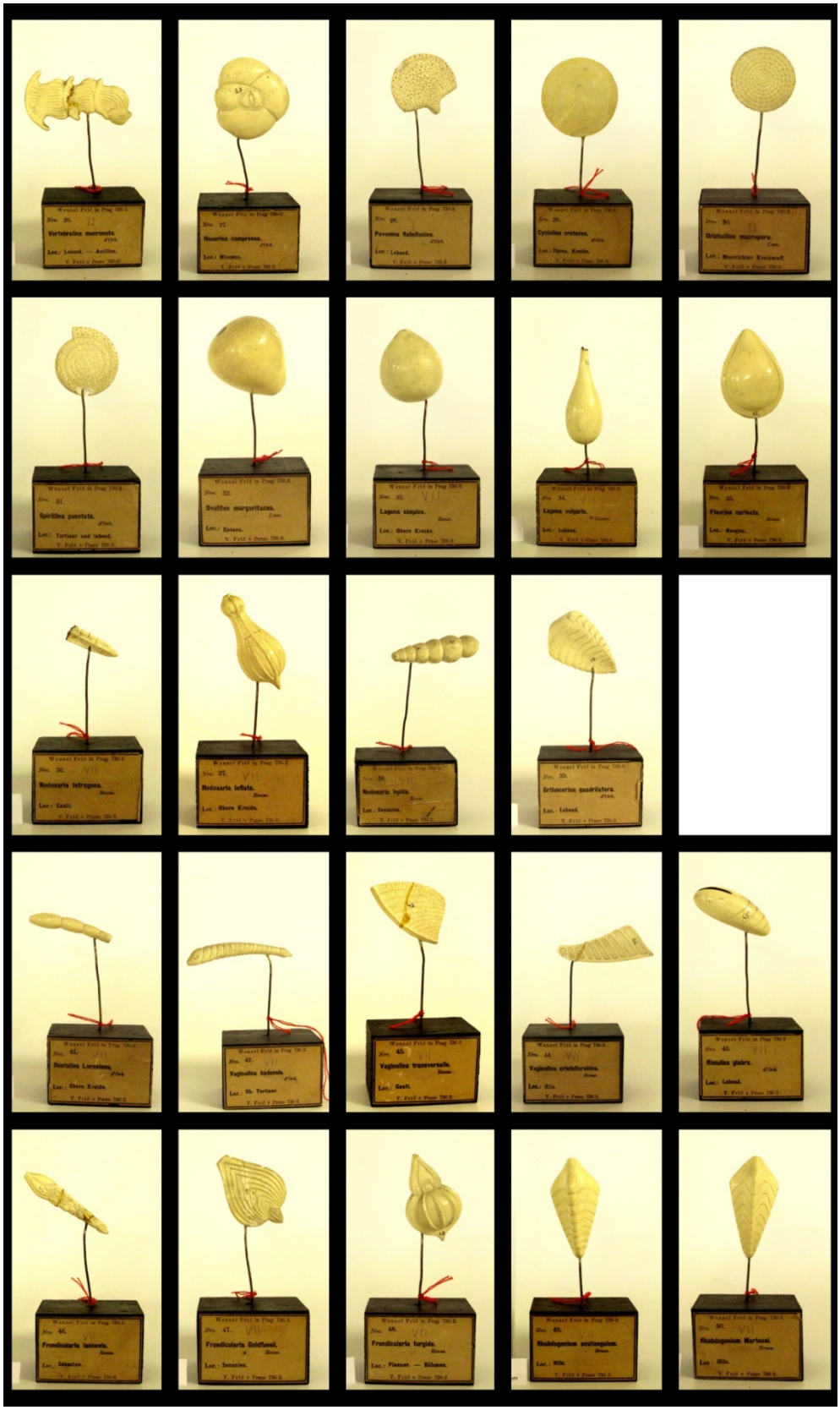

Figure 2: The Reuss & Frič foraminifera model set from the MHNC-UP (specimen nº. 26 to 50), in the original order (from left to right). Please refer to the wooden base of the models for scale, 6 x 4 cm.

