Building a high-resolution digital geological timeline: A perspective for stratigraphy

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Abstract

The Earth has a history of approximately 4.5 billion years, leaving behind a myriad of geological records, and the geologic timeline is the only common language available to unravel the evolutionary history of the Earth. Since the 1960s, the International Commission on Stratigraphy (ICS) aims to establish a universal standard chronostratigraphy for intercontinental and regional correlations. The ICS currently uses the Global Stratotype Section and Points (GSSP) method to define geologic time boundaries. To date, 78 out of 102 GSSPs have been officially defined so far, which is an impressive achievement that is attracting worldwide attention. However, we have all recognized that there are some obstacles to precisely placing the stratigraphic horizon of a GSSP. The most common challenge is that all fossil records are far from complete, and it is theoretically impossible to identify the absolute first occurrence of an index fossil species, and thus the previously defined GSSP can be frequently overthrown by subsequent earlier "first" occurrences of index fossils. In addition, the GSSPs defined by biostratigraphy commonly contradict with other physical or chemical markers (e.g., volcanic ash beds, isotope excursions, geochemical anomalies, etc.) that are of isochronous significance. All geological records have temporal and spatial properties and thus should be valuable for intercontinental and regional correlations. The 21st century has entered an era of the widespread application of big data and artificial intelligence. Building a high-resolution geological timeline based on big data of all geological records is an urgent mission for stratigraphy in the next decade. The new geological timeline program we are expected to propose should bear the following characteristics: 1) Supported by global stratigraphic databases, we should comprehensively collect all stratigraphic sections containing fossil records. Once entered into the database, the data will be permanently stored and can be retrieved anytime to make full utilization of the comparative value of fossil records. 2) We could use applied statistics, artificial intelligence algorithms, etc. to correct the incomplete nature of fossil records and to obtain statistically optimal solutions for the ordering of stratigraphic information. 3) Combined with the geochronology, magnetostratigraphy, chemostratigraphy and cyclostratigraphy data, we could optimize the correlation between each profile and greatly improve the correlation accuracy. 4) The database can be updated at any time, and finally, a geological timeline of any time interval can be generated based on any selected or all data. The new digital timeline, once established, will greatly promote the quantitative study of the detailed timing, duration, and rate of a given event in Earth history, the integrated use of large environmental proxy data for numerical paleoclimate simulations, and the reconstruction of high-resolution biodiversity curves. It will promote and deepen research on the evolution of life, Earth materials, geography, and climate.

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Keywords: digital timeline, big data, GSSP, correlation