Palaeontological collections at the Geological Museum, University of Copenhagen: from Cabinet of Curiosities to databases

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Harper, D.A.T. Palaeontological collections at the Geological Museum, University of Copenhagen: from Cabinet of Curiosities to databases. *In*: Winkler Prins, C.F. & Donovan, S.K. (eds.), *VII International Symposium 'Cultural Heritage in Geosciences, Mining and Metallurgy: Libraries - Archives - Museums': "Museums and their collections", Leiden (The Netherlands), 19-23 May 2003. Scripta Geologica Special Issue*, **4**: 118-126, 5 figs.; Leiden, August 2004.
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Key words — Palaeontological collections, Denmark, Greenland, databases.
Geological collections were established in the University of Copenhagen during the early 1700s with the presentation of fossil, mineral and rock collections by Count A.G. Moltke, mainly assembled by Ole Worm (1588-1654) in his Museum Wormianum. Currently the palaeontological collections in the Geological Museum, alone, contain over 1 million specimens, including 26,000 types. The focus of the collection remains on material from Denmark and Greenland. Highlights from Greenland include evidence of early life from the Archaean Isua Complex, the early Cambrian Sirius Passet fauna, Devonian amphibians, Triassic dinosaurs, mammals and pterosaurs, Jurassic and Cretaceous ammonites together with Jurassic and Cretaceous plants. The Danish collections are dominated by marine invertebrates from the Maastrichtian and Danian of Zealand; spectacular fishes and insects together with less common birds and whales occur in the Paleogene and Neogene rocks of Jutland. The diverse geology of the island of Bornholm has provided rich Early Palaeozoic invertebrate faunas together with abundant brachiopods and molluscs from the Jurassic and Cretaceous together with the first evidence of a dinosaur in the Danish region. Despite this wealth of material the museum faces many challenges associated with the more efficient storage and care of material, computer registration and the encouragement of specimen-based research programmes through both domestic and international networks.

Contents

Introduction

The Geological Museum is an administrative unit within the Faculty of Science of the University of Copenhagen. In addition the museum forms, together with the Geological and Geographical institutes, the Danish Lithosphere Center (DLC) and the

Geological Survey of Denmark and Greenland (GEUS), part of the Copenhagen Geocenter (Harper & Rosing, 2001); and from 2004 will form part of a new, larger administrative unit, The Natural History Museum of Denmark, University of Copenhagen. The Geological Museum fulfils a wide variety of functions involving research, collection care and management, exhibitions, outreach programmes and the education and supervision of graduate students. The majority of staff and students at the museum are engaged in specimen-based research and belong to one of six separate departments: Mineralogy, Petrography, Meteorites, Quaternary-Palaeobotany, Invertebrate and Vertebrate Palaeontology. The collections originated around 1650 and were moved to their present location in 1893. The collections are estimated to contain about 8 million specimens of which about 1 million are fossils.

Short History

The history of Danish Geology has been narrated in some detail (Noe-Nygaard, 1979) in connection with the celebration of the University of Copenhagen's Quincentenary. The university was founded by King Christian I in 1479, but it was unlikely that geology appeared on the curriculum until after the reformation in the late 1530s, when Peder Sørensen (also known as Petrus Severinus) advanced the development of the natural sciences in Copenhagen. Many of these early scholars had good international networks promoting mobility and academic exchange programmes. In particular Thomas Bartholin (1616-1680) made fundamental advances in anatomy including the study of fossil shark teeth. His geological studies were, however, eclipsed by his pupil Niels Stensen (also known as Nicolaus Steno: 1638-1687). Stensen was born in Copenhagen and following studies in anatomy and medicine at university both in Copenhagen and Paris, was appointed court physician to the Grand Duke Ferdinand II in Florence. He later took holy orders and after his death was sanctified. Stensen was, nonetheless, responsible for some remarkable discoveries that helped form the basis for the early development of the earth sciences. Steno's careful anatomical comparisons between fossil sharks' teeth and those of living forms further developed the researches of his mentor Bartholin.

