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In Search of Lost TIME

The study of Earth history and chronology from the 18th to the 21st century

Curated by:
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Rare Book & Manuscript Library
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The related concepts of time, chronology, and history form the lens through which Earth scientists view, understand, and interpret a dynamic planet. Modern geologists operate within the intellectual framework of a 4.55 billion year old planet, but the paradigm of an immensely old Earth was not intuitive. It was only through the development of Earth's history and chronology, beginning in the 18th century, that the science of geology became fully enriched. The discovery of Earth's history therefore represents a profound shift in our understanding of the natural world, and the scientific endeavors to establish "geohistory" and "geochronology" led to a realization that "nature has a history of its own" ([1]Rudwick, 2005).

As we enter the newest geologic Epoch, the Anthropocene, these two histories, Earth's and humanity's, have become more intertwined, to the point that our continued coexistence depends upon a deeper understanding of Earth's past, present, and future.

This exhibit will explore how the chronology of the Earth was established, with a focus on six themes that gradually led to the consensus view that the Earth is roughly 4.55 billion years of age. This age is so vast that Earth's history seems to stretch back in time by an *almost* inconceivable amount, but crucially, intellectual developments since the 18th century have revealed that Earth's age is both finite and can be retrodicted. Although geologic investigations prior to this time contained elements of the temporal, or at least an idea of a sequence of events (e.g., this happened, then that happened), geology was largely *ahistorical* before the 18th century, with no overarching framework that placed such events in the context of a long-lived, prehuman Earth.

[1]Martin Rudwick, *Bursting the Limits of Time* (Chicago: University of Chicago Press, 2005)

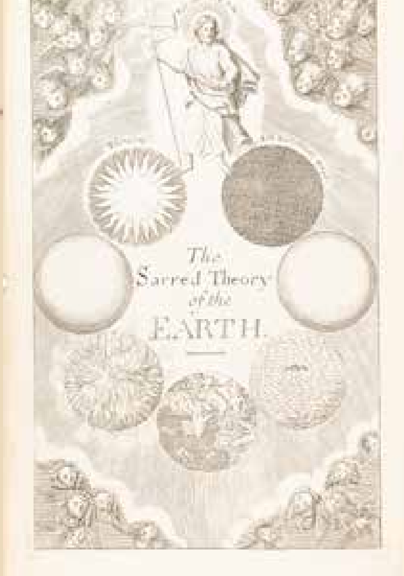
4.55 Billion Years

Establishing the chronology of the Earth in six themes

Each theme presents representative and important texts in a key sub-field of geology that expanded our understanding of Earth time by bringing an element of the historical to the science. In some cases, the progression of texts tracks the changing sentiments of the sub-discipline as it responded to and incorporated the lessons of the burgeoning field of geohistory; in others, the texts demonstrate the establishment of new fields of study within geology that further illuminated Earth's history.

At a still higher level of organization, the exhibit can be divided into two overarching themes: the first (cases 1-4) shows how geologists arrived at the realization that the Earth was in fact very old,
the second (cases 5-6) shows how geologists, in collaboration with physicists, placed an absolute age on this longevity.

Background detail: William Smith,
Strata of England and Wales, 1815



Detail from Thomas Burnet's *Sacred Theory of the Earth*

Case 1

Religious chronologies

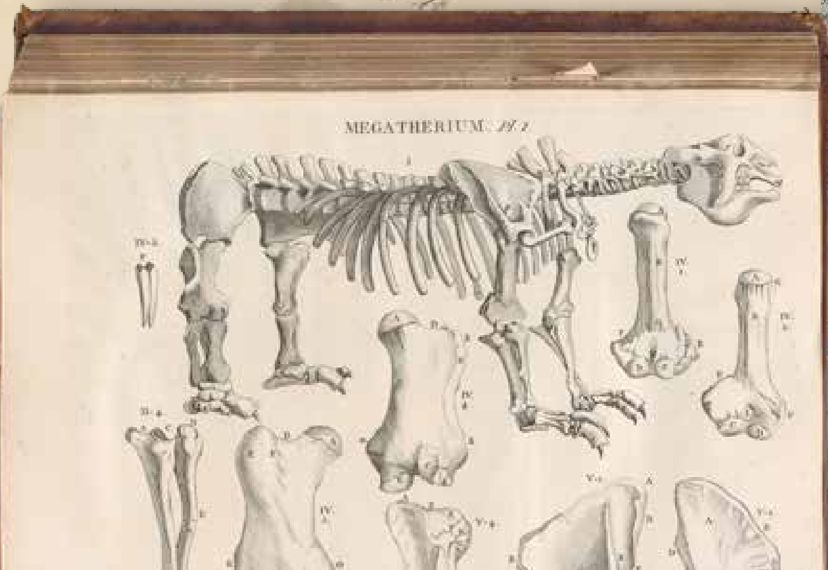
Although "religion" and "science" are typically considered opposing and unrelated pursuits of knowledge by modern scientists, the distinctions between the two were less clear in 18th century Europe. The more flexible boundaries among different branches of knowledge led to interesting intersections in which the geologic work of European savants was informed, either explicitly or implicitly, by religious themes. Religious or theological context stimulated debates about whether the Earth represented a deistic eternal machine held in an infinite state of dynamic equilibrium, that is, *ahistorical*, or was finite, directional, and contingent; that is, *historical*.