Figure 3: The Reuss & Frič foraminifera model set from the MHNC-UP (specimen nº. 51 to 75), in the original order (from left to right). Please refer to the wooden base of the models for scale, 6 x 4 cm.

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Figure 4: The Reuss & Frič foraminifera model set from the MHNC-UP (specimen nº. 76 to 100), in the original order (from left to right). Please refer to the wooden base of the models for scale, 6 x 4 cm.

DISCUSSION AND FINAL CONSIDERATIONS: THE FUTURE OF HISTORICAL MODEL COLLECTIONS: IMPORTANCE, TEACHING, RESEARCH AND DISPLAY

Museums provide knowledge about the past and present and allow to foresee future scenarios, while also assuring the preservation of our collective history. In this context, curatorship stands out as an essential component concerning museum collections. Curatorship can be viewed as the "art" of the triple C´s: Collecting, Cataloging and Conserving, which includes the preservation, organization, study and, when possible, dissemination of the relevance of the collections. When speaking about dissemination, it is important referring to 3D representations as one of the most efficient tools used in education and outreach. Different models or replicas serve different purposes. For instance, some replicas serve as copies of the main specimen. In fossils, replicas of holotype material (holotype is a sample or single specimen that serves as the base reference of the first description and naming of a species of an organism – extant or extinct) are made and sent to various museums for safekeeping, in the event that the original material is destroyed or lost. Other replicas and/or models are used for display purposes only.

In the particular case of foraminifera, these 3D scientific illustrations/representations enabled, for many centuries, a realistic representation of an anatomical imaginary otherwise inaccessible, and should be acknowledged as a teaching tool from the past. Even today, they help to better understand and visualize these small animals and can even be used as an aid in teaching and outreach activities, namely with blind and visually impaired students. However, forams are usually little known by the common citizen, that most of the time, remain unaware of their importance and impact in their daily lives.

These very diverse shelled microorganisms also have an extensive fossil record that dates back to the Cambrian geologic period, making them excellent index fossils and important markers - for specific intervals in geologic time - in biostratigraphy, paleoceanography and paleoclimatology studies. The practical value of foraminifera has led to their application in the fossil fuel industry (oil exploration), which relies on the study and analysis of their morphologies to better explore the sediments and rocks containing this ancient raw material. This has greatly encouraged micropaleontological research[23].

Fossil foraminifera are considered microfossils: fossilized remains that usually require specialized methods of preparation and study (for example, a microscope). The work by Singh[24] reports the association of micropaleontology to oil exploration as being more than a century old, referring the earliest record of its use as the one reported by Josef Gryzbowski of Poland in 1890 on his work in stratigraphic and bed

[23] Marie-Thérèse Vénec-Peyré, "Beyond Frontiers and Time: The Scientific and Cultural Heritage of Alcide d'Orbigny (1802–1857)."
[24] Asheesh Singh, "Micropaleontology in Petroleum Exploration," 2008, 14–16.

correlation. In addition, the work by Schuchert[25], refers to the importance of foraminifera as "small fossils" and their correlation with the occurrence of oil, presenting them as indicators of the viability of oil-well drilling and exploration. Herein, it is also mentioned that the interest in foraminifera as possible guides to underground correlations began in a Dallas meeting led by President Deussen. Moreover, it adds that "as early as 1913, however, Dr. E. T. Dumble had been looking around for someone to make a stratigraphic study of the small fossils found in the Texas Gulf Coastal area, but was not successful", but that the State Geologist Udden of Texas, had, since 1917, been using foraminifera in stratigraphic correlations[26]. However, Vénec-Peyré[27] refers that D´Orbigny had also acknowledged the importance of foraminifera in stratigraphic geology and palaeoenvironmental sciences in his studies.

Therefore, since fossil fuel exploration still has a great impact in modern economy, this could be a good conversation starter when approaching the general public, relying on the aid of the models for a better understanding and bigger visual appeal on the subject. This could be accomplished by, for example, making these foraminifera models part of present and future museum exhibition displays. Also, if we take the extreme example of the Zhongshan Sanxiang Foraminiferal Sculpture Park in China, tourism can be another activity with impact in local economies that can benefit from the striking aesthetics of foraminifera.

