

Precise ages for the Triassic/Jurassic boundary and Hettangian recovery from northern Peru

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The end-Triassic extinction is considered to be one of the most important biotic crises our planet has experienced, involving the disappearance of about 80% of the known species. Flood basalt volcanism of the Central Atlantic Magmatic Province (CAMP) has repeatedly been invoked to have caused this catastrophic event. New precise zircon U-Pb ages are proposed for the Triassic-Jurassic and the Hettangian-Sinemurian boundaries. The ages were obtained with ID-TIMS techniques from single chemical-abraded zircons from volcanic ash layers within the Pucara Group, Aramachay Formation, in the Utcubamba valley, northern Peru. Ammonite biostratigraphy is combined with U-Pb dating to indicate ²⁰⁶Pb/²³⁸U ages of c. 201.5 Ma for the Triassic-Jurassic and of c. 199.5 Ma for the Hettangian-Sinemurian boundaries. The former is established on a tuff located 1 m above the last local occurrence of the topmost Triassic genus *Choristoceras* and the latter was obtained from a tuff collected within the *Badouxia canadensis* beds. Our new ages document total duration of the Hettangian of c. 2 Ma, which has fundamental implications for the interpretation and significance of the ammonite recovery after the end-Triassic extinction.

The new zircon ²⁰⁶Pb/²³⁸U age for the T/J boundary is 2 Myr older than the currently accepted ²⁰⁶Pb/²³⁸U date for this boundary, and is in agreement with the published database of ⁴⁰Ar/³⁹Ar ages, taking into account the systematic 0.6-1.0% age difference between the two isotopic systems. The most precisely dated CAMP rock – the North Mountain Basalt in Eastern United States – is slightly younger than our date for the T/J boundary, with a ²⁰⁶Pb/²³⁸U date of 201.27 ± 0.06 Ma (Schoene *et al.*, 2006). Resolving the question of synchronicity between CAMP volcanism and the T/J extinction, and thereby supporting a causal relationship between these two events, requires further high-precision U-Pb dating of potentially older basaltic units within the CAMP.

References

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Estimating magnesium and silicon isotope fractionation with first-principles lattice dynamics

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Silicon and magnesium are major elements that undergo differentiation in a variety of igneous, metamorphic, and low-temperature environments. In this study first-principles methods are used to calculate equilibrium isotopic fractionations involving these elements, in order to assess potential applications of isotope measurements to understanding geochemical processes. Calculations focus on silicate and oxide minerals, and aqueous Mg²⁺ (by analogy to crystalline Mg(H₂O)₆•SO₃).

Isotopic fractionations are calculated using density functional perturbation theory (DFPT), with norm-conserving pseudopotentials and a gradient-corrected functional (PBE). The energies driving fractionation are determined from changes in the density of states of vibrational (phonon) frequencies when isotopes are substituted into each crystal structure. Comparison with measured infrared and Raman spectra suggests that the DFPT-PBE method underestimates frequencies by 3-5%, and a fitted scale factor is used to adjust model frequencies. 1-5 phonon wave vectors appear to give a sufficiently large sample of the phonon density of states for each crystal.

The models predict measurable equilibrium isotopic fractionation of both magnesium and silicon in common minerals at metamorphic and igneous temperatures. At 1000°C, ²⁶Mg/²⁴Mg will be higher in spinel than silicates (0.6‰ for spinel-forsterite). This agrees with preliminary measurements of peridotite mineral separates (Tonui *et al.*, this meeting). Silicates will have higher ²⁶Mg/²⁴Mg than carbonates (0.5‰ for diopside-dolomite at 600°C). Aqueous Mg²⁺ will also have higher ²⁶Mg/²⁴Mg than coexisting carbonates (by ~2-3‰ at 25°C), in qualitative agreement with speleothem data [1]. There may be a small (0.1‰ at 1000°C) fractionation between forsterite and diopside, with diopside tending to be heavy.

³⁰Si/²⁸Si will also vary, tending to be highest in quartz. This agrees with previous Si-isotope fractionation models [2]. Quartz-zircon fractionation is expected to be ~0.5‰ at 800°C, compared with 0.3‰ observed in a granodiorite. Forsterite-diopside fractionation is small (~0.1‰ at 1000°C, diopside being light), consistent with xenolith data. Our results indicate that processes of igneous and metamorphic differentiation and metasomatism are likely to cause detectable Si- and Mg-isotope signatures.

References

[1] Galy *et al.* (2002) *EPSL* **201**, 105-115.
[2] Méheut *et al.* (2007) *GCA in press*.