Speleothem trace elements as palaeohydrological proxies during the '8,200 year' cold/dry event

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Trace element data were acquired at a very high spatial resolution (ca. 10 μm) in a U-Th dated Holocene stalagmite from SW Ireland using the ion microprobe at the University of Edinburgh. An abrupt 89% increase in Sr and a concomitant 39% decrease in P detected at 8.33 ± 0.08 ky B.P. suggest decreased rainfall and lower temperatures, reflecting the '8,200 year' cold, dry event. The anomaly coincides with a large (ca. 8‰) decrease in oxygen isotope ratios (McDermott *et al*., 2001) and a petrographic change from inclusion rich to clear calcite. The change occurs abruptly in less than 1 year. Trace element concentrations remain at non-baseline values for approximately 37 years before suddenly returning to baseline values. This first-order shift in P and Sr may be the result of an increase in water-rock contact times (Fairchild *et al.*, 2000; Huang and Fairchild, 2001) and a decrease in vegetative activity due to a cold, dry climate.

Antipathetic variations in P and Sr within the first-order trace element excursion reflect seasonal changes in water availability and temperature. These second-order cycles are the correct wavelength to be annual, thus enabling a high-resolution reconstruction of stalagmite growth rates. The lower growth rates gleaned from the resulting reconstruction are consistent with reduced meteoric precipitation and lower temperatures characteristic of the '8,200 year' event. Growth rate variations within the event reveal a brief inter-event amelioration consistent with recent model simulations. Strontium variations have greater amplitudes within the event than either before or after, suggesting a more highly seasonal distribution in rainfall.

References

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Thermochronology of the foot wall of the central segment of the Alpine Fault, South Island, New Zealand

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The South Island of New Zealand straddles part of the obliquely convergent Australian (AUS)-Pacific (PAC) plate boundary. A thermochronologic study of granites in the western foot wall of the central segment of the Alpine Fault records the thermal response to the development of the AUS-PAC plate boundary from a strike-slip to obliquely convergent structure. $^{40}Ar/^{39}Ar$ K-feldspar step heat results reveal pronounced age gradients with youngest $^{40}Ar/^{39}Ar$ apparent ages ranging in general from 4.4-7.6 Ma. A general division of (U-Th)/He apparent ages as a function of proximity to the Alpine and Fraser Faults is identified. The youngest (0.15-2.0 Ma) population of (U-Th)/He ages occurs within an uplifted crustal block bounded by the Alpine and Fraser faults while 3-4 Ma (U-Th)/He ages are found elsewhere in the foot wall of the Alpine Fault.

We interpret the integrated data set to record the cooling and progressive exhumation of portions of the foot wall from mid-crustal depths to the surface, initiated by internal shortening of the foot wall block during convergence. For example, a Paleozoic pegmatite yielded a K-feldspar $^{40}Ar/^{39}Ar$ loss profile with corresponding apparent ages ranging from 6.1- 80.9 Ma. Multi-diffusion domain (MDD) modelling (E=44.2 kcal/mol; log D_0/r_0^2=5.7s^{-1}) indicates the sample remained at temperatures of ~250°C during the Early Eocene to Late Miocene and subsequently cooled rapidly. The low temperature cooling history is further constrained by a 2 Ma (U-Th)/He age and a previously reported apatite fission track age (5.5 Ma). Late Jurassic mylonitic gneiss from the vicinity of the Fraser Fault yielded a complex $^{40}Ar/^{39}Ar$ spectra with apparent ages ranging from 5.1- 50.3 for 90% of the gas released. MDD modelling (E=40.7 kcal/mol; log D_0/r_0^2=5.8s^{-1}) indicates the sample remained at temperatures of ~240°C for ~30 Ma from the Late Eocene to Late Miocene. The model indicates Plio-Pleistocene rapid cooling and exhumation that is supported by apatite fission track and (U-Th)/He ages. The thermal events recorded in the foot wall of the Alpine Fault are the result of changes in the Cenozoic evolution of the AUS-PAC plate boundary and indicate that the AUS plate should not be viewed as an undeforming indentor in this obliquely convergent continental collision zone.