

Geological time is incomprehensibly long. When a geologist speaks of something happening over a short period of time, he probably means that it took a million years or so to happen. Compared to the age of the earth, which is just over four and a half billion years, this is indeed a short period but in a human timeframe it is vast. It is easy for geologists to become complacent about the immensity of geological time, and difficult for non-geologists to assimilate it. An analogy that may help is to picture the history of the earth as a calendar year, in which the earth formed at midnight on the 1st January. Multicellular life appeared during mid-November and mammals on the 15th December. The dinosaurs died out on the 27th December and *Homo sapiens* (us!) appeared at 11.40 pm on the 31st December. On this scale the life of an average person would be about half a second!

Also, geological processes are overall very slow. Geological texts (and this book) are full of statements such as “the continents collided”, “Australia split from Antarctica”, “a mountain range was uplifted”, “the sea advanced across the land”. Processes like these actually take place over many thousands, millions, or even hundreds of millions of years. Australians, had they been around at the time, would not have noticed Antarctica disappearing into the distance. Continents do not collide with a single great crash. For example India is currently colliding with Asia, forming the Himalayan mountain range—and has been doing so for the past 50 million years. Rapid geological events such as earthquakes, volcanic eruptions or landslides certainly occur, but are merely jolts in the overall slow processes.

Because of its vastness, it is impossible to compress a true feeling for geological time into the time it takes to read a book. The narrative must inevitably be rushed.

As you read, it will sometimes seem that the continents are scurrying over the earth's surface like ships ploughing across the ocean and bumping into each other, or that the sea is sweeping over the land like a tidal wave. From time to time it is a good idea to pull back and remember that all this is very, very slow and gradual. A good plan is to look at your little fingernail—it is growing at about the same rate at which continents move, a mountain range is uplifted or sea invades a continent.

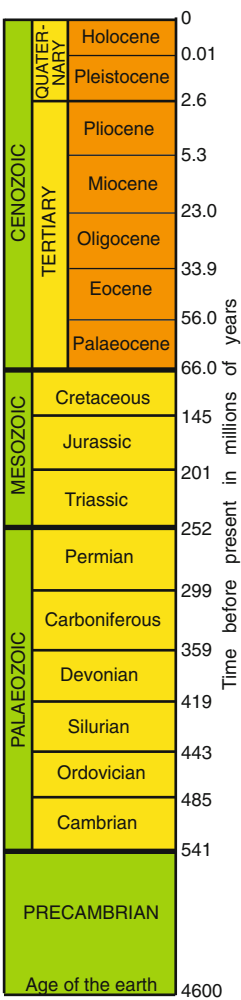
2.1 The Geological Time Scale

Because geological time is difficult to measure precisely, and until the first part of the 20th century could not be measured numerically at all, geologists often prefer to speak in terms of geological eras, periods and epochs rather than numbers. It is similar to the way that we may speak of something as happening during the Middle Ages, or during the Axumite period, rather than stating its precise date. Over many decades a geological time scale has been constructed along these lines, and it is worth taking a little time to examine it since the terms it uses will inevitably crop up throughout this book.

The geological time scale, illustrated in Fig. 2.1, is built largely on the basis of life and evolution. The first major boundary is defined by what was believed at the time to be the first appearance of life on earth. The span of time before life appeared was termed the Precambrian era and that following its appearance was divided into three eras: the Palaeozoic (ancient life), Mesozoic (middle life) and Cenozoic (new, or recent, life). Although it is now known that simple life forms did exist during the Precambrian era, the boundary between it and the Palaeozoic certainly represents the sudden (in geological terms!) appearance of an amazing variety of complex life. An earth almost devoid of life became one teeming with it.

The Palaeozoic, Mesozoic and Cenozoic eras are divided into periods. Most of the period names, such as Cambrian, Ordovician and so forth, are rooted in early geological studies undertaken in Europe. The boundaries between the periods are defined by the appearance or disappearance of particular life forms in the fossil record. For example, the boundary between the Silurian and Devonian periods is defined by the appearance of a certain species of graptolite—a microscopic creature that lived in colonies resembling leaf impressions. Some boundaries are marked by the disappearance of a very large number of species. This is referred to as a mass extinction. The best-known mass extinction is that marking the boundary between the Cretaceous and Tertiary periods, when the dinosaurs and their

Fig. 2.1 The geological time scale (current in 2015). Eras are shown in *green*, periods in *yellow* and epochs in *orange*. Note that it is not drawn to scale. If it were, the Precambrian section would not fit on the page as it would be almost a metre long



relatives, and a great number of other species living at that time, disappeared. The Quaternary period is not defined by life forms, but by the onset of the great ice ages when glaciers and ice sheets advanced and retreated over much of Europe and North America.

The Tertiary period¹ is further subdivided into five epochs whose names reflect the type or number of new species that emerged. Their names all end in “cene”, from a Greek word *kainos* meaning “new”. Thus Palaeocene means ancient new (species); Eocene, the dawn of new (species); Oligocene, few new (species); Miocene, less new (species); Pliocene, more new (species). The Quaternary period is subdivided into two epochs on the same basis: the Pleistocene, most new (species), and Holocene, wholly new (species).

It was not until the mid-20th century that actual ages, in numbers of years, came to be assigned to the eras, periods and epochs. This was thanks to the discovery of radioactivity, and the realisation that tiny amounts of radioactive elements contained in many types of rock acted as a kind of geological clock. Basically, the more a radioactive element has decayed, the older is the rock which contains it. As measurement techniques became more sophisticated, ages became more precisely determined. Even today the ages defining the boundaries on the geological time scale are continually being revised, updated and more significant figures added. The geological time scale illustrated is the current one at the time of writing.

¹Shortly before this book was written the International Commission on Stratigraphy formally abolished the term “Tertiary”, replacing it by the Palaeogene (Palaeocene, Eocene, and Oligocene) and Neogene (Miocene and Pliocene). In my opinion this has served merely to confuse something which is already sufficiently complicated and I will continue here to use the old and more familiar term Tertiary.

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