Furthermore, from an artistic viewpoint, these models stand as a testament of artistry developed to help a greater fulfillment of the production and dissemination of scientific knowledge, illustrating an example of cooperation between artists and scientists. Having had so many different manufacturers produce foraminifera models, shows a demand for such items at the time. Their importance did not fade over time. Nevertheless, today's popularization and dissemination of 3D printers (using plastic, metal, ceramics, among many other materials), turned the manufacturing of replicas into a completely different process, and one that is available to a much broader audience[28].

As a final remark, from the personal viewpoint of the authors of this article, after attending university-level classes in micropaleontology, it is important to share the notion that models such as those described herein help in a better and easier understanding/perception on the subject and foraminifera identification. The handling and observation of the objects helps to increase the curiosity and interest on the subject and, therefore, its use should be encouraged in classes. For these reasons, foraminifera models as education aids are still as relevant today as they were 100 years ago.

[25] Charles Schuchert, "The Value of Micro-Fossils in Petroleum Exploration," *American Association of Petroleum Geologists (AAPG) Bulletin* 8, no. 5 (1924): 539–53.
[26] Charles Schuchert.
[27] Marie-Thérèse Vénec-Peyré, "Beyond Frontiers and Time: The Scientific and Cultural Heritage of Alcide d'Orbigny (1802–1857)."
[28] Giles C. Miller, "A Brief History of Modeling Foraminifera: From d'Orbigny to Zheng Shouyi."

Through this work, we also intended to add, for future reference, the MHNC-UP to the list of institutions that possess this specific type of model collections.

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Table 1 – List of foraminera models; the specimens names and designations, presented in table 1., are the ones present in the original labels (no additional or updated taxonomical and stratigraphic review was made by the authors).

Number	Specimen	Era, Period, Epoch, Stage/Age	MHNC-UP code/number
1	*Placopsilina irregularis*	Mesozoic, Cretaceous, Upper, , Obere Kreide (chalk)	UP-MHNFCP-156062
2	*Haplostiche foedissima*	Mesozoic, Cretaceous, Upper, Senonien	UP-MHNFCP-156077
3	*Haplophragmium inflatum*	Mesozoic, Cretaceous, Upper, , Senonien	UP-MHNFCP-156060
4	*Haplophragmium irregulare*	Mesozoic, Cretaceous, , ,	UP-MHNFCP-156068
5	*Valvulina triangularis*	Cenozoic, Paleogene, Eocene, ,	UP-MHNFCP-156094
6	*Verneulina spinulosa*	Cenozoic, Neogene, Miocene, ,	UP-MHNFCP-156096

