Book reviews

BOOK REVIEW

The Concise Geologic Time Scale

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Felix M. Gradstein

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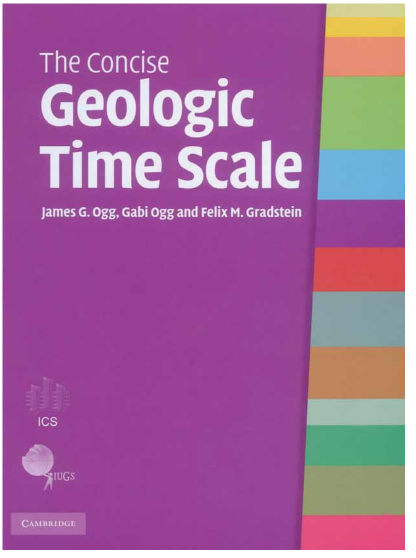

Contents

»This concise handbook presents a summary of Earth's history over the past 4.5 billion years as well as a brief overview of contemporaneous events on the Moon, Mars and Venus«. This first sentence of the preface (p. iii) and the colored plate »Geologic Time Scale« before (left) the title page (p. iv) define and summarize in the best way the rich, highly interesting and important contents of this excellent book. The Geologic Time Scale is especially impressive and instructive, representing in fact the whole »calendar« of Earth's history from the very beginning up to the present day. Therefore it is worth looking first carefully at that Time Scale beginning in the right lower corner of the page: the deeply colored purple field shows, at its left border (see Fig. 1 in this text), a duration from more than 4600 to 4000 Ma (million years)*, thus more than about 600 Ma, which is more than that of the whole Eon Phanerozoic (542 Ma). The wavy line at the bottom symbolizes the uncertainty in time determination. Due to the absence of any reliable data the Hadean is left out of the Eon – Era … system. On the left side of the same column, one sees that, after the Hadean, the Eons Archean (4000–2500 Ma) and Proterozoic (2500–542 Ma) follow which, together with the Hadean, represent the enormously long time interval commonly called Precambrian (4600–542 Ma). The time interval from 542–0 Ma is the Eon Phanerozoic, the already well known part of Earth's history, which has been, for a century, an important chapter of the natural history teaching in grammar-schools. It should explicitly be pointed out that the Precambrian was about 7.5 (7.487) times longer than the whole Phanerozoic.

The Eons are subdivided into Eras, Eras into Periods, Periods into Epochs, Epochs into Age/Stage units. To facilitate the reading of age-values (Ma) the age scale is doubled. The scale on the left side is continuous, while the scale on the right border marks only the exact values of the boundaries between the divided and the subdivided parts of the Eon-Era-Period-Epoch-Age/Stage system (see Fig. 1).

In the Introduction (p. 1), the book The Concise Geologic Time Scale is characterized as the framework for deciphering the history of our planet Earth, and, in this sense, this book is a summary of the status of that scale and is intended to be a handbook. The readers who desire more background and details will find the necessary references at the end of each chapter and especially in the book by Gradstein, F.M., Ogg, J.G., Smith, A.G. et al.: A Geologic Time Scale 2004, CambridgeUniversity Press, Cambridge. In the Introduction, the following topics are also explained and discussed: International divisions of geologic time and their global boundaries; Biologic, chemical, sea-level, geomagnetic and other events or zones; Methods for assigning numerical ages; Time scale creator database and chart-making package; A geologic time scale 2010.

In the second chapter the formal stratigraphic systems, developed for the surfaces of Earth's Moon, Mars, Mercury and Venus, using the results of contemporaneous interdisciplinary space research, are presented and discussed. Some of the results are visible from the developed time scales.

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* In the book, the following time units are used:
Ma Megaannuum = l myrs: l million years = 10^6 years;
Ga Gigaannuum = 1 billion years = 10^9 years.

