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GEOLOGICAL PERIODS

Geologists have developed a standard geologic timescale that allows them to communicate consistently about events in the distant geologic past. The largest time divisions are eons, which are subdivided into eras, periods, epochs, and ages.

Origins of the Timescale. The geologic timescale (Figure 1) was developed in Europe, primarily between 1795 and 1840. It was not organized in a logical or systematic fashion from first principles, but grew in a haphazard way, with different parts of the timescale named at different times by different people. The names of the geologic periods follow no logical pattern, but reflect historical accidents of naming. However, it is such a fundamental tool that geologists find it the most useful way to communicate about the age of geological events. This system is much more practical than referring to such events by numerical dates (which are often poorly known and subject to change). The method is analogous to describing historical events by such landmarks as the monarchs of England. Although we can often refer to historical events by the precise year, terms such as *Elizabethan* and *Victorian* are often more useful to the historian in providing a time context and require only a knowledge of the sequence of kings and queens of England and the approximate years of their reign.

Before 1800, geologists viewed the rock record as a product of Noah's Flood, with Primary, or primitive, granites and metamorphic rocks (typically found in the cores of mountains) representing the rocks of the original created earth, tilted, layered Secondary rocks representing sedimentary deposits of the Flood itself, and horizontal, less consolidated "Tertiary" sediments above them as post-Flood deposits. Today, only the term *Tertiary* survives from this system, the term referring to rocks now dated between 65 and 2 million years ago.

Although scholars attempted to force the rock record into a biblical straitjacket, miners were more concerned with practical matters such as naming and describing distinct rock layers. All over Europe, the industrial revolution and the demand for coal had led to widespread mapping and mining of the beds, known as the "coal measures." In 1822 William Conybeare and William Phillips (following J. J. Omalius d'Halloy) formally renamed these rocks the Carboniferous, meaning "coal-bearing" in Latin. (In the United States, the early Carboniferous was named the Mississippian in 1870, and the late Carboniferous was called the Pennsylvanian in 1891; these terms are still widely used in the United States.) Likewise, the limestone of the white cliffs of Dover inspired their name for the Cretaceous period (from the Latin for "chalk"). Even earlier (1795), the famous explorer Alexander von Humboldt had coined the name *Jurassic* for the rocks exposed in the Jura Mountains of the southwestern Alps. In 1815 Friedrich von Alberti used the term *Triassic* for the threefold succession of rocks found over Germany and elsewhere in Europe.

In the 1830s Adam Sedgwick (first professor of geology at Cambridge University) and the gentleman geologist Roderick Impey Murchison did fieldwork in western England and Wales to decipher the base of the Secondary sequence. In 1834 Sedgwick named the lowest rocks the Cambrian (after the Roman name for Wales), and Murchison called the upper rocks the Silurian (after the Roman name for an ancient Welsh tribe, the Silures). However, they used different criteria for recognizing their systems. Murchison based the Silurian on distinctive fossils, so it could be recognized around the world, while Sedgwick used more parochial features of particular geological formations. Arguments arose about the boundary between their two systems, and soon Murchison's Silurian had swallowed up Sedgwick's Cambrian. The dispute was not settled until after they died, when Charles Lapworth recognized a distinctive interval between the Cambrian and Silurian in Scotland, which he called the Ordovician (after the Roman name for another Welsh tribe, the Ordovices) in 1879.

Before the Cambrian-Silurian feud destroyed their friendship, however, Murchison and Sedgwick collaborated on the naming of the rocks just beneath the Carboniferous. In most of the British Isles, they are river deposits known as the Old Red Sandstone, but in southwestern England (Devonshire and Cornwall), they

