The Natural History Museum Fossil Porifera Collection

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Abstract:	This is the status update on the Porifera Collection at The Natural History Museum, London. There is still very little information available regarding fossil sponge digitisation or any similar initiative, with molluscs being the main goal of digitisation worldwide. This paper covers the type and figured specimens and drawer label content data of the Porifera Collection and also describes the collection and its research potential. With approximately 71,000 specimens at the NHM, of which more than 60 % are Mesozoic, this is the best Mesozoic sponge collection in the world and one of the most important. It covers all stratigraphic periods and all taxonomic groups and includes almost 3000 cited and figured specimens including types. Although most of the specimens come from the British Isles, there are also worldwide samples, with abundant specimens from other Commonwealth countries and from Antarctica.

The Natural History Museum Fossil Porifera Collection

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ABSTRACT - This is the status update on the Porifera Collection at The Natural History Museum, London. There is still very little information available regarding fossil sponge digitisation or any similar initiative, with molluscs being the main goal of digitisation worldwide. This paper covers the type and figured specimens and drawer label content data of the Porifera Collection and also describes the collection and its research potential. With approximately 71,000 specimens at the NHM, of which more than 60 % are Mesozoic, this is the best Mesozoic sponge collection in the world and one of the most important. It covers all stratigraphic periods and all taxonomic groups and includes almost 3000 cited and figured specimens including types. Although most of the specimens come from the British Isles, there are also worldwide samples, with abundant specimens from other Commonwealth countries and from Antarctica.

INTRODUCTION

Historically sponges were studied by their external form and growth habit, until this method was proved to be unreliable. Hinde, a leading authority on fossil sponges in the 19th century, published in 1883 the catalogue of fossil sponges of the Geological Department of the British Museum (Natural History), now the Natural History Museum (NHM), classifying sponges according to their microscopic structure, this collection being one of the first to be studied in this way. This allowed Hinde to confirm the indisputable resemblance between fossil calcareous

sponges and living ones. Hinde's catalogue condensed descriptions of mainly fossil British species and also new species from France, Switzerland, and Germany, all accompanied with figures. 185 specimens (with types) of all groups were described and figured in this monograph, including his own Hinde Collection and other collections such as those of William Smith, "The Father of English Geology," Toulmin Smith, Mantell, Phillips, Miss Benett, Bowerbank, and Cunnington.

The Hinde Collection includes the vast slide collection that Hinde prepared to describe sponge species. This collection was transferred to the NHM in several batches (1878, 1892, 1903, 1918) by Hinde and after his death by his widow. Other specimens come from other researchers such as the zoologist Tomes who in 1894 presented the calcisponges that Hinde (1893) described from the English Inferior Oolite.

Other important fossil sponges were presented to the NHM by Benett, from the Upper Greensand of Warminster, and by William Smith whose collection of British fossil sponges illustrated in his *Strata Identified by Organized Fossils* was purchased by the NHM in 1816. Benett (1831) listed forty-seven species and 'varieties' of sponges, all without descriptions but with good illustrations and also using taxonomic names which were respected by Hinde (1883). Phillips (1829, 1835), in *Illustrations of the Geology of Yorkshire*, listed sixteen species of sponges from the White Chalk (Senonian) of Danes Dyke in Yorkshire that Hinde (1883) grouped into ten species. Although Phillips did not describe these species and gave poor quality illustrations, Hinde (1883) had the opportunity to study the types, described them and credited Phillips as the species author as he did with Benett. Other sponges in the NHM Collection are those of the geologist Lee from the Yorkshire Chalk which were presented to the Museum in 1885, sponges with which Lee described eight new species in 1839.

Additional sponges were figured by Parkinson in his *Organic Remains of a Former World* (1808); some of them came to the Museum from other collections and form part of the Porifera Collection, such as the iconic specimen that Parkinson (1808) figured on the frontispiece of the second volume, *Chenendopora michelini*; he identified the specimen as *Alcyonium*. Mantell was one of the fossil collectors who attended the Parkinson sale of 1827 and presumably bought some of the Parkinson sponges (Cleevely, 1983). The Mantell Collection arrived in two batches (1839, 1853) with the sponges published and mostly figured in 1815, 1822, 1848 and 1854 (see

Table 1 and references). In his publications, he already recognised that external form was not reliable for sponge identification. The Toulmin Smith Porifera Collection was also housed at the NHM from 1869; these are the British Cretaceous specimens that Toulmin Smith described in 1847 (a-b) and 1848(a-e). Toulmin Smith advanced the knowledge of sponges and wrote noting differences in the tissues and network meshes under the microscope, but he did not use these differences for taxonomic identification. Later, the British geologist Sollas described the fossil sponges collected on the Challenger Expedition (Sollas, 1888) through their microstructure with the use of thin sections and also described the British Jurassic and Cretaceous sponges (Sollas, 1877, 1883). The former specimens, from the Challenger Expedition, are kept in the Department of Life Sciences at the NHM.

Treacher presented part of his collection from the Faringdon Sponge Gravels and other British Cretaceous localities between 1907 and 1921 and Pulfrey presented his collection of sponge spicules from the Lower Palaeozoic of North Wales in 1933.

Minor collections, in terms of number of sponge specimens, are those of Bowerbank, which was acquired at a sale in 1865, after his retirement, and the Morris Collection which was acquired in two batches (1863, 1867). There are also sponges collected by the Welsh naturalist Thomas Pennant.

