To solve many geological puzzles we need to know the sequence of events at the highest possible precision. **Daniel Condon[1]** and **Samuel Bowring[2]** describe a community-driven initiative for the improved quantification of geological time.

Earthtime

Quantification of geological time represents one of the fundamental challenges for earth scientists as it permits the determination of rates of change, integration of disparate geological datasets and assessment of coincidence (or lack thereof) so often central to hypothesis testing. Knowing the age of certain rocks, be it a thick accumulation of volcanic lava or an extinction layer, allows us to say something about causality. The extinction of the dinosaurs at the end of the Cretaceous Period, 'about' 66 million years ago is the poster child for such cause-and-effect arguments. At 'about' the same time, a large asteroid struck what is now the Gulf of Mexico, however a series of voluminous volcanic eruptions in India are also 'about' the same age. Both are viable kill mechanisms, and both are closely correlated in time with the extinction, but knowing they are 'about' the same age is not good enough.

As a result of demand for more constraints there are an increasing number of radioisotopic dates being produced, but they are often of variable quality and often not directly comparable, hindering our ability exploit the potential these methods offer. The EARTHTIME initiative is a community-based effort to focus attention on improving the techniques used for determining the absolute ages of rocks and minerals, and the application of these improved techniques to the calibration of at least the past 800 million years of Earth history. This requires using a unified, multichronometer (radioisotopic and cyclostratigraphical) approach integrated with palaeobiological and climate proxy datasets, enabling earth scientists to pose questions that rely on knowledge of precise rates of biological, geological, and climatic change. The goals of the first phase were to:

- forge links between geochronologists, palaeontologists, and stratigraphers, and identify key intervals of Earth history for which higher resolution temporal constraints are essential;
- develop the tools necessary to calibrate Earth history using both uranium and lead (U–Pb), and argon (^{40}Ar–^{39}Ar) geochronology; and
- develop a programme of education and public outreach.

Mass spectrometry is an analytical technique used to determine the amount of a given isotope such as ^{238}U or its daughter product ^{206}Pb. Advances in the technique mean that the radioisotopic dating of minerals can produce dates for certain rock types, such as volcanic ash, with a precision of 0.1 per cent or better. At 50 million years, this is an error of just plus or minus 50 000 years. These techniques, such as uranium–thorium–lead decay schemes exploited at the NERC Isotope Geoscience Laboratory (NIGL), can be used on rocks of nearly any age, from corals a few thousand years old to meteorites formed during the early years of our solar system.

Geologists examining the Cretaceous–Palaeogene boundary in Italy.

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Synthetic U-Pb 'age solutions'.

There has been a major effort to minimise and/or eliminate inter-laboratory and inter-technique bias. The U–Pb community has manufactured, distributed, and calibrated a ^{205}Pb–^{233}U–^{235}U tracer solution and synthetic 'age standards' to monitor long-term analytical reproducibility. The ^{40}Ar–^{39}Ar community has undertaken two major inter-laboratory comparison experiments involving more than twenty labs. Under controlled experimental conditions, variability between laboratories for relative ages of commonly used standards is significantly outside individually quoted precision.

Progress is being made in data reduction software that links to global databases for the long-term archiving of the data and metadata. This will ensure longer-term usefulness of the dates produced. Current efforts involve engagement with the U-series community in order to facilitate an improvement in the accuracy and comparability of methods used for dating climatic and environmental change during the past half million years. Furthermore, EARTHTIME outreach activities include development of curriculum for middle- and high-school students and hands-on exercises.

Our goal is to seamlessly integrate U–Pb, U–Th, ^{40}Ar–^{39}Ar, and cyclostratigraphical techniques to construct high-fidelity records of Earth history. Ultimately, the level of community involvement in general, and the forging of alliances between geochronologists and other earth science subdisciplines in particular, will determine the degree to which the goals of EARTHTIME are realised.

www.earth-time.org
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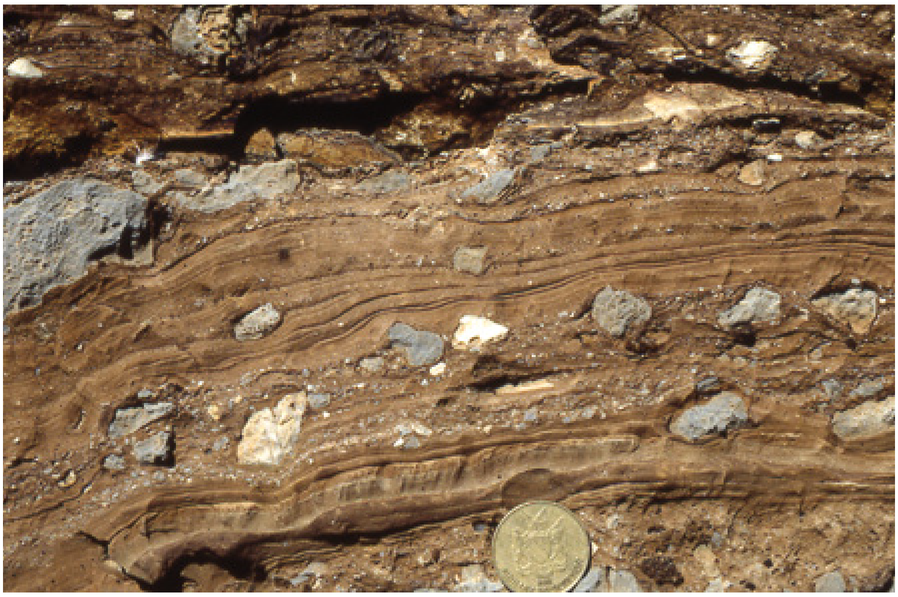

Evidence of 'snowball Earth'. Glacial rocks in Namibia dated at 635 Ma.