According to the data in the book (p. 18–19) the following time intervals are proposed, on the:

- Moon of the Earth: the pre-Nectarian (4600–4200), the Nectarian (4200–3800), the Imbrian (3800–3200), the Eratosthenian (3200–2200,? (2200–1250) and the Copernican Period (1250–0) Ma.
- Mars: the pre-Noachian (4600–4200), the Noachian (4200–3600), the Hesperian (3600–2600) and the Amazonian Period (2600–0) Ma.
- Venus/Mercury: the pre-Tolstojan (4600–4000), the Tolstojan(4000–3800), the Calorian (3800–3200), the Mansurian (3200–1700) and the Kuiperian Period (1700–0) Ma.

About other bodies in the Solar System there is not much known as yet.

The third chapter treats the Precambrian, which is not a stratigraphic unit at all. The period just refers to all rocks originating from the beginning of the Earth to the onset of the Cambrian (the first Period of the Phanerozoic), i.e. during the time interval from 4600–542 (= 4058) Ma (see Fig. 2).

Before the formation of the oldest preserved rock, the Earth already passed the first phase of its history in a time interval of more than 537 Ma, called mostly the Hadean, which was nearly as long as the whole Eon Phanerozoic. The Hadean is followed by the Eons Archean (4000–2500 Ma) and Proterozoic (2500–542 Ma). The whole Precambrian (Hadean + Archean + Proterozoic) lasted thus, as already mentioned, 4058 Ma, i.e. 7.5 (7.487) times longer than the whole Phanerozoic, which is the only subject of the following 12 chapters (4^{th}–15^{th}, pp. 37–158).

The Eon Archean comprises 4 Eras: the Eoarchean (4000–3600), the Paleoarchean (3600–3200), the Mesoarchean (3200–2800) and the Neoarchean (2800–2500) Ma (see Fig. 2).

The Archean-Proterozoic transition is generally considered significant and useful, although it is not yet scientifically well defined.

The Eon Proterozoic is subdivided into 3 Eras: Paleoproterozoic (2500–1600), Mesoproterozoic (1600–1000), and Neoproterozoic (1000–542) Ma (see Fig. 2).

The Paleoproterozoic has four Periods: the Siderian (2500–2300), the Rhyacian (2300–2050), the Orosirian (2050–1800) and the Statherian (1800–1600) Ma. The Mesoproterozoic has 3 Periods: the Calymmian (1600–1400), the Ectasian (1400–1200), and the Stenian (1200– 1000) Ma. The Neoproterozoic Era has three Periods: the Tonian (1000–850), the Cryogenian (850–650), and the Ediacaran (650–542) Ma.

The Eras Archean and Proterozoic are still under investigation by the chronostratigraphs, while the Cryogenian and the Ediacaran already appear to be better explored, to some extent.

In the North Pole Dome area of the Pilbara Craton (Craton is a relatively rigid and immobile region of the Earth's crust), northwestern Australia, in the Dresser formation, there is some evidence of the earliest life on Earth in the form of fossil stromatolites and highly fractionated $\delta^{13}C$ values of kerogen indicating a methan consuming life. This sedimentary unit of 3.49–3.48 Ga is conformably bound by well preserved pillow basalts of the Warrawoona Group.

Many scientists believe that the most significant change in Earth's history was the development of an oxygenated atmosphere, as this allowed for the evolution of complex life on Earth, including even Primates and the genus *Homo*. Oxygenation is considered to be the result of the processes of gas exchange in cyanobacteria which use CO_2 and sunlight to produce energy-rich carbon compounds releasing free oxygen as a waste product. Some geological changes followed this change in atmospheric composition. So e.g. detrital uraninite and pyrite disappeared in sandstones, and redbets and Mn-rich sedimentary rocks appeared. Many redox-sensitive chemical tracers could be identified, including Mo-isotopes, Ce, Fe, Re-Os data, sulfur isotopes, and platinum group element concentration. As these products have various sensitivities to redox conditions, their ages could be determined according to various stages of the increase of oxygen levels.

The Archean-Proterozoic boundary only approximately indicates the rise of cyanobacteria and oxygenation of the atmosphere. There is some strong evidence that cyanobacteria arose considerably earlier (2.7 Ga) than the onset of oxygenation of the atmosphere. A critical step in the oxygenation of the atmosphere occurred at ~2.32 Ga with the disappearance of the mass-independently fractionated isotope signature (S-MIF), which indicates the development of an ozone layer requiring a partial pressure of oxygen of $\sim 10^{-5}$ of the present atmospheric level. This signal disappeared within the period of global, low-latitude Paleoproterozoic glaciations and near the onset of the Lomagundi-Jatuli positive $\delta^{13}C$ isotopic excursion.