Regarding their shapes and dimensions, this NHM Fossil Collection presents a great diversity, with forms such as cups, funnels, vases, cylindrical, club-shaped, fan-shaped, and branching examples. One of the smallest specimens belongs to the calcareous *Peronella* which measures 5.5 mm in length by 4 mm in width, whilst the largest is a demospongea, belonging to *Chenendopora*, with 400 mm long and 200 mm wide.

The NHM Porifera Collection contains almost 3000 referenced individuals as hand specimens and thin sections. From these, more than 2000 are figured and the rest are cited in more than 140 bibliographic references (see Fig. 1 and Appendix).

FIGURE 1

Very few specimens of this Collection have been fully digitised (less than 2%) on our NHM collection management system, but a Microsoft Excel database of 752 entries has been populated, with drawer label content that has been used to help write this article. The data

recorded includes taxa, geographic site and stratigraphic locations of the specimens, with some labels also showing the donor collection. Most of the specimens have been assigned stub records in the NHM collection management system, Emu (blinded, 2009), that are linked to images from the catalogue books where the specimen registration number is recorded with taxon, geographic and stratigraphic information and acquisition details. The results shown here are based on the drawer label data concerning hand specimen and slide cabinets. In order to estimate the most accurate proportions, the specimen size has been considered. The number of specimens has been determined by counting how many specimens a drawer contains and this figure was multiplied by the entire number of drawers for each Porifera class (for hand specimen and slide cabinets). Drawers containing larger than standard-sized specimens were counted separately. Total data and percentages were estimated using Microsoft Excel. This is the first time that the drawer label content has been used to show the collection rough data and also that a complete museum fossil sponge database has been shown. This is a useful starting point for collections still not completely digitised and a good method to allow online accessibility of what museums keep in their collection. It helps with gathering taxonomic, geographic and stratigraphic data of the collection that can be used in research and curation fields such as biogeography and also highlights gaps in the collections for each group. This is a good basis for a more comprehensive database as an important source for understanding Porifera biodiversity.

FOSSIL PORIFERA COLLECTIONS ELSEWHERE

Although Hinde (1887, 1888) studied the British and German Palaeozoic sponges, many of those specimens kept at the NHM, there are other historically important German Palaeozoic collections which could compete with the NHM Collection. Among these are those studied by Hermann Rauff at the Göttingen Geoscience Museum and at the Naturkunde, Rudolf Kolb at the Palaeontological Museum of Munich, and Schrammen mainly at the Roemer Museum in Hildesheim and also at the American Museum of Natural History in New York. It is also important to cite the Bohemian Palaeozoic sponges studied by the zoologists and palaeontologists Antonín Jan Frič (who also published as Anton Fritsch) and Filip Počta (also published as Phillip Počta) in Bohemia.

With regards to Mesozoic sponges there is no collection that can compete with that of the NHM. Frič, Počta, Kolb and Schrammen created and described Mesozoic collections (O'Connell,

1919), and some of these were purchased by the NHM, such as the Cretaceous Porifera Collection from both Počta (Počta, 1907) in 1909 and Schrammen in 1920 (Cleevely, 1983). Therefore, these collections are surpassed by the NHM Fossil Porifera Collection which is also cited by these authors. The NHM keeps numerous types and figured specimens that are key to taxonomic identification, including not only hand specimens, but also thin sections and cavity slides (see some of the most striking NHM fossil sponges of this Collection in Fig. 2). The thin sections make the NHM Fossil Porifera Collection unique as they come from historical specimens, for which justification for destructive sampling for preparation of specimens would now be difficult, and in the specific case of the siliceous samples would be expensive to prepare as well as problematic.

FIGURE 2

SPECIMEN PRESERVATION METHOD

This NHM Collection constitutes mainly fossil specimens that are kept as hand specimens (88%) and thin sections (12%). The Recent specimens (0.2%) are preserved as dried specimens. The sponges are stored within the collection cabinets. Each cabinet holds drawers that store individual specimens from the same family, geographic location (region or country) and stratum.

There are almost 8000 thin sections, of which more than half are of stromatoporoids, and the rest are represented in the same proportions as the hand specimens. Therefore, the taxonomic representation of these thin sections in descending order is as follows: demosponges, hexactinellids, calcareous sponges and archaeocyaths. Most of these are historical specimens, prepared by Nicholson and Hinde. These thin sections are fundamental for viewing morphology and the internal microstructures required to meet criteria for taxonomic identification.

TAXONOMIC COVERAGE

The NHM Fossil Porifera Collection covers most of the Porifera groups such as demosponges, hexactinellids, calcareous sponges, archaeocyaths and stromatoporoids. The class Demospongea is the most represented in the NHM Collection, including the polyphyletic lithistid group of massive skeletons which are easily preserved in the geological record. These reached their greatest dominance during the Cretaceous. The NHM has the most important collection of

Cretaceous sponges in the world, with hundreds of non-lithistid demosponges and more than 10,000 lithistids, mostly from Europe and North America. These are useful in unveiling the diverging silicification levels over time. This class is represented from the Palaeozoic to Cenozoic eras (Fig. 3) and includes almost half of the total number of the sponges in the Collection.

FIGURE 3

Hexactinellids are siliceous sponges that also range in time, as do the demosponges, from the Cambrian to Recent. They have been found living in both cold deep and warm shallow waters and have been defined as the oldest lineage of animals alive on earth today. The NHM Porifera Collection has almost a quarter of fossils of this group (Fig. 3), mainly from the Mesozoic of Europe.

