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Improving the Geologic Time Scale (Jean Baptiste Lamarck Medal Lecture)

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The Geologic Time Scale (GTS) provides the framework for the physical, chemical and biological processes on Earth. The time scale is the tool "par excellence" of the geological trade, and insight in its construction, strength, and limitations enhances its function and its utility. Earth scientists should understand how time scales are constructed and its myriad of physical and abstract data are calibrated, rather than merely using ages plucked from a convenient chart or card.

Calibration to linear time of the succession of events recorded in the rocks on Earth has three components: (1) the standard stratigraphic divisions and their correlation in the global rock record, (2) the means of measuring linear time or elapsed durations from the rock record, and (3) the methods of effectively joining the two scales, the stratigraphic one and the linear one.

Under the auspices of the International Commission on Stratigraphy (ICS), the international stratigraphic divisions and their correlative events are now largely standardized, especially using the GSSP (Global Stratigraphic Section and Point) concept.

The means of measuring linear time or elapsed durations from the rock record are objectives in the EARTH TIME and GTS NEXT projects, that also are educating a new generation of GTS dedicated scientists. The U/Pb, Ar/Ar and orbital tuning methods are intercalibrated, and external error analysis improved. Existing Ar/Ar ages become almost 0.5% older, and U/Pb ages stratigraphically more realistic. The new Os/Re method has potential for directly dating more GSSP's and its correlative events. Such may reduce scaling uncertainty between the sedimentary levels of an age date and that of a stage boundary.

Since 1981, six successive Phanerozoic GTS have been published, each new one achieving higher resolution and more users.

The next GTS is scheduled for 2011/2012, with over 50 specialists taking part. New chapters include an expanded planetary time scale, sequence stratigraphy, Osmium, Carbon and Oxygen stratigraphy, the Cryogenian period, history of the plants, hominid prehistory, and last but not least the Anthropocene.

The Cambrian Period is radically improved with 10 standard stages and detailed trilobite biochronology. Ordovician now has a stable international stages and graptolites scale. The integration of a refined 100 and 400 ka sedimentary cycles scale and a truly high-resolution U/Pb ages scale for the Mississippian is a major step towards the global Carboniferous GTS.

The Devonian GTS leaves to be desired with lack of firm definitions for its upper boundary, and the long Emsian stage; it also lacks age dates. Its stages scaling is disputed.

The Rhaetian and Norian stages in the Triassic and the Berriasian stage in the Cretaceous urgently require lower boundary definitions, and also boundary age dates.

The single $\sim$400 ka eccentricity component is very stable and can extend orbital tuning from the Cenozoic well into the Mesozoic portion of the GTS. Jurassic and Cretaceous now have long orbitally tuned segments.

A completely astronomical-tuned Geological Time Scale (AGTS) for the Cenozoic is within reach showing unprecedented accuracy, precision and resolution. Burdigalian in the Miocene, and Lutetian, Bartonian and Priabonian stages in the Eocene still require formal definition. The K/T boundary will become about 0.5 ± 0.1 Ma older.

After 25 years of research and authorship in the GTS it behoves me to especially thank my colleagues James Ogg, Frits Agterberg, John McArthur and Roger Cooper for longstanding collaboration. As a final note I urge construction of more regional time scales(like developed 'down under') calibrated to the standard global GTS, to scale regional rock units.