The predicted drop in partial pressure of CO_2 in the atmosphere across the Archean--Proterozoid boundary should produce a change from predominantly chemical weathering to dominantly physico-mechanical weathering. This change in weathering manner is the consequence of decreasing concentration of carbonic acid (H_2CO_3 formed by the binding of H_2O and CO_2 being under higher partial pressure, increasing in this way the acidity (lowering the pH) of the water in oceans, rivers and rain (taken from pp. 28 and 29).

Beginning with chapter 3 (Precambrian Period) there is, at the top of the first paragraph, a paleogeographic map showing the geographic distribution and position of the developing continents during the treated Period. These instructive and attractive paleogeographic maps were provided by Christopher Scotese. It should be mentioned that some positions of continents are, however, still uncertain. In chapter 3 (Precambrian Period), the paleogeographic map shows the situation at the Cryogenian Period (650 Ma), thus, just before the beginning of the Cambrian Period.

On the paleogeographic map of chapter 9 (Permian Period) in the complex of later continents and continental parts one can recognize the future: Australia, Antarctica, India, Africa (with its whole southern part), South America, parts of North America (with Alaska), Siberia, Kazahstan, North and South China, and Malaya (see Fig. 3).

Each of the chapters 4 to 15 treats one Period of the Phanerozoic Eon (see Contents) and contains, according to the schedule mentioned in the Introduction, the following sections: History and base of the treated Period; International subdivisions of the Period; Selected aspects of the Period's stratigraphy; Numerical time scale (current status / GTS 04, corrections –or:/current status and future developments; Acknowledgments – Further reading -Selected on-line references.

After the last chapter (15) the book finishes with Appendix 1 (Standard colors of international divisions of geologic time), Appendix 2 (Ratified Global boundary sections and points for geologic stages) and the Index.

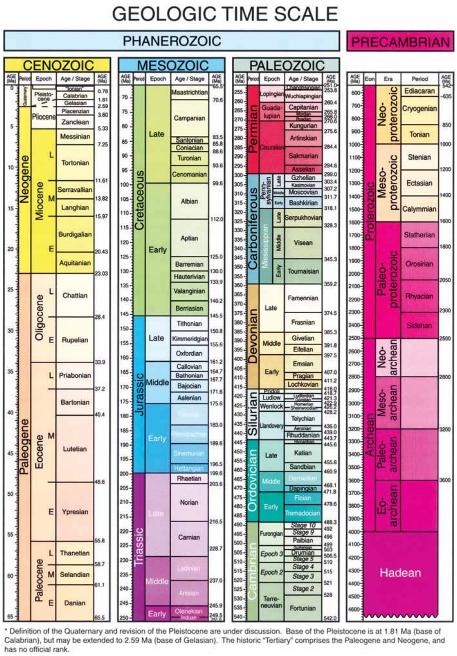

Fig. 1.

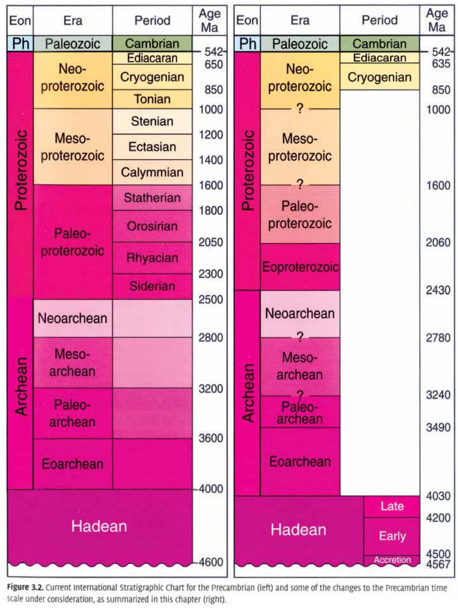

Fig. 2.