Calcareous sponges have skeletons with spicules of calcium carbonate and have persisted, as the previous groups, from Cambrian to Recent times, having their greatest diversification during the Cretaceous. Their Mesozoic representation stands out in the NHM Porifera Collection and represents the third biggest group of sponges. Most of them are from Europe, but there are representatives from Asia, South America and the Middle East as well. The calcareous sponges represent 10 % of specimens of the entire Collection (Fig. 3).

The other classes are hypercalcified sponges, the stromatoporoids and the archaeocyaths. The Stromatoporoidea, an extinct class of non-spiculate poriferans, are very well represented (Fig. 3). They appeared for first time in the Middle Ordovician and became abundant and widespread through the Silurian and Devonian, until finally disappearing in the Cretaceous. The NHM Porifera Collection has more than 15000 specimens, including thin sections, and contains the most outstanding Silurian specimens such as the historical Nicholson Collection (1885-1892) of British stromatoporoids. Archaeocyaths characterize the first substantial diversification of the phylum Porifera, to which they are now generally assigned as a distinct class. They flourished in carbonate shelf and reef environments of the early Cambrian and a depauperate stock persisted into the late Cambrian. The Archaeocytha Collection at the NHM contains more than 700 specimens, mainly from Antarctica, Australia, Canada, Morocco, Sardinia, Siberia, Spain and USA. This is one of the most important Archaeocyatha Collections in the world, including a mixture of over 100 cavity slides and thin sections. About a hundred type and figured

specimens are present among these specimens (such as in Hill, 1965 and Debrenne, 1969). They represent 1% of the Collection (Fig. 3).

More than 4% of the NHM Collection, 3000 individuals, have been cited and figured, including types that are key to taxonomic identification studies and should be the main goal of digitisation regarding marine palaeofauna.

STRATIGRAPHIC COVERAGE

Stratigraphically, the NHM Fossil Porifera Collection is represented by specimens from the Cambrian to Pleistocene, but is particularly rich in Mesozoic and Palaeozoic (Fig. 3) sponges. The reason for this is explained by the localities from where they were collected, a large proportion originating from the British Isles.

The fossil demosponges are mainly Mesozoic specimens (79%), followed by Palaeozoic (20%) and Ceinozoic (1%). Fossil calcareous specimens are represented by Mesozoic (86%), Cainozoic (9%), Recent (3%) and Palaeozoic (2%). Fossil hexactinellids are mostly Mesozoic (98%) and a small proportion Palaeozoic.

As noted above, archaeocyaths are Cambrian (100%), therefore Palaeozoic. Stromatoporoids are mainly Palaeozoic (77%) and in less proportion Mesozoic (23%).

GEOGRAPHIC COVERAGE

Although the distribution of this Collection is worldwide, it is mainly European (80%). There is the same trend in most of the groups, with the exception of archaeocyaths. The majority of the collection is from the British Isles (61%) followed by European continental (18%). There are also abundant specimens from the Commonwealth countries (9%) and Antarctica (less than 1%).

If we study geographic origin by class, most of the demosponges are from the British Isles (62%), the European continent (25%) and in much less proportion from North America, the Arctic, Oceania, Middle East, Russia, Africa, Caribbean, Asia and South America (Fig. 4).

FIGURE 4

The hexactinellids are also mainly from the British Isles (66%), followed by European continental (24%) and North America, Oceania, Middle East, Russia, Africa Caribbean, and Asia.

The NHM fossil calcareous sponges follow similar proportions: British Isles (70%), European continental (12%), Asia (4%) and the other regions have similar number of specimens (North America, South America, Oceania, Middle East, Russia, Africa and Caribbean).

In the case of the stromatoporoids are also mainly from the British Isles (63%) followed, this time, by Middle East specimens (12%), Europe non-British (10%), North America (6%) and the rest from Oceania, Russia, Africa and Oceania. The archaeocyaths are mainly from Oceania (63%), Antarctica (25%) and in much less proportion from Europe, North America, Russia and Africa.

POTENTIAL RESEARCH PROJECTS

Sponges are the oldest known metazoan group with an outstanding importance as both a living fossil and the closest related to the hypothetical ancestor of all metazoans, the Urmetazoa (Thakur & Müller, 2004). Currently their importance is also economic, being used for treating skin conditions and diseases, with, for instance, some compounds derived from *Spongilla* species. The three living fossil sponge classes, Hexactinellida, Demospongiae and Calcaera, are currently being used in molecular biological studies and this data could be extrapolated to fossil taxa by molecular clock technique. This Collection keeps approximately 8000 thin sections and cavity slides that will save time in preparing the specimens for taxonomic studies, as well as for climate change research and functional morphology studies. Some of the samples come from sites that are currently difficult to access, such as in the Middle East. They will also be useful in revealing the biodiversity of fossil sponges and their role as reef builders in Palaeozoic and Mesozoic times.

The study of this comprehensive collection will help to fill the gaps in our knowledge of the evolution of fossil faunas and for study of their phylogenetics. In the case of lithistids, a better understanding is needed of the diagnostic biological characters that are potentially best preserved to separate apomorphies and synapomorphies in order to distinguish subgroups and integrate them in phylogenetic studies.

Additionally, the study of the rocks associated with the specimens will disclose the paleoenvironmental conditions that favoured silicification and calcification processes. These conditions are considered to be very different from those of extant taxa (Pisera, 2004), with fossil lithistids and hexactinellids with fused siliceous skeletons inhabiting shallower waters. Current fossil sponge silica research opens a door to better understanding the evolution of the group and their relevance to climate change.

Finally, new resources and tools such as 3-D reconstructions (Luo & Reitner, 2014), CT Scanning and Big Data are revolutionizing sponge biology as sponge microstructure did in Victorian times with taxonomic studies of Porifera.

