CHAPTER 4

# The measure of time

**Key words:** Chronostratigraphy, radiometric dating, biostratigraphy.

## Introduction

For easily communicating the age of the rocks and other geological materials we find on planet Earth, we need a stable and internationally agreed sequence of named time units, into which the history of the planet can be divided. Such a sequence is known as Chronostratigraphic time scale (see 4.1) and the definitive version of this is the 'International Stratigraphic Chart' produced by the International Subcommission on Stratigraphy and available at www.stratigraphy.org. All the rocks making up the crust of planet Earth – and the processes that created them or affected them after their initial formation – can be related to this time scale and their relative age stated. Correlation with this timescale is carried out using a range of methods including lithostratigraphy, biostratigraphy, isotope stratigraphy, radiometric dating, magnetostratigraphy, event stratigraphy, cyclostratigraphy, seismostratigraphy, sequence stratigraphy, tectonostratigraphy and tephrochronology (see also 4.2 and 4.3).

## 4.1. What is the Chronostratigraphic Time Table

The chronostratigraphic time scale divides the time which has passed since the first formation of the Earth, some 4.6 billion years ago, into a series of named time units, based on geologic rock-sections (for all but the oldest rocks). The basic chronostratigraphic unit is the 'Stage'. Stages are grouped together into Series, series into systems (which are equivalent to 'periods'), systems in erathems and erathems in Eonothems.

The lower boundary of a chronostratigraphic unit is defined at a fixed level in a rock sequence, at a 'type locality'. This sequence forms a standard reference for the unit and the locality is known as a '**G**lobal **S**tratigraphic **S**ection and **P**oint', or GSSP. The top of the unit is equivalent to the base of the next, younger chronostratigraphic unit, correlated from its own GSSP. For instance the Zanclian and Piacenzian stages make up the Pliocene Series, the Pliocene and the Miocene series together comprise the Neogene System; the Neogene together with the Paleogene and Quarternary systems make up the Cenozoic Erathem and the Cenozoic with the Paleozoic and the Mesozoic erathems comprises the Phanerozoic Eonothem.

## 4.2. How determine the age of strata by studying fossils

We can use various correlation methods to establish the relative age of rocks around the world and correlate them with the international time scale. These include matching rocks of a distinctive type (or 'lithology') or similar fossil contents, or by using actual dates in millions of years derived from the study of certain radioactive isotopes of certain elements that they might contain. 'Biostratigraphy' is a correlation method using fossils and is used to date most sedimentary rocks. If we find fossils in a rock, we usually know from studies elsewhere their age relative to the chronostratigraphic time scale, and hence we can demonstrate that our samples must belong to the same named chronostratigraphic units, such as a system or stage (or sometimes an even finer time division, known as a 'chronozone' or 'biozone').

Biozones are relative time divisions recognized solely by their fossil content. The difference between successive biozones is often a consequence of evolutionary changes in the selected 'indicator' fossil, each successive biozone being equivalent to the time interval through which a named species lived. Sometimes, however, changes in ecology can mean that biozones can be recognized by changes in the relative abundance of certain species through time or even different assemblages of fossil species.

## 4.3. How determine the age of the Earth by using radiometric methods

Radiometric dating uses the fact that radioactive isotopes of different elements (known as "parent-isotopes"), decay to form a specific "daughter isotopes" at a fixed rate known as the elements 'half-life'. The parent isotope is incorporated into the crystal structure of a mineral in an igneous or metamorphic rock when it forms, after which it decays to its "daughter" isotope at a constant rate. By analyzing the relative amounts of both parent and daughter isotopes in a sample of the rock or mineral, for instance using masspectrometry, it is possible to calculate the age of the sample using the known half-life for the decay of the parent to the daughter isotope. This date is quoted in years, for instance millions of years, but as there may be experimental errors, this date is known as a 'radiometric date', rather than an 'absolute date', as it may change slightly as analytical techniques improve.

**Intended learning outcomes:**

- Know how rocks and geological events may be dated, both relatively and in terms of radiometric dating.
- Know what is meant by an "a geological time scale".
- Understand the principles of stratigraphy.
- Interpret a Chronostratigraphic timescale.
- Know the age of the rocks of your region.

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