Issues with the Precambrian time scale: The status quo and beyond

Wouter Bleeker
Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada, K1A 0E8
email: wbleeker@nrcan.gc.ca

From the genesis of planet Earth (ca. 4.55 Ga) to the emergence of shelly fossils at the beginning of the Cambrian Period (ca. 542 Ma), the Precambrian spans 88% of Earth's history. Yet, there is no complete and coherent time scale and nomenclature for this larger part of the history of our planet. The present time scale (Fig. 1) is incomplete, partly informal, used inconsistently and, as some would argue, fundamentally flawed because of its reliance on boundaries defined by absolute ages [e.g., 1]. Due to small but non-trivial uncertainties in decay constants, even for the U-Pb decay system, it is strictly impossible to pin-point externally defined absolute age boundaries in extant stratigraphic sections with any certainty. For instance, at ca. 2500 Ma, typical fuzziness due to decay constants is +/- 6.5 Ma.

In agreement with ICS[1] objectives to define all major boundaries in terms of GSSPs[2], the Precambrian time scale should be redefined in terms of the extant rock record and first-order events in Earth history. The final construct should be a comprehensive and "natural" time scale that 1) is pragmatic, 2) allows for easy and stable communication between scientist from different disciplines (e.g., early Earth researchers, planetary scientists, Precambrian stratigraphers), and 3) honours many of the first-order events and transitions in the history of our planet. The early part of the time scale should be in agreement with the latest insights from planetary science. Such a natural time scale would be more intuitive and help convey the dynamic history of planet Earth, to scientists and non-scientists alike.

A new international Subcommission on Precambrian Stratigraphy has been established, tasked with completing the time scale and advancing proposals for GSSP-based boundary definitions. General requirements for Precambrian GSSPs are that they reflect first-order stratigraphic events. If possible, these events should be global in expression. And the selected boundaries and stratotype sections should lend themselves to precise dating, ideally by multiple methods. Boundaries will become fixed in the rock record, whereas their calibration in absolute time will involve an inherent uncertainty and may even change in detail if decay constants improve. Precisely dated boundaries may be correlated worldwide by using zircon geochronology or other methods, as long as similar methodology is employed in different locations (e.g. $^{207}Pb/^{206}Pb$ intercept ages). It is acknowledged that some potential boundaries may be largely symbolic, with little prospect for global correlation. An example would be a formal Hadean-Archean boundary defined by the first appearance (preservation) of supracrustal rocks in the geological record.

Overall, the evolution of planet Earth divides itself into six natural eons:

- An early eon of accretion and differentiation.
- A Hadean Eon, starting with the Moon-forming giant impact, a tailing heavy bombardment, vigorous internal convection, and little remaining rock record.
- The Archean Eon, starting with the first appearance of a meaningful supracrustal record and culminating with a period of rapid crustal growth.
- A transition eon, starting with giant BIFs in regionally extensive and little deformed platform sequences and culminating with the progressive oxygenation of the atmosphere.

[1] International Commission on Stratigraphy, a body of IUGS.
[2] Global boundary Stratotype Section and Point, also known informally as "golden spikes".

- A (shortened) Proterozoic Eon characterized by a geodynamically and geochemically almost modern Earth, its onset defined by the first appearance of unequivocal terrestrial red beds (~2.2 Ga).
- The Phanerozoic Eon, characterized according to its classical definition by the appearance of obvious metazoan life forms.

Replacing the present time scale with a GSSP-based time scale could be implemented without major change to terminology that has at least been partly accepted. An interesting question is whether the newly defined Ediacaran Period should be part of a downward extended Phanerozoic Eon (i.e. "obvious life") or remain in the Proterozoic Eon.

References:

[1] Bleeker, Wouter, 2004. Towards a 'natural' time scale for the Precambrian—A proposal. Lethaia, vol. 37, p. 219-222.
[2] Plumb, K.A., 1991. New Precambrian time scale. Episodes, vol. 14 (2), p. 139-140.

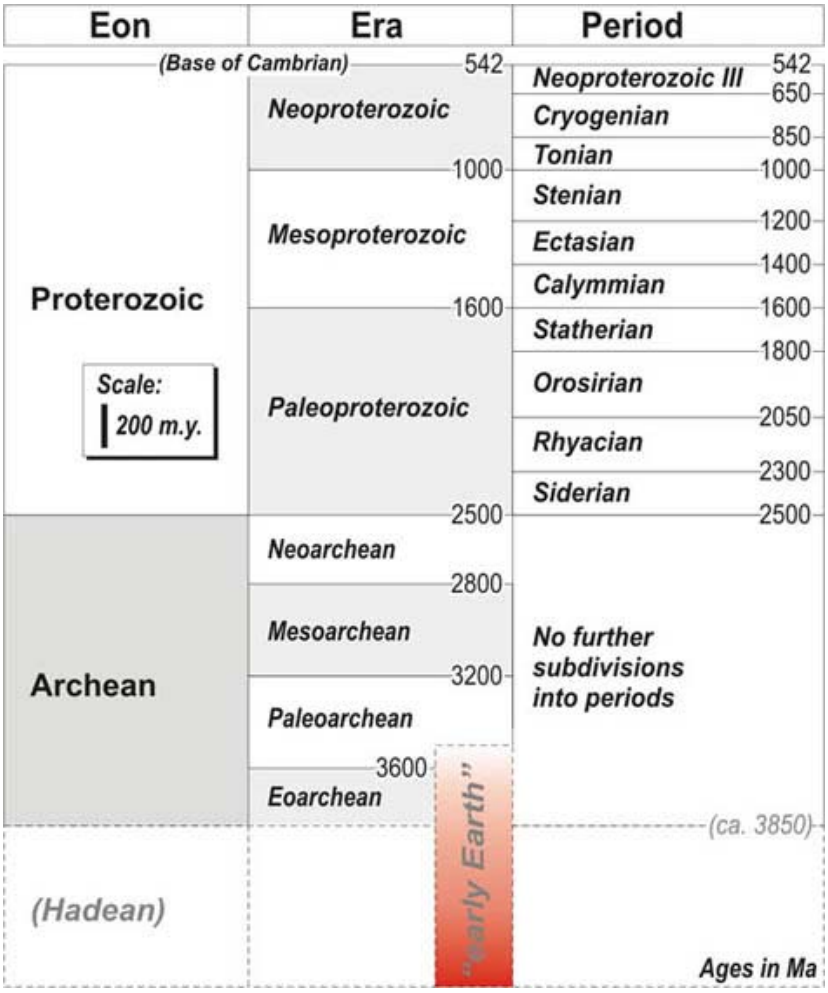

Figure 1: The "status quo". The present chronometrically defined Precambrian time scale (after [2]). The Archean and its subdivisions remain informal, with no defined beginning. The commonly used Hadean eon has been added here for completeness but was not part of the 1991 proposal. The Neoproterozoic III has been redefined as the Ediacaran Period.