CONCLUSION

This large NHM Mesozoic Porifera Collection has approximately 71000 individuals and 4% of the collection cited and figured in bibliographical references. It is key to Porifera taxonomic identification and having historical thin sections associated with the hand specimens makes this Collection unique. This article is a first step in the digitization of this Collection and is an example of how the data populated from the drawer label content can be used to show the collection's content. The data recorded includes taxa, geographic site and strata where the specimens come from and some of the labels also named the donor collection. This is also the first time that a museum fossil sponge database has been shown.

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FIGURES & CAPTIONS

Figure 1. Number of bibliographic references by year group regarding the NHM sponges kept in the Department of Earth Sciences.

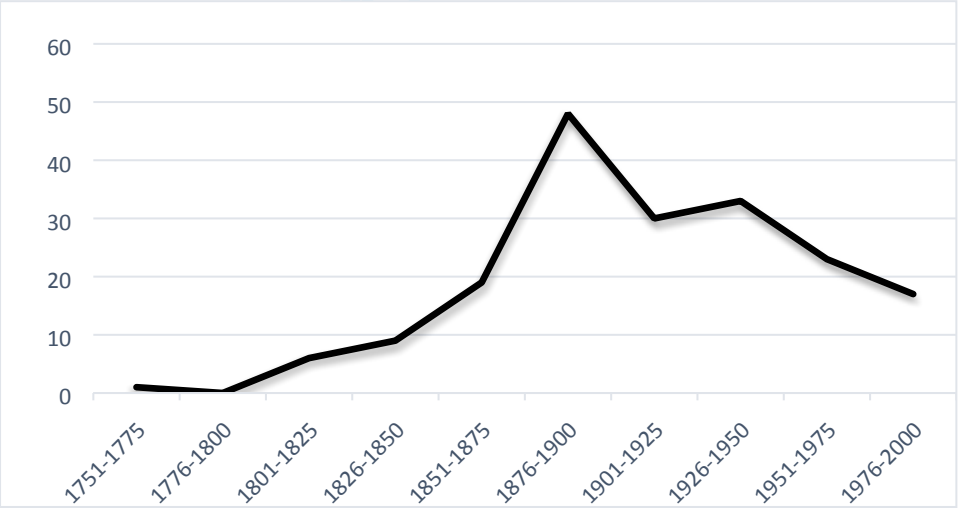


Figure 2. A. NHMUK PI H3062. *Actinostroma stellulatum* Nicholson, 1889. HOLOTYPE. Middle Devonian. Newton Abbot, England. B. NHMUK PI S7856. *Sporadoscinia* Pomel, 1872. Chalk Group. Foreshore, Dover, England. C. NHMUK PI P5877. *Stromatopora hupschii* (Bargatzky, 1881). Middle Devonian. Dartington, England. D. NHMUK PI P1240. *Stachyspongia spica* (Roemer, 1864). Late Cretaceous, Cenomanian. Chalk Group. Dover, England, Kent. E. NHMUK PI PO 12121 (or ZN7). *Lerouxia digitata* Pisera, 2000. HOLOTYPE. Oligocene. Ukraine. F. NHMUK PI S4566. *Siphonia koenigi* (Mantell, 1822). Chalk Group. Seaford Head, Sussex, England. G. NHMUK PI S4549. *Verruculina reussii* (M'Coy, 1848). Chalk Group. Flamborough, Yorkshire, England. H. NHMUK PI S4730 and NHMUK PI S

4731. a. *Loculicyathellus floreus* (Bedford & Bedford, 1934). PARATYPE. b. *Diplocyathellus retezona* (Taylor, 1910). Cambrian, Terreneuvian. Flinders Range, South Australia. I. NHMUK PI S2659. *Theneopsis steinmanni* (Zittel, 1879). Late Cretaceous (Senonian). Misburg, Region Hanover, Germany. A. Schrammen Collection (1920). J. NHMUK PI P7965a. Necklace made with *Porosphaera globularis* (Phillips, 1829). Chalk Group. France? K. NHMUK PI P3280. *Tremacystia anastomans* Mantell, 1848. Lower Greensand Group. Faringdon, England. L. NHMUK PI P3185. *Pharetrospongia strahani* Sollas, 1877. Chalk Group. Kent, England. M. NHMUK PI OR48174. *Hallirhoa costata* Lamouroux, 1821. Selborne Group, Upper Greensand Formation. Warminster, Wiltshire, England. N. NHMUK PI P3227. *Exanthesis labrosus* (Smith, 1848). Selborne Group, Upper Greensand Formation. France. O. NHMUK PI S3115. *Exanthesis labrosus* (Smith, 1848). Chalk Group. Hanover, Germany. Original skeleton of opaline silica replaced by pyrites (iron sulphide) which has subsequently recrystallized. P. NHMUK PI P3444a. *Diaplectia helvelloides* (Lamouroux, 1821). Bathonian. Great Oolite Group. Ranville, Basse-Normandie, Calvados, France. Q. NHMUK PI S4599. *Coeloptychium agaricoides* Goldfuss, 1826. Late Cretaceous, Senonian. Coesfeld, Westfalia, Germany. R. NHMUK PI S4599. *Coeloptychium agaricoides* Goldfuss, 1826. Late Cretaceous, Senonian. Coesfeld, Westfalia, Germany. S. NHMUK PI P1370a. *Siphonia tulipa* Zittel, 1878. Late Cretaceous, Cenomanian. Selborne Group, Upper Greensand Formation. Blackdown, Devon, England. T. NHMUK PI P3066. *Pachastrella convoluta* Hinde, 1883. SYNTYPE. Chalk Group. Flamborough, Yorkshire, England. U. NHMUK PI S2140. *Cyclostigma meandrina* Schramen, 1912. HEAUTOTYPE. Late Cretaceous, Campanian. Oberg, Hanover, Germany. V. NHMUK PI P4116. *Elasmostoma scitulum* Hinde, 1883. Chalk Group. Charing, Kent, England. W. NHMUK PI P1829. *Hydnoceras tuberosum* Conrad, 1842. Devonian. Chemung Group. Cohocton, New York, United States.