Case 2

Fossils and the record of previous worlds

By the end of the 18th century, fossils were well established as the remains of formerly living creatures. However, their full significance, as both archival evidence of past environments and as diagnostic tools for describing the relative age of the rocks in which they were found, was only just coming into view. Prior to the 18th century, savants considered fossils along with minerals as objects of "natural history"; or related to taxonomy and classification. For the modern Earth scientist interested in the delineation of geologic time, the fossil record serves a crucial means for dividing and classifying different Eons, or slices of Earth's history. In this sense, fossils are markers of the environments of past worlds and have a *historical* context.

Georges Cuvier, *Recherches sur les Ossemens Fossiles de Quadrupedes,* 1812



Georges Cuvier, *Recherches sur les Ossemens Fossiles de Quadrupedes,* 1812

Case 3

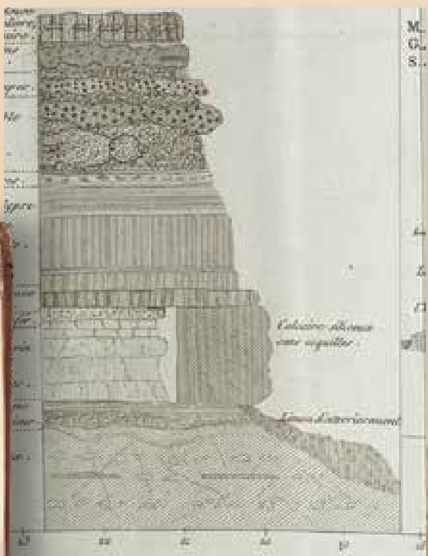
History in the layers of the Earth

The layers of the Earth have long been recognized as providing a temporal sequence of events, with broad classifications of “Primary” (igneous) and “Secondary” (sedimentary) hinting at a generic age progression. But crucially, prior to the beginning of the 19th century, this temporal sequence provided no insight into the chronology, or related *history* of the rocks. The landmark research into the layers of rock in the Paris Basin and their associated fossil assemblages by Georges Cuvier and Alexandre Brongniart (published in several forms but displayed here in *Recherches sur les Ossemens Fossiles de Quadrupedes,* 1812) fundamentally altered the study of Earth’s layers into one that was “doubly enriched”: both to correlate geologic units across a broad region, but also to provide a *history* of the different environments, or previous worlds, that the Paris Basin represented.

Case 4

Maps and cross-sections: correlations across space and time

Just as Cuvier and Brongniart were enriching the study of Earth’s layers in a specific region (the Paris Basin), other geologists were using the fossil record to correlate distinct rock units across entire countries. The work of William Smith *(Strata of England and Wales,* 1815) is the example par excellence of this new ability to tie rock units together with a common history as revealed by their fossil assemblages (beautifully shown in Smith’s map by common colors), and, even more importantly, to infer the contiguous nature of these rocks from isolated outcrops by their fossils alone.



William Buckland, *Geology and Mineralogy considered with reference to Natural Theology,* 1836

Case 5

Earth's chronology from "geotheory"

The search for an all-encompassing "theory of the Earth" (or "geotheory") that could unite disparate natural observations was a much pursued (and sometimes much maligned) sub-discipline of the Earth sciences throughout the time period covered by this exhibit. An intriguing offshoot of various geotheories were the attempts to calculate absolute chronologies from first principles, or assumptions and calculations based on an understanding of universally applicable physical processes. Collectively, these estimates seemed, both then and now, unsatisfactory as absolute chronometers as they were based upon conjecture and assumption, rather than direct observation and measurement. New discoveries of the 20th century were required before true measurement-based estimates of the age of the Earth could be made.