More holistic, and perhaps more influential, were his studies in the Appenines, exposed in the hills and valleys of Tuscany. Here Steno unravelled the Law of Superposition of Strata, still the most fundamental concept in any stratigraphical investigation. Although the folded rocks of the Appenines now form part of the Alpine chain, the strata were originally deposited horizontally with oldest rocks forming the base of the sedimentary pile and the youngest rocks on top. In his last and probably most famous treatise, *De solido intra solidum naturaliter contento dissertationis prodromus*, published in Florence, Steno (1669) established the primary relationships between various groups of strata in Tuscany; clear in this study was his understanding of sedimentary processes and importance and significance of marine and terrestrial fossils. Mountains and volcanoes had not existed since the beginning of time, but were part of an evolving world modified by escaping gases, fire and running water.

Some hundred years later teaching programmes in geology were established in the University of Copenhagen aided by the presentation to the university of fossil, mineral and rock collections from Count A.G. Moltke. It is almost certain that palaeontological specimens were present in the private collections of Ole Worm. The Museum Wormianum, established in the 1620s, was one of the better-known European Cabinets of Curiosities (Weschler, 1995). The collection was assembled by exchanges or gifts and brought a new concept to Danish culture (Bendix-Almgreen, 1993), a showcase of organized natural history material displaying both order and a sense of wonder. Following Worm's death, the collections eventually passed into the hands of King Frederik III, where they constituted part of the Royal Cabinet of Curiosities. Apart from some insects in amber, little palaeontological material can be traced back to these spectacular royal cabinets (Gundestrup, 1991). Nevertheless, by the mid 1650s Thomas Bartholin had established a new collection within the Domus Anatomica. Sadly these collections were lost in the Fire of Copenhagen in 1728, but palaeontological collections again surfaced some thirty years later in the Moltke Cabinet, assembled by Count A.G. Moltke in the 1750s. This material almost certainly included some 500 specimens still extant from Albert Seba's (1665-1736) cabinet; some of this material was subsequently sold to Tessin and became part of the Queen of Sweden's own cabinet. It was Count Joachim Moltke (1746-1818; Fig. 1), however, who pulled together the various collections to establish in 1810 the combined natural history collections within the university. When the Faculty of Science was formally established in 1850, geology was centred on 'Grev Moltkes Universitetet tilhørende Mineralogiske Museum' in Frue Plads (Fig. 2). J.G. Forchammer (1794-1865), a student of the famous physicist H.C. Ørsted, held the chair in mineralogy and 'geognosi' together with the directorship of the Mineralogical Museum.

During the latter part of the 19th Century geology was again relocated. J.F. Johnstrup (1818-94) was instrumental in the establishment of the Commission for the Scientific Study of Greenland in 1876, and the founding of the Danish Geological Survey (DGU) in 1888. The new museum building (Fig. 3) on Øster Voldgade 5-7 was completed during 1893, a year before Johnstrup's death. During the later stewardship of the influential Arne Noe-Nygaard (1908-1991) geology continued to expand. But the core of geological activity was fragmented during 1967 with the expansion and movement of the teaching environment to Øster Voldgade 10, where within the Geological Institute, the departments of General Geology, Historical Geology and Palaeontology, Mineralogy and Petrology evolved soon afterwards. The museum building, however, was retained and renamed 'The Geological Museum' in 1976, more

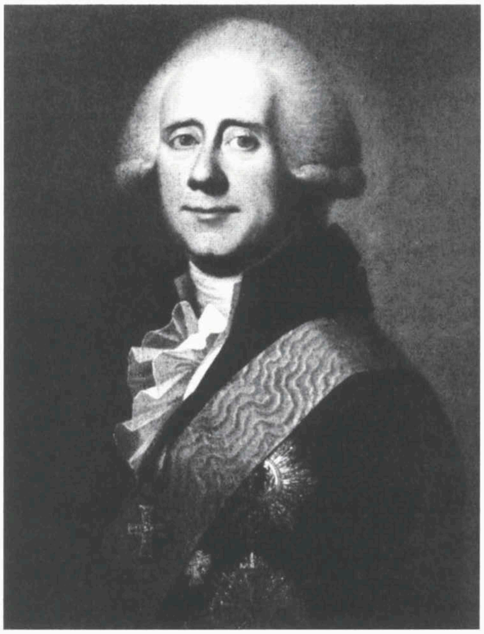

Fig. 1. Count Joachim Godske Moltke, patron of the University of Copenhagen and credited with the establishment of the natural history collections in 1810 (reproduced from Noe-Nygaard, 1979).