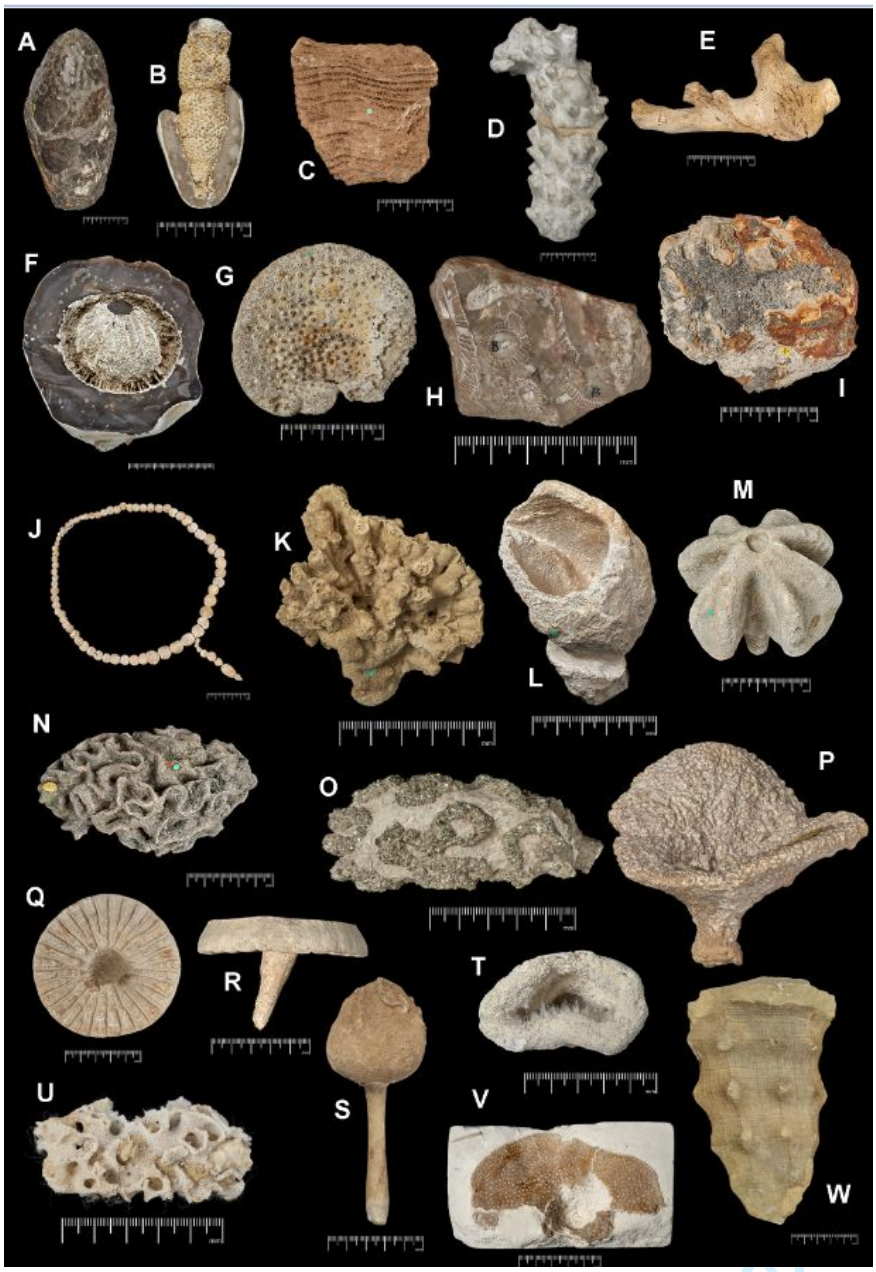


Figure 3. Number of specimens per stratigraphic era and Porifera classes present in the Earth Sciences Department at the NHM.