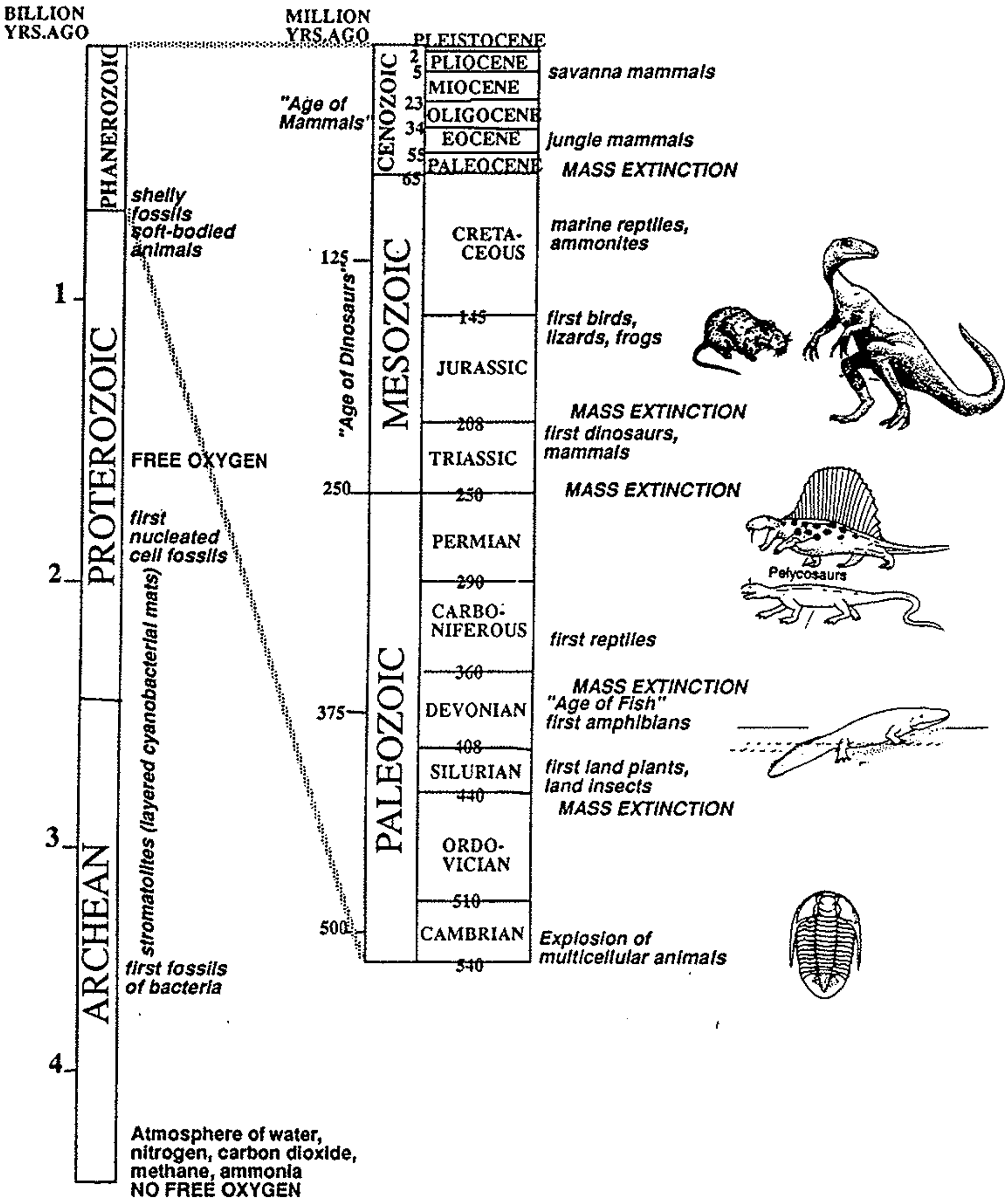

FIGURE 1. Geologic Time Scale.
Shown are the major events in earth and biologic history. Donald Prothero.

change in character into marine beds that were long confused with the Carboniferous or Silurian. In 1840 Sedgwick and Murchison coined the term *Devonian* for rocks of this age, whether they were marine or nonmarine. In 1841 Murchison went to Russia at the invitation of the czar, where he studied the region's geology and confirmed much of what he had already discovered about European geology. In the Ural Mountains he recognized a sequence of rocks above the Carboniferous which he called the Permian (after the town of Perm in the Urals).

By the late 1830s, the character of these time divisions was becoming apparent, and large-scale patterns could be recognized. In 1838 Sedgwick proposed the Paleozoic era for the early part of the timescale (ending with the Permian), and in 1840 John Phillips used the term *Mesozoic era* for the Triassic-Jurassic-Cretaceous, and *Cenozoic era* for the post-Mesozoic. In 1833 Charles Lyell named the subdivisions (or epochs) of the Cenozoic and Tertiary as the Eocene, Miocene, and Pliocene; the Paleocene epoch was named by the paleobotanist W. P. Schimper in 1874, and the Oligocene epoch by H. E. von Beyrich in 1854.

Highlights of Geologic History. Some periods in the history of earth and life are particularly eventful. For example, the beginning of the Paleozoic era and Phanerozoic eon is the Cambrian period, which marked the first abundant fossils with shells. Likewise, the boundaries between the eras are marked by major mass extinctions. The boundary between the Paleozoic and Mesozoic eras (Permian and Triassic periods) was marked by the largest mass extinction in earth's history, when 95 percent of the marine species on earth vanished. The majority of typical seafloor invertebrates of the Paleozoic, such as brachiopods ("lampshells"), crinoids ("sea lilies"), bryozoans ("moss animals"), and horn corals vanished, and were replaced by modern shelly marine groups such as clams, snails, and sea urchins. The boundary between the Mesozoic and Cenozoic eras (Cretaceous and Tertiary periods) saw another major mass extinction, when the dinosaurs vanished from the land and many marine groups (such as the ammonites, distant relatives of the octopus, squid, and chambered nautilus) died out. When Phillips and Sedgwick first proposed the Paleozoic, Mesozoic, and Cenozoic eras, they did so with the full awareness that the typical fossil assemblage of each era was highly distinctive. Since that time, we have come to understand why these faunas look different, and we also know much more about the causes of these two major mass extinctions.

Geologic Time. The geologic timescale was created by geologists almost 200 years ago to describe the relative ages of geologic events, and has been internationally accepted ever since. The terms now in use, delineating the various eras, periods, and epochs, may not be logically arranged, since they grew by accident, but their meaning has remained consistent for over 100 years. Numerical age estimates of the duration of these time intervals have been known for less than a century, and sometimes are revised as newer and better dates become available. Thus, for geologists the relative timescale is the only practical means of describing events in the geologic past.

[*See also* Paleontology.]

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