7	*Tritaxia tricarinata*	Mesozoic, Cretaceous, , , Kreideformation	UP-MHNFCP-156085
8	*Ataxophragmium variabile*	Mesozoic, Cretaceous, Upper	UP-MHNFCP-156114
9	*Ataxophragmium variabile*	Mesozoic, Cretaceous, Upper	UP-MHNFCP-156058
10	*Clavulina communis*	Cenozóico, , , , Tertiaer	UP-MHNFCP-156055
11	*Gaudryina pupoides*	Cenozoic, Quaternary, Holocene, , extant but with fossil record since the Cretaceous	UP-MHNFCP-156082
12	*Bigenerina nodosaria*	Cenozoic, Quaternary, Holocene, , Extante	UP-MHNFCP-156049
13	*Conulina conica*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156091
14	*Chrysalidina gradata*	Mesozoic, Cretaceous, Upper, Cenomanian,	UP-MHNFCP-156064
15	*Cornuspira involvens*	Cenozoic, Neogene, Miocene, ,	UP-MHNFCP-156117
16	*Uniloculina indica*	Cenozoic, Quaternary, Holocénico, , Lebend in Indien	UP-MHNFCP-156120
17	*Biloculina lunula*	Cenozoic, Neogene, , ,	UP-MHNFCP-156041
18	*Spiroloculina dilatata*	Cenozoic, Neogene, Miocene, ,	UP-MHNFCP-156046
19			
20	*Quinqueloculina sp.*	Cenozoic, , , , Tertiiaer	UP-MHNFCP-156066
21	*Fabularia discolithes*	Cenozoic, Paleogene, Eocene, ,	UP-MHNFCP-156105
22	*Peneroplis pulchellus*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156073
23	*Peneroplis planatus*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156109
24	*Dendritina arbuscula*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156059
25	*Spirolina austriaca*	Cenozoic, , , , Mitteltertiaer	UP-MHNFCP-156110
26	*Vertebralina mucronata*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156047
27	*Hauerina compressa*	Cenozoic, Neogene, Miocene, ,	UP-MHNFCP-156069
28	*Pavonina flabelloides*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156088
29	*Cyclolina cretacea*	Mesozoic, Cretaceous, Upper, Turoniano,	UP-MHNFCP-156086
30	*Orbitulites macropora*	Mesozoic, Cretaceous, , , Mastrichter kreidetuff	UP-MHNFCP-156116
31	*Spirillina punctata*	Cenozoic, Quaternary, Holocene, , extant but with fóssil record since the Tertiary	UP-MHNFCP-156067
32	*Ovulites margaritacea*	Cenozoic, Paleogene, Eocénico, ,	UP-MHNFCP-156053
33	*Lagena simplex*	Mesozoic, Cretaceous, Upper, , Obere Kreide	UP-MHNFCP-156102

34	*Lagena vulgaris*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156056
35	*Fisurina carinata*	Cenozoic, Neogene	UP-MHNFCP-156112
36	*Nodosaria tetragona*	Mesozoic, Cretaceous, , , Gault	UP-MHNFCP-156054
37	*Nodosaria inflata*	Mesozoic, Cretaceous, Upper	UP-MHNFCP-156045
38	*Nodosaria lepida*	Mesozoic, Cretaceous, Upper, , Senonien	UP-MHNFCP-156035
39	*Orthocerina quadrilatera*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156032
40			
41	*Dentalina lorneiana*	Mesozoic, Cretaceous, Upper, ,	UP-MHNFCP-156040
42	*Vaginulina badensis*	Cenozoic, Neogene, , , Ob. Tertiaer	UP-MHNFCP-156031
43	*Vaginulina transversalis*	Mesozoic, Cretaceous, , , Gault	UP-MHNFCP-156042
44	*Vaginulina cristellaroides*	, , , , Hils.	UP-MHNFCP-156050
45	*Rimulina glabra*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156121
46	*Frondicularia lanceola*	Mesozoic, Cretaceous, Upper, , Senonien	UP-MHNFCP-156071
47	*Frondicularia goldfussii*	Mesozoic, Cretaceous, Upper, , Senonien	UP-MHNFCP-156115
48	*Frondicularia turgida*	, , , , Plaener - Böhmen	UP-MHNFCP-156106
49	*Rhabdogonium acutangulum*	, , , , Hils	UP-MHNFCP-156092
50	*Rhabdogonium martensi*	, , , , Hils	UP-MHNFCP-156075
51	*Amphimorphina haueri*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156070
52	*Dentalinopsis semitriquetra*	, , , , Hils	UP-MHNFCP-156122
53	*Flabellina oblonga*	Cenozoic, Paleogene, Oligocene	UP-MHNFCP-156079
54	*Flabellina cordata*	Mesozoic, Cretaceous, Upper, , Obere Kreide	UP-MHNFCP-156104
55	*Psecadium ellipticum*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156030
56	*Lingulina costata*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156093
57	*Lingulinopsis bohemica*	, , , , Plaener	UP-MHNFCP-156080
58	*Pleurostomella fusiformis*	Mesozoic, Cretaceous, , , Gault	UP-MHNFCP-156033
59	*Marginulina ensis*	Mesozoic, Cretaceous, Upper	UP-MHNFCP-156038
60	*Marginulina bullata*	Mesozoic, Cretaceous, Upper	UP-MHNFCP-156113