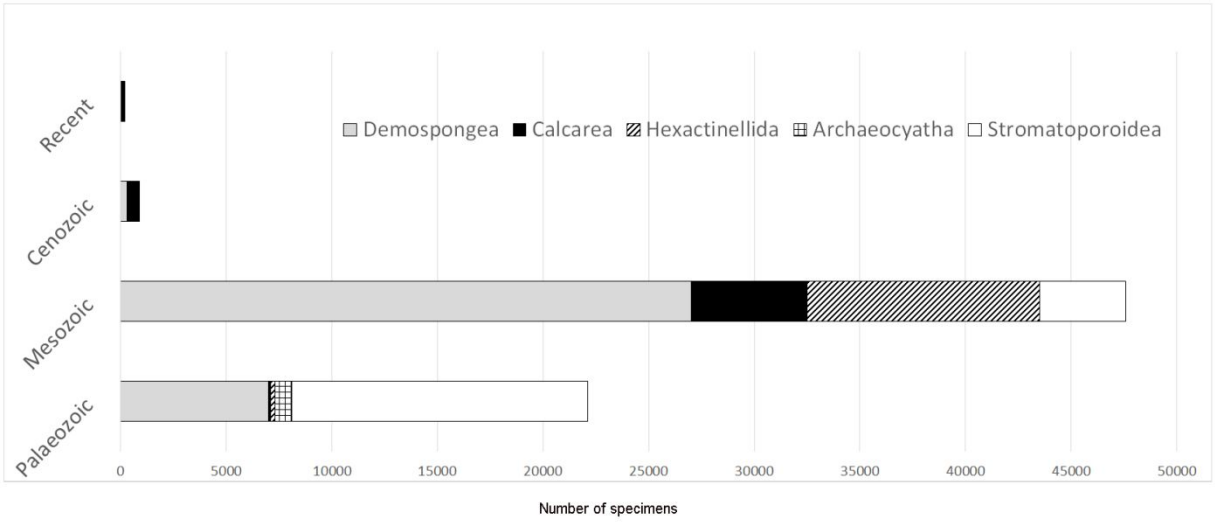


Figure 4. Geographic distribution of the NHM fossil sponges and abundance of specimens.

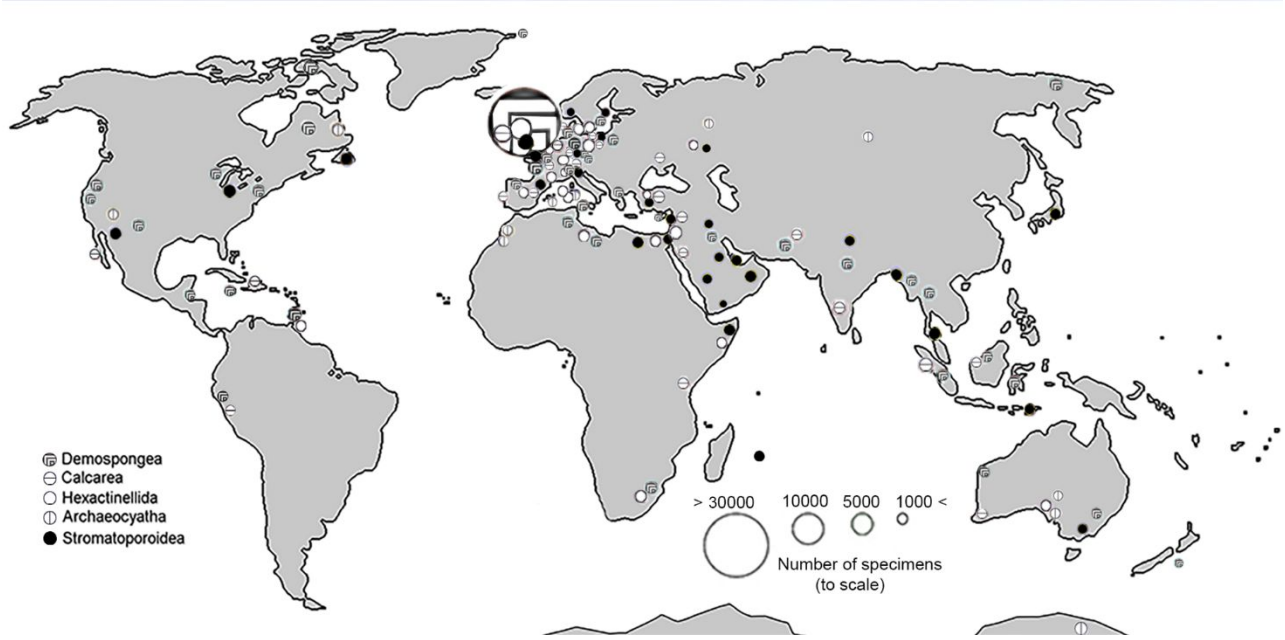
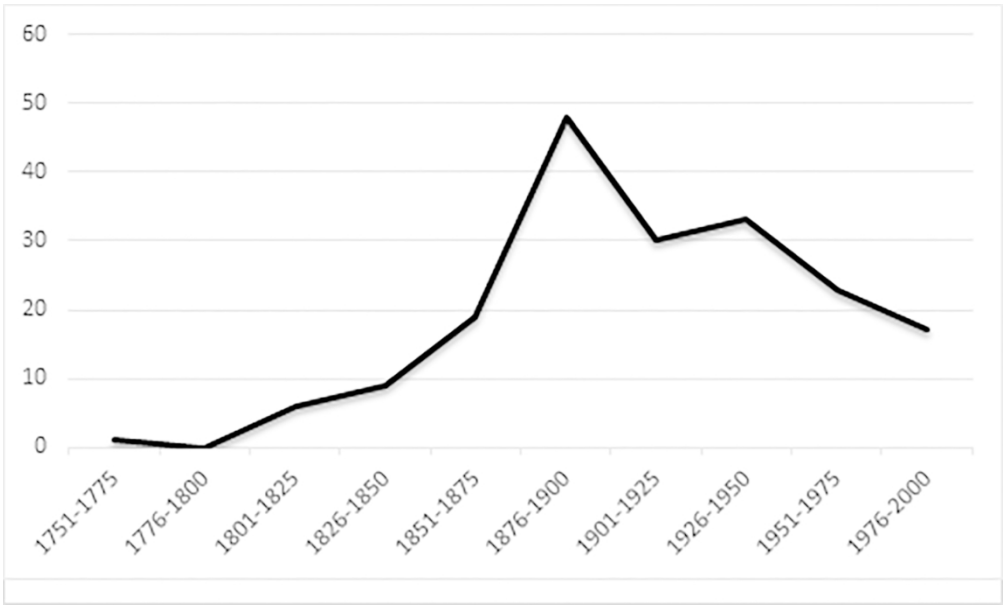


Table 1. Most important Collection contributors (by alphabetical surname order) to the NHM Fossil Porifera Collection and publications.