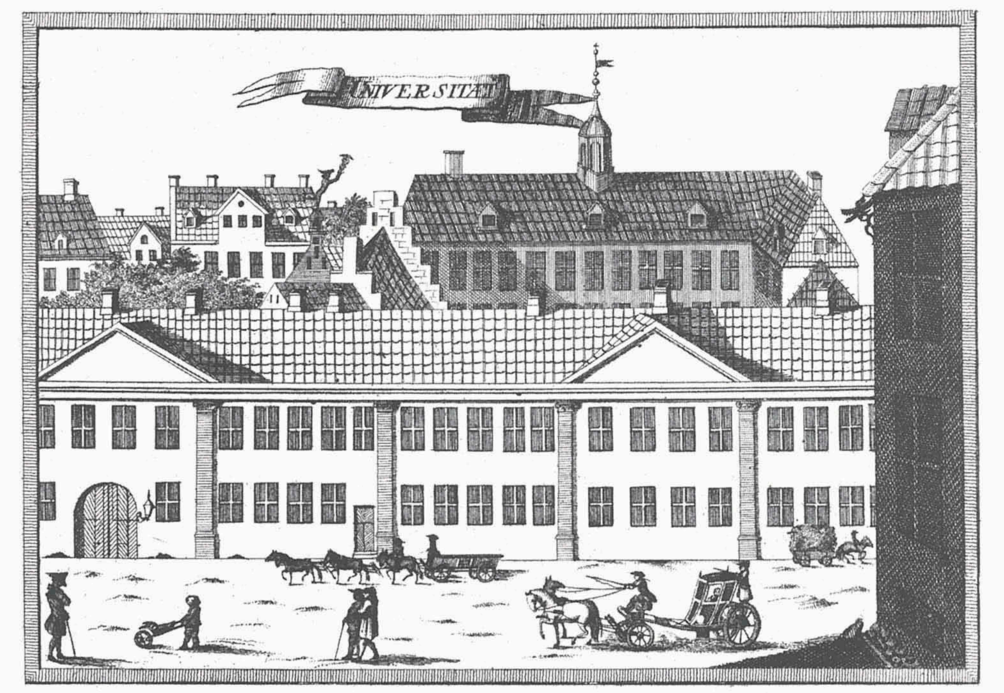

Fig. 2. The Natural History Museum in Nørregade, *c.* 1780 (reproduced from Noe-Nygaard, 1979).

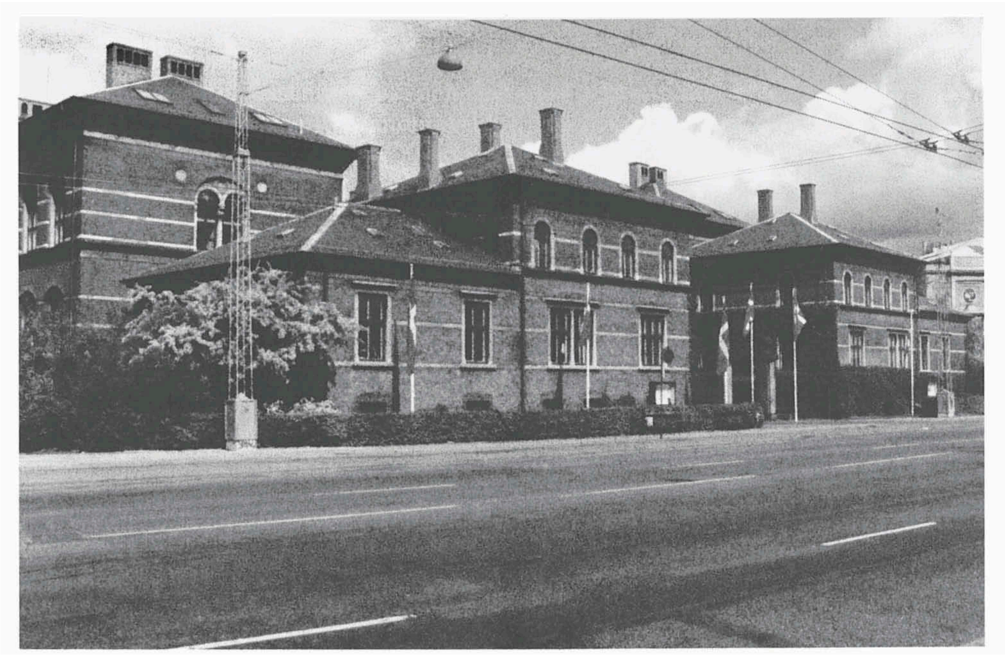

Fig. 3. Purpose built 'Geological Museum', on Øster Voldgade; constructed in 1893. Photograph taken during the museum's centenary (photo: Walter Kegel Christensen).

accurately reflecting the collections, functions and scope of Øster Voldgade 5-7 (Bendix-Almgreen, 1993). Independence was complete, when the museum received its own budget in 1991.

