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THE GEOZOIC SUPEREON

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Geological time units are the lingua franca of earth sciences: they are a terminological convenience, a vernacular of any geological conversation, and a prerequisite of geo-scientific writing found throughout earth science dictionaries and textbooks. Time units include terms formalized by stratigraphic committees as well as informal constructs erected ad hoc to communicate more efficiently. With these time terms we partition Earth’s history into utilitarian and intuitively understandable time segments that vary in length over seven orders of magnitude: from the 225-year-long Anthropocene (Crutzen and Stoermer, 2000) to the ~4-billion-year-long Precambrian (e.g., Hicks, 1885; Ball, 1906; formalized by De Villiers, 1969).

Given the importance of such chronostratigraphic units (sensu Zalesiewicz et al., 2004), it is surprising that the key event in the Earth’s history, the first appearance of life, is not recognized as a major time boundary. This omission may reflect the relative youth of the field of Precambrian paleobiology. The earliest definitive reports of pre-Ediacaran fossils date to the 1950s (Tyler and Barghoorn, 1954), and only in the last few decades have details of life’s early history begun to emerge (e.g., Schopf, 2001; Knoll, 2004). This recent progress in the understanding of early life sets a foundation for augmenting the geologically-derived time units used for the Earth’s early history with biological ones, which have already proven so effective when organizing the chronology of the more recent geological past.

In recognition of the importance of life in the Earth’s history and the efficiency offered by chronostratigraphic terms, we propose to divide the geological time scale into two informal supereons: Pregeozoic (the abiotic supereon) and Geozoic (the biotic supereon).

DEFINITION OF THE GEOZOIC

The Geozoic denotes the time of life’s existence on our planet. Its lower and upper boundaries are defined by the first and last appearance of life, respectively. The upper boundary cannot be defined until life has gone extinct on our planet. However, ample precedent exists for open-ended boundaries. For example, the Cenozoic and the Quaternary are formal units that potentially (and continually) transcend the present. Yet, their top boundaries are set at 0 yrs on geological time scales, which is not only permissible, but also conservative. The end point of the Geozoic can be only younger than today: life is still unequivocally present on Earth.

The lower boundary is uncertain due to controversies surrounding the earliest records of life. Molecular clock analysis places the divergence between archaeabacteria and the archaebacterial genes in eukaryotes at 3.97 ± 0.32 Ga (Hedges et al., 2001), but such estimates are not without problems. The oldest proposed direct geological evidence for life comes from geochemical signatures in ca. 3.8 Ga rocks.
The term Geozoic denotes the time of life on Earth (Geo = Earth and zoic = life). To be semantically precise, -zoic denotes animal life. However, in geological terminology, the suffix -zoic is used more broadly to denote any life. Thus, textbooks and dictionaries translate Phanerozoic as the time of visible, obvious, evident, or well displayed life (e.g., Whitten and Brooks, 1978; Stanley, 2009), and not the time of visible animal life. The largely abandoned term Cryptozoic is defined as the time of hidden or obscure life (e.g., Prothero and Dott, 2010), and not obscure animal life. Although some of the -zoic terms were originally proposed to denote animals, usage of the suffix has evolved to denote all life.

Following our conference presentation on the Geozoic (Kowalewski et al., 2009), multiple colleagues inquired why we had not considered the term Biozoic. This term is problematic. First, the suffix -zoic is used by geologists to denote all life, which makes Biozoic redundant. Also, the prefix bio, could be misread as an emphasis of the strict meaning of life (e.g., Whitten and Brooks, 1978; Stanley, 2009), and not the time of life. Rather, they aim to codify our vocabulary by acknowledging the most important event in the history of life.

**ETYMOLOGY AND ALTERNATIVE TERMINOLOGY**

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The term Pregeozoic is derived based on the same logic that had been used to coin the term Precambrian (but see Martinsson, 1973). Pregeozoic is synonymous with Azoic (Martinsson, 1973; see also Goldblatt et al. [2009] for discussion of pre-Archean, non-biotic time units). The term Azoic does not make any reference to Earth and could serve as a counterpart to the term Zoic to denote the prebiotic history of the Universe. Admittedly, the terms Zoic and Azoic sound like
names of evil characters from a low budget sci-fi movie and may thus be not mundane enough to be acceptable as chronostratigraphic terms.

Online searches (Georef, ISI Web of Knowledge, and Google Scholar; 11/30/2009) suggest that the term Geozoic has not been used in the geoscience literature. Our recent abstract (Kowalewski et al., 2009) is the only relevant occurrence of the term. A Google search (11/30/2009) yielded 57 hits for the Geozoic. Except for those pertaining to our abstract, these entries represented blogger names, e-Bay postings, and other obscure hits, including a Trojan virus that delayed somewhat the preparation of the manuscript.