Collection contributor	Publications
Armstrong, Henry Edward (1848 -1937)	Anonymous, 1948
Bedford, Robert (1874-1951)	Bedford & Bedford, 1934, 1936, 1937, 1939
Benett, Etheldred (1776–1845)	Benet, 1831 Hinde, 1883
Bowerbank, James Scott (1797-1877)	Bowerbank, 1841, 1842, 1849, 1869, 1876, 1870

Cunnington, William (1813-1906)	Cunnington, 1849
Harford, Frederick (1820–1895)	
Hinde, George Jennings (1839-1918)	Hinde, 1880, 1882, 1883, 1884a, 1884b, 1886, 1887-1912, 1888, 1889a, 1889b, 1889b, 1890,a 1890b, 1891a, 1891b, 1892, 1900, 1904, 1905, 1908, 1910, Hinde & Holmes, 1892
Lee, John Edward (1808-1887)	Lee, 1839
Mantell, Gideon Algernon (1790-1852)	Mantell, 1815, 1822, 1848, 1854
Morris, John (1810-1886)	Morris, 1851, 1854 Hinde, 1883
Muir-Wood, Helen M. (1895-1968)	
Parkinson, James (1755–1824)	Parkinson, 1808
Pennant, Thomas (1726-1798)	Pennant, [1757]
Phillips, John (1800-1874)	Hinde, 1883 Phillips, 1829, 1835
Filip Počta (1859-1924)	Počta, 1907
Pulfrey, William (*f.* 1936-1960)	Pulfrey, 1933
Rowe, Arthur Walter (1858-1926)	
Schrammen, Anton (1869–1953)	Schrammen, 1899, 1901, 1902, 1910, 1912, 1924a, 1924b, 1936a, 1936b
Simmons, Jeremiah	
Smith, William (1769–1839)	Smith, 1816
Smith, Joshua Toulmin (1816-1869)	Smith, 1847a, 1847b, 1848a, 1848b, 1848c, 1848d, 1848e
Sollas, William Johnson (1849-1936)	Sollas, 1877, 1883
Tesson (-d.?1864)	Hinde, 1883
Tomes, Robert Fisher (1823-1904)	Hinde, 1883, 1911
Treacher, Llewellyn (1859-1943)	Treacher & Young, 1907
Vicary, William (1811-1903)	Nicholson, 1889 Sollas, 1877



CONSUELO SENDINO

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c.sendino-lara@nhm.ac.uk

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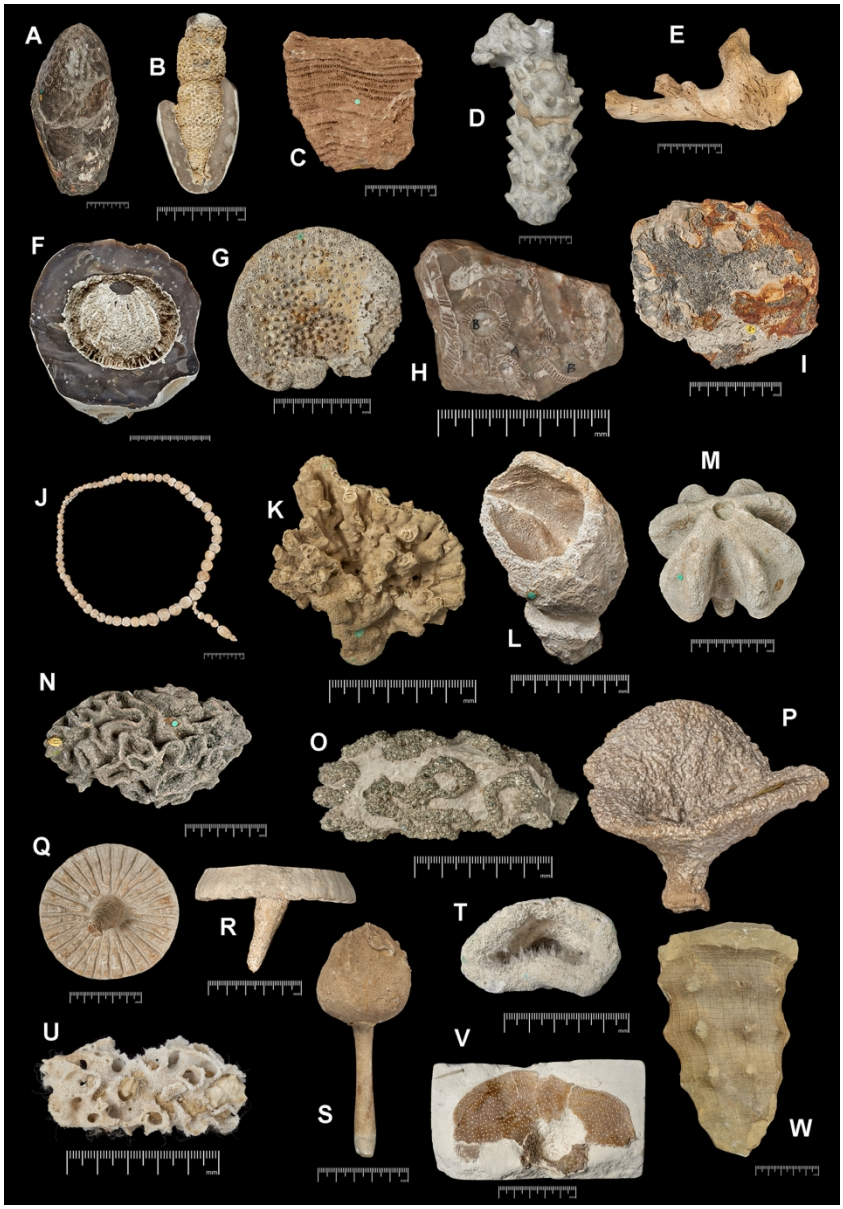

