Combining U–Th/He eruption age dating and ^{3}He cosmogenic dating to constrain landscape evolution

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Earth analogues for Martian canyons. Steep-walled, amphitheater canyons on Mars have been invoked as evidence for underground water flow because of their similarities to seepage or sapping valleys/canyons on Earth. However, seepage canyon formation on Earth is speculative, particularly in basalt terrains (Lamb et al., 2006), and therefore analogies to Mars may be inappropriate.

One of these Earth analogues is Box Canyon, a spring-fed tributary of the Snake River Canyon in southern Idaho cut into young basalt. Because of its amphitheater shape and absence of overland flow, it is a seepage canyon type locality. However, there is evidence for large-scale flooding in the area (scour marks), which has been linked to the Bonneville flood (11 kyr). One way to constrain the formation history is to determine a timescale over which the canyon forming processes occurred.

Eruption ages and cosmogenic exposure ages. We have measured the ^{3}He cosmogenic exposure ages and U–Th/He eruption ages of a series of boulders and flows from Box Canyon. Combining the two methods allows us to evaluate the possible pre-exposure of the boulders within the canyon. Furthermore, we measured the U–Th/He eruption age of similar, nearby basalt dated by Ar–Ar to demonstrate the efficacy of our calculated eruption ages.

U–Th/He ages of 300 kyr and 3 Ma for samples collected along the Snake River Canyon agree with previously published Ar–Ar ages. U–Th/He ages of the Box Canyon samples indicate volcanism approximately 100 kyr ago that lasted for $\sim$20 kyr. The exposure ages of boulders (20–50 kyr) within the canyon and scoured bedrock at the canyon head (50 kyr) indicate that the canyon was carved before the Bonneville flood. A simple hypothesis that the canyon was incised rapidly as a result of damming of the Snake River by the erupted basalts cannot be fully accurate because of the lag between the eruption age of the basalt and exposure ages of the boulders and scour surface. The combined eruption–exposure history of the canyon would indicate a rate of formation that requires more than a single flood event. Mechanisms for formation, given the current flow volume of the spring, still need to be investigated.

Reference

Lamb, M.P., Howard, A.D., Johnson, J., Whipple, K., Dietrich, W.E., Perron, J.T., 2006. J. Geophys. Res. (in press).

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Combined experimental and geochemical evidence for the origins of Tasmanian intraplate basalts

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A suite of primitive xenolith-bearing basalts from Oatlands in Tasmania, Australia, spans the compositional range olivine nephelinite to olivine tholeiite. The basalts are sodic (with $Na/K > 2$) and have high concentrations of total alkalis, P_2O_5, Nb and LREE relative to most OIB-type basalts with similar SiO_2 and MgO concentrations. When mantle-normalized, the more alkaline compositions show strong relative depletions in Pb and have high U/Pb similar to basalts of high-μ type. Measured $^{143/144}$Nd for the basalts have a limited range (0.51293–0.51308) whereas $^{87/86}$Sr is more variable (0.703090–0.704681) due to relatively radiogenic Sr in the olivine tholeiite.

Overall, the geochemical data are consistent with the derivation of the original basalt magmas from a relatively uniform peridotitic mantle source that was slightly less depleted in LREE and LILE than the MORB source. However, model calculations made using experimentally obtained mineral/melt partition coefficients for one of the basalts (UT-70489) show that incompatible element concentrations in the nephelinites and basanites are too high for them to have been produced by melting of unenriched peridotites, even if magma production involved infinitesimally small degrees of melting. This contradiction can be explained if melting to produce the magmas was initiated at depths below where the magmas finally equilibrated with their local host rocks. The ascent of near-solidus melts along a sub-adiabatic geotherm would have caused them to partially crystallize and accumulate at shallower depths. Tapping of the residual melts by surface volcanism could then have produced nephelinites and basanites with strong incompatible element enrichments. We have used our partition coefficients to quantitatively model this process and to reproduce the relative and absolute concentrations of incompatible elements in the basanite UT-70489 from a source similar to the MORB source.

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