EARTHTIME: A community-based effort towards high-precision calibration of earth history

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Geological time is customarily treated as an "independent variable"; deductions and conclusions are made assuming that the geological timescale as given is precise and accurate. Current geological timescales are based on data of variable quality, commonly averaging dates obtained by different techniques, with differing (though often ignored) absolute uncertainties. Consequently, the greatest uncertainty in most analyses of geologic and evolutionary rates is the timescale itself. Recent advances in geochronology and correlation methods now allow us to reframe research into the timing and rates of geological and biological processes in deep time, producing a newly calibrated geological timescale with significantly improved accuracy and precision standards commensurate with new and emerging geochronologic and chronostratigraphic methodologies. To address these issues the EARTHTIME initiative has been proposed as a new community-based effort to focus attention on the calibration of at least the last 800 million years of earth history. This will allow earth scientists to address a whole new series of questions that rely on knowledge of precise rates of biological, geological, and climatic change. Two EARTHTIME workshops have been held, the first to discuss the need for better integration of geochronology and paleontology and the second, on intercalibration of the U-Pb and Ar-Ar chronometers. As an outgrowth of these two meetings we have proposed the production of a mixed ^{202}Pb-^{205}Pb-^{235}U-^{238}U spike for distribution to the international community and the sponsorship of a community wide intercalibration experiment using standard material (see Heizler et al., and Condon et al., this session). Community support is growing and we expect that this effort will fundamentally change our knowledge of the distribution of time in the rock record and give us unprecedented insight into the rates of geological, biological, and climatic processes in deep time. The EARTHTIME concept has wide application to all parts of the geological record and the Earth Sciences.

Intercalibration of astronomical and radioisotopic time

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Geological time scales (GTS) may be chronometrically calibrated using a variety of absolute dating techniques. In a recent version of the GTS (Gradstein, 2004), the entire Neogene is calibrated on the basis of astronomical ages, while the older part of this timescale relies on radioisotopic ^{40}Ar/^{39}Ar and U/Pb methods. In order for the timescale to remain accurate and consistent throughout, it is crucial that astronomical and radioisotope dating methods produce identical results when the same geological event is evaluated.

The Mediterranean Neogene provides an excellent opportunity to compare these different dating methods through direct isotopic dating (^{40}Ar/^{39}Ar, U/Pb) of volcanic ash layers intercalated in astronomically tuned marine successions. We will present ^{40}Ar/^{39}Ar ages for many of these tephra from parallel determinations in two laboratories (BGC and VU). These results allow the calculation of an astronomically calibrated age for the widely used FCT sanidine standard. A major advantage of an astronomically calibrated FCT age against a K/Ar calibrated standard is twofold: 1) consistency with Neogene timescales which increasingly are based on astronomical ages, and 2) a much smaller error in the absolute age due to absence of uncertainties in absolute ^{40}K and radiogenic ^{40}Ar content or ^{40}K/K in the primary standard, and a smaller error contribution of the decay constants because the branching ratio of decay to ^{40}Ca and ^{40}Ar is not required. A next step would be the introduction of a directly astronomically dated standard, eliminating the ca. 0.1% typical intercalibration error for unknown samples within the appropriate age range of the standard.

We will discuss all potential uncertainties in the astronomical ages of ash layers, as we have determined for ash layers in astronomically calibrated Mediterranean sections. This approach may be extended to other (U/Pb, U/Th) techniques and to older time intervals.

Reference

Gradstein, F., Ogg, J, and Smith, A. (2004) A Geological Timescale 2004. Cambridge Univ. Press.