Case 6

Radioactivity and the science of Geochronology

The year 1905 featured the publication of the very first radiometric age. Once the power of radioactive elements for constructing chronologies was revealed, the promise of measuring the true age of the Earth was within sight. The centerpiece of the case is the study by Clare Patterson in 1956 that marked the Earth as 4.55 billion years old; an age that has stood ever since. Research on the earliest phases of Earth history continues today, and the case features imagery of instrumentation in the Department of Geology that is used to conduct geochronologic research.

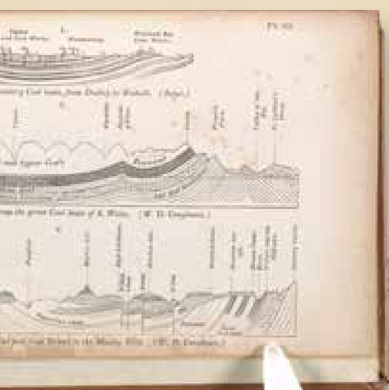
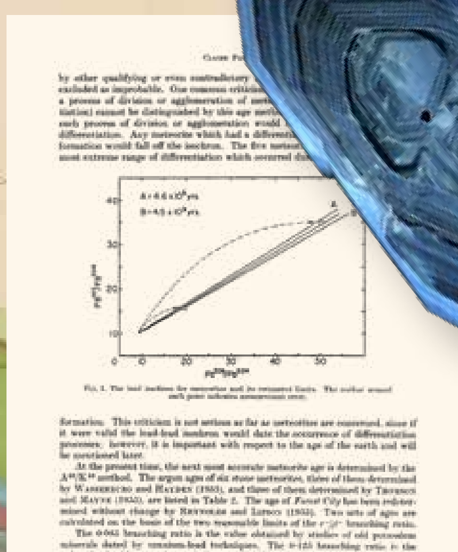


Image of zircon provided by Dr. George Gehrels (University of Arizona). See Wilde, Valley, Peck, and Graham, *Evidence from Detrital Zircons for the Existence of Continental Crust and Oceans on the Earth 4.4 Gyr Ago,* 2001

Clare Patterson, *Age of Meteorites and the Earth,* 1956



List of texts and manuscripts featured in this exhibit:

Case 1

Burnet, Thomas. *Sacred Theory of the Earth.* London: Roger Norton, 1697. Shelfmark: Q. 213 B93tE1691

de Luc, Jean Andre. *Lettres physiques et morales sur l'historie de la terre et de l'homme.* Vol. 2. Paris, 1779. Shelfmark: 550 D38L

Ussher, James. *Annales Veteris Testamenti.* London, 1654. Shelfmark: XQ. 930 US7A

Case 2

Agassiz, Louis. *Recherches sur les poissons fossiles (vol. 1).* Neuchatel: Petitpierre, 1833-1844. Shelfmark: Q. 567 Ag1r

Brongniart, Alexandre. *Histoire naturelle des crustacés fossiles, sous les rapports zoologiques et géologiques.* Paris: Chez. F.G. Levrault, 1822. Shelfmark: Q. 565.3 B86H

Knorr, Georg and Walch, J.S. Emmanuel. *Sammlung von Merckwürdigkeiten der Natur und Alterthümern des Erdbodens.* Vol. 1. Nürnberg: A. Bieling, 1755-1774. Shelfmark: Q. 560 K75s

Knorr, Georg and Walch, J.S. Emmanuel. *Sammlung von Merckwürdigkeiten der Natur und Alterthümern des Erdbodens.* Vol. 3. Nürnberg: A. Bieling, 1755-1774. Q. 560 K75s v.3

Mantell, Gideon. *Wonders of Geology.* London: Rolfe and Fletcher, 1839. Shelfmark: 550 M31W1839

Case 3

Buckland, William. *Geology and Mineralogy considered with reference to Natural Theology.* London: William Pickering, 1837. Shelfmark: 210 B76 v.6

Cuvier, Georges. *Recherches sur les Ossemens Fossiles de Quadrupedes.* Paris: Chez Deterville, 1812. Shelfmark: Q. 560 C98r1812

Hutton, James. *Theory of the Earth, with Proofs and Illustrations.* Edinburgh: Printed for Messrs Cadell, junior, and Davies, London; and W. Creech, 1795-1899. Shelfmark: 551.7 H979t

Hutton, James. *Theory of the Earth, or, An investigation of the laws observable in the composition, dissolution, and restoration of land upon the globe.* Edinburgh, 1788. Shelfmark: Q. 551.7 H979th1788

Whitehurst, John. *Inquiry into the Original State and Formation of the Earth.* London: Pater-noster Row, 1786. Shelfmark: Q. 550 W58i1786