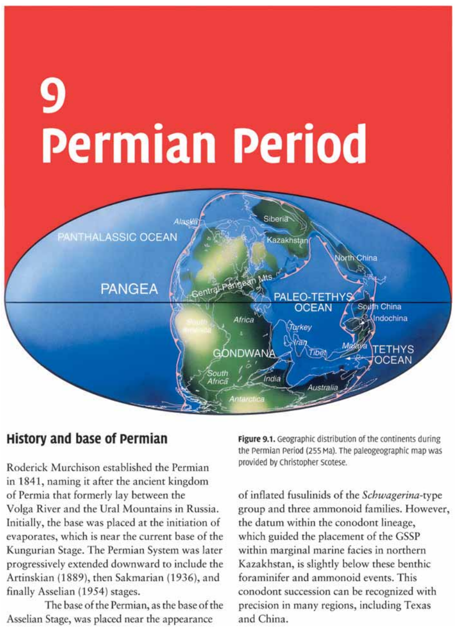

Fig. 3.

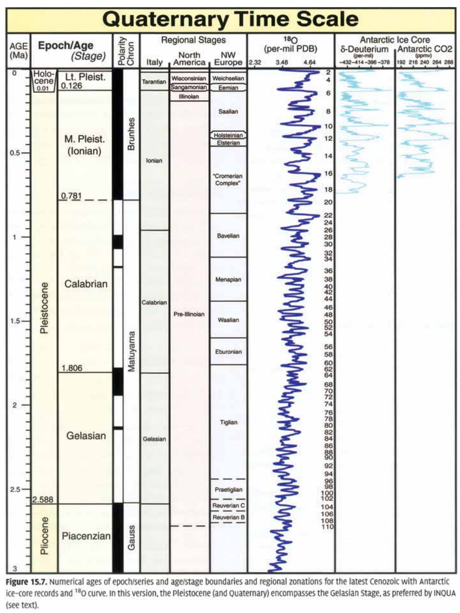

Fig. 4.

Figs. 1–4. Illustrations in the book. Fig. 1 – geologic time scale (p. ii). Fig. 2 – current international stratigraphic chart for the Precambrian… (p. 25). Fig. 3 – paleogeographic map showing the distribution of the continents during the Permian Period (p. 85). Fig. 4 – Quaternary time scale (p. 155).

The text of the book is perfect in any regard, being accompanied by many illustrations of the highest quality: drawings, photographs, in the chapters 4 to 15 predominantly photographs and profiles of GSSP-localities as well as time scales containing also regional subdivisions, and in the last columns, details about Biostratigraphy, Magnetic stratigraphy, Cycle- and Stable- isotope stratigraphy, Eustatic stratigraphy (Sea level changes) etc. (see Fig. 4).

In this book, it is repeatedly pointed out that this is an essential reference book for all geoscientists, including researchers, students and mining professionals. The present book review, written by a non-geoscientist, has the explicit intention to draw the attention of the reader to the fact that biologists (especially paleobiologists, paleobotanists, plant phylogeneticists, plant taxonomists, plant physiologists, paleozoologists, evolutionists, cell biologists, molecular geneticists etc. as well as general biologists) are also highly interested in The Concise Geologic Time Scale 2008, which is doubtlessly a fascinating, attractive and in any regard most important book.

If we remember that about a half of century ago we did not know any fact which would allow us to make even some of the simplest reasonable speculations about the beginning of the early history of our planet Earth, then we must now confess that one can indeed hardly find words to express one's admiration of the magnificent progress which the geoscientists-chronostratigraphs and their multidisciplinary coworkers accomplished in this part of geosciences. In this sense, it is even not easy to praise enough the high value of The Concise Geologic Time Scale 2008.

Therefore there is no doubt that this handbook will soon be on the bookshelf of any natural scientists in the world.

Acknowledgment

The author of this book review wants to express his best thanks to The Cambridge University Press for giving him the permission to publish at reduced size the front cover and the pages ii, 25, 85, and 155 of the book The Concise Geological Time Scale, by James G. Ogg, Gabi Ogg and Felix M. Gradstein, Cambridge University Press, Cambridge, 2008.

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