The previous five years, however, have exemplified an international trend to create larger administrative and collaborative units. Geocenter Copenhagen was launched in September 2002 (initially a loose amalgamation of the Geological Survey of Denmark and Greenland [GEUS], the Geological and Geographical institutes, the Geological Museum and the Danish Lithosphere Center) and on the 1st of January 2004 the Natural History Museum of Denmark, University of Copenhagen will commence as a major new institute including the Botanical Museum and Botanical Gardens, the Geological Museum and the Zoological Museum.

Breadth and depth of the collections

The core palaeontological collections of the museum are from Denmark and Greenland although the galleries contain much foreign material. Although relatively little material has been noted in the major compendia of world collections (e.g., Cleevely, 1983; Webby, 1989), the collections have a remarkable breadth and depth. The type and figured material, consisting of over 26,000 types, forms a separate department in the museum. The material is well curated and easily located and also contains a number of historically important specimens including some illustrated by Carl von Linné (Nielsen & Jakobsen, 1993) and Charles Lyell (Bjerreskov, 1993). In broad terms, the very large main collections are divided into those from Denmark, Greenland and elsewhere. These geographic collections are further divided stratigraphically into essentially Palaeozoic, Mesozoic and Cenozoic groups and the material is further divided on the basis of taxonomy. Standards of care and curation are variable across the main collection and there is a need to centralize and conserve large parts of this important collection.

The geology of Denmark is remarkably varied (Rasmussen, 1968; Håkansson & Surlyk, 1997). The Danish collections are derived from a number of key areas from Zealand, the Jutland Peninsula and Bornholm (Fig. 4). The island of Bornholm has provided much material from its relatively complete Lower Palaeozoic successions, developed mainly in deeper-water facies. Both graptolite and shelly faunas have been described in a series of publications. The Mesozoic formations contain diverse ammonite, belemnite and bivalves faunas together with brachiopods; terrestrial facies developed during the mid Jurassic and early Cretaceous contain plants and some vertebrates, including evidence for dinosaurs in the Danish area. Collections from Bornholm have been a focus for scientific study for over a hundred years whereas the material has formed the basis of a number of popular articles (Nielsen, 1988; Hamann, 1988) and provide some of the core material for the museum's permanent exhibition on the 'Geology of Denmark'. On the mainland, exposures south of Copenhagen, particularly along the coast at Stevns Klint and Møns Klint together with those in Faxe Quarry, have yielded abundant and diverse late Cretaceous (Maastrichtian) and Paleogene (Danian) material; the unusual cool-water carbonate facies contains brachiopods, bryozoans, corals and echinoderms together with a wide variety of molluscs and arthropods. West, on the Jutland Peninsula, Paleogene and Neogene rocks,

Erathems		Systems	
Cenozoic		Quaternary	
	Tertiary	Neogene	+ Molluscs
		Palaeogene	+Insects, birds, fishes and whales
Mesozoic		Cretaceous	+ Maastrichtian and Danian marine fossils
		Jurassic	+ Diverse floras from Bornholm + Ammonites and bivalves from Bornholm
		Triassic	
Palaeozoic	Upper	Permian	
		Carboniferous	
		Devonian	
	Lower	Silurian	+ Graptolite faunas from Bornholm
		Ordovician	+ Graptolite and shelly faunas from Bornholm
		Cambrian	+ Mollusc and trilobite faunas from Bornholm

Fig. 4. Highlights from Denmark's fossil record (original).

particularly those in the Eocene 'Mo Clay' facies have yielded extraordinarily preserved bird and insect fossils; occasional whales are found in the younger Oligocene-Miocene strata. Acquisition of material depends not only on research programmes but also on amateur and semi-professional collectors together with local interest groups. An essential part of the acquisition process is Denmark's danekræ ('Danish creature') legislation that allows for the purchase of specimens of exceptional display or scientific value for the Danish State.