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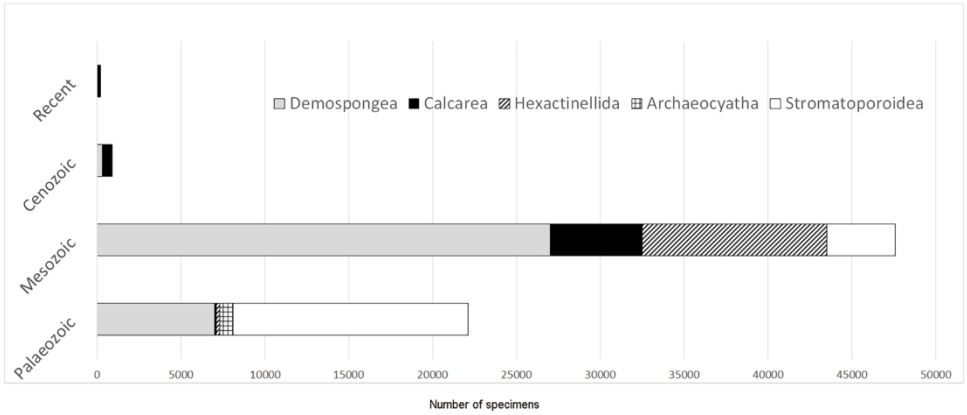

Figure 3. Number of specimens per stratigraphic era and Porifera classes present in the Earth Sciences Department at the NHM.

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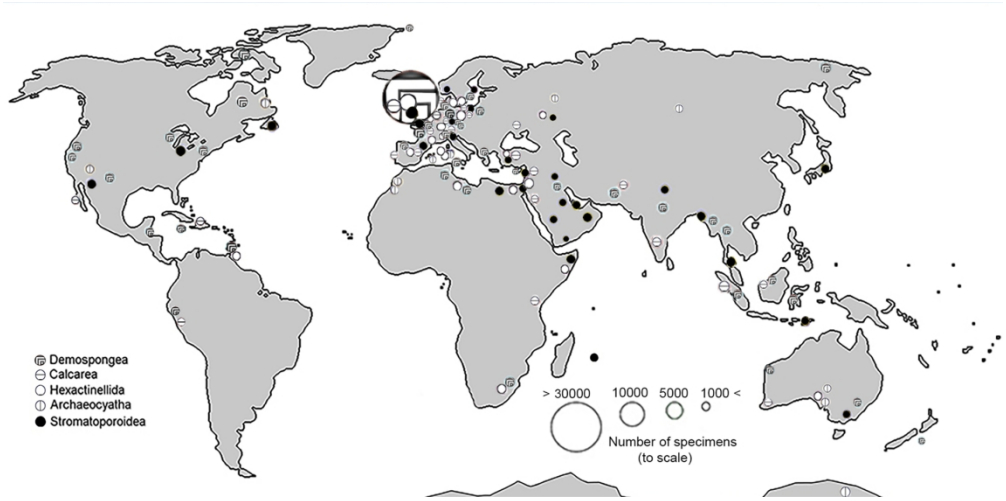

Figure 4. Geographic distribution of the NHM fossil sponges and abundance of specimens.

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Cunnington, William (1813-1906)	Cunnington, 1849
Harford, Frederick (1820–1895)	
Hinde, George Jennings (1839-1918)	Hinde, 1880, 1882, 1883, 1884, 1884a, 1886, 1887-1912, 1887a, 1888, 1889, 1889a, 1889b, 1890, 1890a, 1891, 1891a, 1892, 1900, 1904, 1905, 1908, 1910, Hinde & Holmes, 1892
Lee, John Edward (1808-1887)	Lee, 1839
Mantell, Gideon Algernon (1790-1852)	Mantell, 1815, 1822, 1848, 1854
Morris, John (1810-1886)	Morris, 1851, 1854 Hinde, 1883
Muir-Wood, Helen M. (1895-1968)	
Parkinson, James (1755–1824)	Parkinson, 1808
Pennant, Thomas (1726-1798)	Pennant (ca. 1757)
Phillips, John (1800-1874)	Hinde, 1883 Phillips, 1829, 1835
Filip Počta (1859-1924)	Počta, 1907
Pulfrey, William (*f.* 1936-1960)	Pulfrey, 1933
Rowe, Arthur Walter (1858-1926)	
Schrammen, Anton (1869–1953)	Schrammen, 1899, 1901, 1902, 1910, 1912, 1924, 1924a, 1936, 1936a
Simmons, Jeremiah	
Smith, William (1769–1839)	Smith, 1816
Smith, Joshua Toulmin (1816-1869)	T. Smith, 1847, 1848a, 1848b

Sollas, William Johnson (1849-1936)	Sollas, 1877, 1883
Tesson (-d.?1864)	Hinde, 1883
Tomes, Robert Fisher (1823-1904)	Hinde, 1883, 1912
Treacher, Llewellyn (1859-1943)	Treacher & Young, 1907
Vicary, William (1811-1903)	Nicholson, 1886-92 Sollas, 1877

APPENDIX

References of NHM fossil sponges referred in the bibliography:

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