61	*Cristellaria josepnina*	Cenozoic, , , , Mitteltertiaer. Wiener Becken	UP-MHNFCP-156111
62	*Cristellaria rotulata*	Mesozoic, Cretaceous, , , Kreideformation	UP-MHNFCP-156063
63	*Robulina deformis*	Cenozoic, Paleogene, Oligocene	UP-MHNFCP-156087
64	*Bulimina pupoides*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156043
65	*Virgulina pertusa*	Cenozoic, Neogene	UP-MHNFCP-156036
66	*Uvigerina pygmaea*	Cenozóico, , , , Tertiaer	UP-MHNFCP-156078
67	*Polymorphina complanata*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156039
68	*Pyrulina gutta*	Cenozoic, , , , Tertiaer	UP-MHNFCP-156028
69	*Globulina aequalis*	Cenozoic, Neogene, , , Obertertiaer	UP-MHNFCP-156099
70	*Guttulina austriaca*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156098
71	*Sphaeroidina austriaca*	Cenozoic, Neogene	UP-MHNFCP-156100
72	*Dimorphina obliqua*	Cenozoic, , , , Tertiaer	UP-MHNFCP-156090
73	*Chilostomella ovoidea*	Cenozoic, Paleogene, Oligocene	UP-MHNFCP-156076
74	*Allomorphina cretacea*	Mesozoic, Cretaceous, Upper, , Senonien	UP-MHNFCP-156097
75	*Textillaria conulus*	Mesozoic, Cretaceous, Upper, , Obere Kreide	UP-MHNFCP-156118
76	*Proroporus complanatus*	Mesozoic, Cretaceous, , , Gault	UP-MHNFCP-156107
77	*Sagraina pulchella*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156108
78	*Vulvulina gramen*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156074
79	*Bolivina beyrichi*	Cenozoic, Paleogene, Oligocene	UP-MHNFCP-156051
80	*Schizophora neugeboreni*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156026
81	*Cassidulina crassa*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156057
82	*Ehrenbergina serrata*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156081
83	*Rotalia brongniarti*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156065
84	*Rotalia girardana*	Cenozoic, Paleogene, Oligocene	UP-MHNFCP-156034
85	*Rotalia bulimoides*	Cenozoic, Paleogene, Oligocene	UP-MHNFCP-156101
86	*Siphonina reticulata*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156061
87	*Asterigerina planorbis*	Cenozoic, Neogene	UP-MHNFCP-156029
88	*Siderolithes calcitrapoides*	Mesozoic, Cretaceous, , , Kreidetuff von Mastricht	UP-MHNFCP-156095
89	*Siderolithes*	Mesozoic, Cretaceous, , , Kreidetuff von	UP-MHNFCP-156027

	calcitrapoides	Mastricht	
90	*Planorbulina mediterranea*	Cenozoic, Quaternary, Holocene, , Extante	UP-MHNFCP-156037
91	*Globigerina bulloides*	Cenozoic, , , , Tertiaer	UP-MHNFCP-156072
92	*Orbulina universa*	Cenozoic, Quaternary, Holocene, , extant, but with fossil record since the Tertiary	UP-MHNFCP-156025
93	*Polystomella aculeata*	Cenozoic, Quaternary, Holocene, , extant, but with fossil record since the Tertiary	UP-MHNFCP-156083
94	*Nonionima communis*	Cenozoic, , , , Tertiaer	UP-MHNFCP-156044
95	*Nonionima bulloides*	Cenozoic, Quaternary, Holocene, , extant but with fossil record since the Neogene	UP-MHNFCP-156084
96	*Fusulina cylindrica*	Paleozoic, Carboniferous, Mississippian, Lower, Kohlenkalk	UP-MHNFCP-156052
97	*Amphistegina quoyi*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156048
98	*Operculina sp.*	Cenozoic, Quaternary, Holocene, , Lebend v.d. Philippinem	UP-MHNFCP-156119
99	*Heterostegina sp.*	Cenozoic, Quaternary, Holocene, , Extant	UP-MHNFCP-156089
100	*Heterostegina costata*	Cenozoic, Neogene, Miocene	UP-MHNFCP-156103