High-precision Re-Os shale geochronology

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The ^{187}Re-^{187}Os system has been known to yield depositional ages for organic-rich clastic sedimentary rocks like black shales for some time. However, only with improved analytical method-ologies for digestion and optimal sampling strategies have "high-precision" Re-Os ages (precision better than ± 1% 2σ) been routinely attained. In addition, we have shown that the Re-Os geochronometer in shales remains undisturbed through hydrocarbon maturation and in some cases chlorite-grade metamorphism, which together with "organic-selective" dissolution techniques, allows precise depositional ages to be determined from a greater range of shales than previously thought possible, even with TOC contents as low as ~ 0.5%. Accuracy of our Re-Os shale dates is best illustrated by comparison to units or boundaries for which precise U-Pb age determinations also exist. For example, our recent study of directly dating black shale at the Devonan-Carboniferous boundary in Western Canada, has yielded a Re-Os age of 361.3 ± 2.4 Ma (2σ, including λ uncertainty), in accord with the most recent interpolations of the DC boundary age using U-Pb zircon age determinations. This result, and other high-precision results for Jurassic units, demonstrate that the Re-Os shale geochronometer has a role to play in timescale calibration research, especially in sections with limited potential for ashbed dating. In another application, precise (< ± 1% 2σ) Re-Os shale dates have been determined for several shale units associated with Neoproterozoic glaciations which have resulted in a more detailed understanding of the timing of these glacial event(s). Limitations of the method include the restriction to < chlorite-grade metamorphism, and accuracy, intercalibration and decay constant issues related to uncertainties in Os standard compound stoichiometry.

Triassic-Jurassic time scale and mass extinction: Current status and new constraints

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The Triassic-Jurassic (Tr-J) boundary coincides with one of the most profound mass extinctions known in the history of life on Earth. A number of potential causes for the biotic crisis have been proposed but most constraints for the timing are restricted to terrestrial sequences which have been studied in detail in eastern N America as well as NW Africa. Recent research presented geochronological evidence supporting a link between the Tr-J biotic crisis and the CAMP (Central Atlantic Magmatic Province) volcanism. $^{40}Ar/^{39}Ar$ ages from CAMP magmas cluster around 199.9 Ma and have been documented to coincide with an abrupt change of both fauna and flora on land.

In contrast, the preserved marine geologic record is scarce. The only recent radio-isotopic age, a U/Pb zircon date of 199.6 ± 0.3 Ma (Palfy et al., 2000), was obtained from a volcanic ash predating the Tr-J boundary. Although in apparent agreement with the $^{40}Ar/^{39}Ar$ age for the CAMP volcanism, recent results from several studies applying U/Pb and $^{40}Ar/^{39}Ar$ analyses to minerals from the same rocks show that there is a systematic bias between the two isotopic systems, with $^{40}Ar/^{39}Ar$ ages being ca 1% younger than U/Pb ages. Accounting for this discrepancy consequently shifts the expected U/Pb age for the main pulse of the CAMP volcanism to 202 Ma and therefore predates the U/Pb age for the marine extinction by more than 2 Ma. Additional constraints come from a preliminary age of 198.0 ± 0.6 Ma (single-crystal IDTIMS U/Pb analyses) applied to a volcanic layer within early Sinemurian marine sediments in S Hungary, which suggests that the Tr-J boundary is older than 199.6 Ma, unless the lowermost stage of the Jurassic (Hettangian) is extremely short.

A number of potential scenarios arise, none of which can be unambiguously accepted from the currently available database, and therefore await a rigorous test. Among them is the possibility that the extinction on land and in the ocean was diachronous, or that the biotic crisis was synchronous in both environments and the geochronology, particularly in marine environments, needs significant improvement.

Reference

Palfy J. et al., (2000), *Geology* **28,** 39-42.