Dating erosion events using $^{4}He/^{3}He$ thermochronometry

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The timing of rapid erosion events, e.g., induced by river incision or by glaciation, can be determined using chronometric systems sensitive to low temperatures provided that a sample was cooled from above the system's bulk T_c to the point of quantitative retention. Even in the case of apatite He ages this requires cooling by more than 60 C, or more than a few km of erosion. Thus for all but large magnitude erosional events, traditional thermochronometry is not useful.

Determination of the ^{4}He spatial distribution by the $^{4}He/^{3}He$ method may provide an alternative approach. An apatite residing at a temperature where significant diffusion occurs will develop a diffusive ^{4}He distribution decreasing to zero at the grain edge. If this apatite then rapidly cools to Earth's surface temperatures and thereafter remains cold, the concentration profile increases uniformly across the grain and the concentration *at the edge* is a direct reflection of the age of the event, the U+Th concentration, and α ejection. The local "age" at the edge of the grain constrains the timing of the coooling event. Depending on timescale, the temperature at which these outermost few microns have a zero effective concentration is in most cases ~30°C, i.e., the "edge age" can be measured and constrains the timing of an erosion event provided the sample was cooled rapidly from >30°C. In reality, cooling histories must be more complex than this, but the full ^{4}He concentration distribution is a remarkably sensitive indicator of cooling over the range ~80°C to ~20°C.

Preliminary results and challenges with this technique will be discussed with reference to ongoing studies in the Sierra Nevada. Additional results will be presented by Shuster et al. (this volume).

Calibration of a Pleistocene geomagnetic instability time scale (GITS) using $^{40}Ar/^{39}Ar$-dated lavas

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Advances in the measurement of paleomagnetic intensity recorded by marine sediments, as well as $^{40}Ar/^{39}Ar$ dating of paleomagnetic directional recordings in Pleistocene lava flows, offer a powerful means of calibrating a global magnetostratigraphy for the last 2 myr. This involves moving beyond the classic geomagnetic polarity time scale (GPTS) and resolving temporally not only the undisputed polarity reversals, but also the many short-lived geomagnetic "events," or cryptochrons that are thought to signal periods of instability in the geodynamo. Some cryptochrons may be best described as geomagnetic excursions, others aborted reversals, and still others, rapid successions of back-to-back reversals. Even the shortest events are now revealed as distinct paleointensity minima in global stacked sediment records (*e.g.,* SINT-800; GLOPIS-75). When the degree of stability of the geodynamo is considered, rather than lengths of polarity intervals, an alternative approach to the study of the GPTS is appropriate.

Hence, a challenge is to calibrate a Geomagnetic Instability Time Scale (GITS) via $^{40}Ar/^{39}Ar$ dating of transitionally-magnetized lava flows. As an example, the Laschamp event—expressed as a sharp paleointensity minimum in the GLOPIS-75 marine sediment stack—was dated by matching O-isotope variations in North Atlantic sediments to those recorded in annually counted layers of the GISP2 ice core. By matching a few ^{14}C ages from the sediments to specific varves in the ice core, the paleointensity minimum was found to span ~1500 years between 41 and 39 ka. $^{40}Ar/^{39}Ar$ incremental heating and unspiked K-Ar dating of two lavas that record the event at Laschamps, France yield an age of 40.4±1.1 ka (2σ, analytical uncertainty). Thus, despite systematic uncertainty in the ^{40}K decay constant, both the accuracy and precision of the K-Ar clock—carefully applied to basaltic lava flows—can be remarkably good, *i.e.*, better than 2% for the entire Pleistocene. A GITS based on intercomparison of several $^{40}Ar/^{39}Ar$-dated geomagnetic events will contribute further to quantifying: (1) astrochronologic age models based on O isotopes and orbital tuning, (2) long-term correlations of marine sequences, (3) the long-term behavior of earth's geomagnetic vector field, (4) production of cosmogenic isotopes, including ^{14}C, and (5) paleoclimate records at sub-orbital time scales.