Palaeontological collections from Greenland (Fig. 5) have been assembled over a hundred years from the many and various expeditions to different parts of the island by a large variety of Danish and foreign researchers (Escher & Watts, 1976). Exceptional are the early Cambrian, 'Burgess Shale' type faunas from Sirius Passet in North Greenland, the late Devonian amphibians from Kap Stosch, East Greenland, the Triassic mammals from the Carlsberg Fjord region and the spectacular Triassic and Jurassic floras of Scoresby Sound together with the Jurassic and Cretaceous ammonites of East Greenland. The Cretaceous of West Greenland has yielded one of the world's largest mussels (Jakobsen, 1993) and some spectacular floras, including early angiosperms. Such material has provided some important windows on many key events in the history of life on our planet including its origin (Rosing, 1999).

Erathems		Systems	
Cenozoic		Quaternary	
	Tertiary	Neogene	+ Tropical floras
		Palaeogene	
Mesozoic		Cretaceous	+ Early angiosperms
		Jurassic	+ Jurassic ammonites from Jameson Ld + Late Triassic - Early Jurassic floras
		Triassic	+ Late Triassic dinosaurs, mammals and pterosaurs + Early Triassic amphibians and sharks
Palaeozoic	Upper	Permian	+Permo-Carboniferous marine fossils
		Carboniferous	
		Devonian	+ Late Devonian Kap Stosch tetrapods
	Lower	Silurian	+ Ordovician-Silurian reefs
		Ordovician	
		Cambrian	+ Early Cambrian Sirius Passet fauna

Fig. 5. Highlights from Greenland's fossil record (original).

Role of a Geological Museum within both a Geocenter and Natural History Museum Complex

Although most university museums have teaching responsibilities together with the supervision of graduate students, a museum's basic products are usually quite different from those of related teaching departments. The care of collections, development of exhibitions and outreach programmes together with research determine the core activities of a museum. Much research is specimen-based and commonly taxonomic. Nevertheless geological research is commonly more process based than that of the biologically-orientated museums. The key products of a museum involve typically the numbers of visitors (including school, college and society groups) to exhibitions, guest scientists to the collections together with the numbers of public enquiries and acquisition and registration of material; additionally the rate of development of new and relevant exhibitions together with the numbers of field excursions and popular lectures are important indicators of the success of a museum system. The Geological Museum has already defined its role within Geocenter Copenhagen as the focus for the promotion of new data and discoveries within the earth sciences (Harper & Rosing, 2003) through exhibitions, publications and the media. The museum will bear all responsibility for the fossil, mineral and rock collections within the new Natural History Museum of Denmark, University of Copenhagen and will drive exhibition and research programmes in these areas.

Towards a web-based database

A high priority is the computer registration of the palaeontological collections in Copenhagen. Increasing numbers of enquiries from the global scientific community has promoted an increase in both loans and visitors, particularly through the EU funded COBICE (Copenhagen Biosytematics Center) scheme. A relational database based on Microsoft ACCESS built around subsets of information targeting the taxonomy together with the stratigraphical and geographical location and distribution of the taxon has been developed. The database also combines the ability to generate loan forms, various styles of labels and tracks outstanding loans. The palaeontological type collection is currently being converted into electronic data with an aspiration to generate a web-based system in the next few years. The type collection alone involves the computerization of some 26,000 specimens together with all relevant information on associated labels and in the museum's protocols.

Concluding remarks

Increasing interest in fossil collections from Denmark and Greenland has promoted a reorganization of many parts of the collections and the development of a computerized database. A greater awareness that museum collections are not just objects for curation but the basic scientific tools of specimen-based researchers, has prompted a more responsible attitude to the collections. But should museums be characterized by their existing collections or should they now develop new and more relevant acquisition strategies (Thomson, 2002)? The palaeontological collections in Copenhagen are principally from Denmark and Greenland; the museum is a centre of excellence in this area. The museum remains a focus for collections from these regions together with data and information relevant to the cultural aspects of the material and the acquisition. Within the last number of years palaeontological collections that developed from a sense of wonder displayed in Worm's Cabinet of Curiosity, have emerged as objects of intensive and serious scientific study, ready to take their place in global databases.

Acknowledgements

I thank the Carlsberg Foundation for support to present this paper in Leiden (May 2003) and am grateful to my colleagues at the Geological Museum for much useful discussion. I thank Arne Thorshøj Nielsen for his comments on a final draft of the manuscript.

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