PRACTICAL JUSTIFICATIONS

Successful terms are invented because they are needed for a specific reason and then propagate because they prove useful beyond their original need. The term Geozoic was invented because the NESCent Body Size Working Group (2006–2009) needed a simple term to refer to the entire fossil record (as in “the Geozoic history of body size”). With that need came a realization that such a term would be useful, for multiple reasons, to many researchers who study the bulk or the entirety of life’s history.

1. A purely pragmatic reason for introducing new terminology is linguistic parsimony. Terms save words and characters, allowing for shorter titles and succinct abstracts. Brevity is not just desirable, but often required: many journals set stringent limits on the length of titles, abstracts, or text. The published literature offers many cases that illustrate potential utility of the term Geozoic. For example: “…little evolution at the macroscopic level took place for over half of the entire history of life on Earth” (Schulze-Makuch and Irwin, 2004, p. 39) could be “…little evolution at the macroscopic level took place for over half of the Geozoic;” “We would argue that it is simplistic to expect only one pattern of stability in the entire fossil record” (Tang and Bottjer, 1997, p. 475) could be “We would argue that it is simplistic to expect only one pattern of stability in the Geozoic”; and “…together comprise <20% of the total duration of life on Earth” (Payne et al., 2009, p. 24) could be “…together comprise <20% of the Geozoic.” The time terms are particularly useful in titles, which are often more effective when brief. For example, the title: “Biotic enhancement of weathering and surface temperatures on earth since the origin of life” (Schwartzman and Volk, 1991, p. 357) could be shortened as “Biotic enhancement of weathering and surface temperatures in the Geozoic.”

2. The need for Geozoic is illustrated by inadequacy of existing terms, often used due to lack of appropriate terminology. An ISI Web of Knowledge search (12/02/2009) for the subject “Phanerozoic” revealed that the journal *Precambrian Research* published 119 papers apparently focused on post-Precambrian times (only four journals published more papers on the Phanerozoic). Very likely, those papers dealt with both the Precambrian and Phanerozoic, but lacked a single subject tag to denote such a long time interval. The Geozoic tag could allow one to highlight papers (whether published in *Precambrian Research* or elsewhere) that deal with both the Precambrian and the Phanerozoic. Use of the term could also place greater emphasis on the origin of life as a critical temporal event. The term would likely work even for studies that do not pertain to the entirety of the Geozoic. Chronostratigraphic terms are used often to denote major portions or select segments of a given time interval. For example, authors find it convenient to use Phanerozoic when analyzing its select parts (e.g., Powell and Kowalewski, 2002; Riding, 2002) or Cenozoic when primarily focusing on the Neogene (e.g., Funk et al., 2009).

3. Temporal units are indispensable indexing tags for identifying publications that deal with specific time intervals or target temporal scales of a given magnitude. Anyone interested in large-scale patterns in the evolution of multicellular life can use the Phanerozoic tag to find many relevant publications, while those interested in recent changes in ecological communities can use the Holocene tag to assemble their initial bibliography. Why then, having such efficient terms for biologically relevant time scales and time intervals, do we lack the most important tag? We have a special name for the time of old life on Earth (Paleozoic). We have a name for the time of obvious life on Earth (Phanerozoic). However, absurdly, we lack a name for the time of life on Earth (Geozoic).

4. The Geozoic–Phanerozoic terminology could also facilitate a more transparent organization of introductory geological textbooks. Currently, textbooks are organized lucidly for the Phanerozoic part of the Earth’s history, often having time-parallel sections on biological and geological processes (e.g., Paleozoic Life and Paleozoic Earth), but their Precambrian parts are less intuitive chronologically. In particular, the text dedicated to the origin of life and earliest life is often buried in chapters that deal with the whole Archean or even Archean and Hadean. This problem relates to the lack of explicit separation of the prebiotic and biotic Earth. The Geozoic offers a convenient tool for presenting the Precambrian history of life in a more structured manner in textbooks and in classrooms.

5. Finally, the term Geozoic may become increasingly useful as the perspective of evolutionary research continues to expand, especially with the discovery of water-bearing worlds in our own Solar System.
linguistically—fast in dispersal and resistant to terminological extinctions.

“In the world of components there are no equivalents,” noted Erofeev (1994, p. 68), when discussing substitute alcoholic drinks that Russians enjoyed during the Soviet Era. We believe that this dictum applies to the Geozoic; a supereon that denotes the entire documented history of life on our planet with just one seven-letter word. None of the currently used time units offers comparable terminological expedience. None recognizes the historical importance of life as concisely.

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