Case 4

Englefield, Henry, and Webster, Thomas. *A description of the principal picturesque beauties, antiquities, and geological phenomena of the Isle of Wight.* London: W. Bulmer and Co., 1816. Shelfmark: Q. 914.228 EN3D

Lyell, Charles. *Elements of Geology.* London: John Murray, 1838. Shelfmark: 550 L981838

Smith, William. *A delineation of the strata of England and Wales, with part of Scotland.* London, 1815. Shelfmark: F. 554.2 Sm6d

Case 5

Buffon, Georges Louis Leclerc, comte de. *Historie Naturelle, Generale et Particuliere.* Vol. 1. London: T. Bell, 1775. Shelfmark: 500 B86hEk

Kelvin, William Thomson, Baron. *Treatise on Natural Philosophy.* Vol. 1. Oxford: Claredon Press, 1867. Shelfmark: 531 K29t

LeConte, Joseph. *Elements of Geology: A textbook for colleges and the general reader.* New York: D. Appleton and Company, 1879. Shelfmark: IUB03317

Walcott, Charles. "Geologic time, as indicated by the Sedimentary Rocks of North America." *Journal of Geology* 1, no. 7 (1893): 639-675. [Facsimile]

Williams, Henry. "Studies for students: the elements of the geological time-scale". *Journal of Geology* 1, no. 3 (1893): 283-295. Shelfmark: Main Library 550.5 JG

Case 6

Holmes, Arthur. "The Association of Lead with Uranium in Rock-Minerals, and its Application to the Measurement of Geological Time". *Proceedings of the Royal Society of London, Series A* 85 (1911): 248-256. [Facsimile]

Patterson, Clare. "Age of Meteorites and the Earth". *Geochimica et Cosmochimica Acta* 10 (1956): 230-237. [Facsimile]

Rutherford, Ernest, and Frederick Soddy. "The Radioactivity of Uranium". *Philosophical Magazine* 6 (1903): 441-445. [Facsimile]

Rutherford, Ernest. *Radioactive Transformations.* New York: C. Scribner's Sons, 1906. Shelfmark: 537.55 R93r

Wilde, Simon A., John W. Valley, William H. Peck, and Colin M. Graham. "Evidence from Detrital Zircons for the Existence of Continental Crust and Oceans on the Earth 4.4 Gyr Ago". *Nature* 409 (2001): 175-178. Shelfmark: Main Library Q. 505 N

Courtesy of the Map Library
Smith, William, and John Cary. *William Smith 1815 Geological Map: a Delineation of the Strata of England and Wales….* [London]: Reproduced by the British Geological Survey, 2013. Shelfmark: Map Library G5751.C5 1815.S6 2013.

Acknowledgments: **Ruthann Mowry** and **Marco Valladares Pérez** for all their efforts in procuring texts, preparing the items for exhibit, conservation work, and guiding the exhibit to its full realization. **Ana Rodriguez** for her help in setting up the exhibit. **Gillen Wood** and **Max Christie** for helpful discussion and guidance concerning text and fossil selection. **Digitization Services** for the creation of all facsimiles used in this exhibit. **Lynne M. Thomas** as director of RBML. This exhibit was partially supported by NSF-EAR grant 1848013 to William Guenthner.

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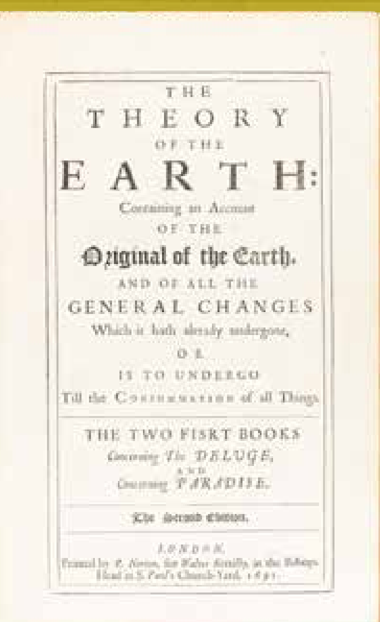

THE
THEORY
OF THE
EARTH:
Containing an Account
OF THE
Original of the Earth,
AND OF ALL THE
GENERAL CHANGES
Which it hath already undergone,
OR
IS TO UNDERGO
Till the CONSUMMATION of all Things.

THE TWO FISRT BOOKS
Concerning The DELUGE,
AND
Concerning PARADISE.

The Second Edition.

LONDON,
Printed by R. Norton, for Walter Kettilby, at the Bishops-Head in S. Paul's Church-Yard, 1691.