Sub-m.y. age resolution for Precambrian igneous events by thermal extraction (TE-TIMS) Pb dating of zircon: Application to progressive crystallization of the 1849 Ma Sudbury impact melt

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Age precision of Precambrian zircon dated using ID-TIMS is usually limited to about 1 m.y. by variable isotopic fractionation in the mass spectrometer and by secondary Pb loss. Thermal pre-heating of cracked and/or altered zircon grains to 1550C removes most Pb from damaged domains as noted by Kober (1986, 1987), but extraction of primary Pb by evaporation produces relatively small ion beams. Embedding a pre-treated zircon in silica glass by fusion with silica gel on a Re filament allows the primary radiogenic Pb isotopic composition to be measured to high precision on a multi-collector mass spectrometer during thermal extraction of Pb into the silica melt. ^{206}Pb emission from embedded grains shows a rapid increase at 1600C to several 100 mv and can be maintained for up to an hour. ^{207}Pb/^{206}Pb ages, corrected for common Pb on a cycle-by-cycle basis, generally show a plateau around maximum emission with no systematic increase due to fractionation until near the end of the run. Comparison of TE-TIMS ages on Archean rocks precisely dated by ID-TIMS consistently shows an isotopic fractionation factor of 0.18%/AMU, slightly higher than with ID-TIMS. This new approach has been applied to two phases of the Sudbury impact melt, previously dated at 1850 +/- 1 Ma by Krogh *et al*. (1982, 1984). TE-TIMS on five single zircon grains from one phase, collected near the northern boundary of the intrusion (Felsic Norite), defines an age of 1849.53 ± 0.21 Ma. Six grains from a second phase, collected from the middle of the intrusion on its southern side (Mafic Norite), yielded a younger age of 1849.11 ± 0.19 Ma. No difference was found between abraded and unabraded grains from each sample. Errors are 95% confidence limits and include no error for fractionation. MSWD is 2.0 for both data sets but adding an error of 0.01% (0.18 m.y.), to account for variability of fractionation, to the age of each grain reduces the MSWD's to about 1 and results in essentially the same errors for the weighted averages as above. New, less precise ID-TIMS results on abraded zircon from the Felsic and Black Norite agree with TE-TIMS results, with intercept ages of 1849.6 ± 0.8 Ma and 1849.1 ± 1.2 Ma, respectively. This ca. 0.4 m.y. time interval is longer than expected for passive cooling. It suggests that either the impact melt volume was much larger than previously thought or excavation of the crust resulted in decompression melting and advection of heat from the underlying mantle, which maintained a long-term thermal anomaly beneath the zone of crustal melting.

Stable isotopic evidence of evolving Laramide landscape in the central North American Cordillera

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A growing dataset of stable isotopic records from the western United States is evidence of an evolving landscape during the early Cenozoic. New isotope records from three intraforeland basins of Paleogene Utah are characterized by large (>5‰), diachronous shifts in $\delta^{18}O_{cc}$ values. Combined with previous studies of provenance and paleoflow, these isotopic results are interpreted to reflect changes in hydrology and catchment hypsometry as the basins responded to growing relief in the foreland.

Decreasing isotopic trends indicate an increase in hypsometric mean elevation of catchments feeding each of the studied basins during the Middle and Late Eocene. Along with isotopic trends, evidence of hydrology, sediment provenance and active tectonism supports the development of relief as the subsiding foreland was segmented by Laramide uplifts. Although hypsometry of catchments increased, there are no signs that mean elevation in the foreland increased. Thus, we prefer a model of landscape evolution in which the area of catchments decrease, and sources of water to intraforeland basins are increasingly confined to elevated bounding structures.

The timing and magnitude of isotopic shifts in the studied Utah basins is coincident with the previously observed pattern of similar shifts spreading southward from Montana to southern Nevada between Early Eocene and Oligocene, suggesting that a progression of large-scale topographic development affected both hinterland and foreland. With this study, we increasingly favor an explanation for topographic modification wherein relief grows but mean elevation stays the same or possibly decreases.