U-Pb dating of stable isotope records in Alpine speleothems from the late Pliocene/early Pleistocene

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Speleothems from the Wilder Mann and Wildmahd caves in the Allgäu Alps, western Austria have well-preserved, probably annual, microscopic laminae and high resolution stable isotope records suggesting no post-depositional alteration. These samples encapsulated a detailed history of environmental variations at the time of spelothem growth. These speleothems are characterised by high uranium concentrations, typically around 10 ppm, and coupled with some initial lead concentrations as low as 2 ppb this leads to highly radiogenic lead compositions at the present day.

Two flowstones and two stalagmites have been dated using the U-Pb isotopic system. All four samples yielded sufficient spread in isotopic composition to define chords on the Tera-Wasserburg diagram from which concordia intersection ages were calculated using an iterative procedure to account for the effects of isotopic disequilibrium. Ages are in the order of 2 Ma and for samples of this age 'normal' levels of initial ^{234}U excess are no longer detectable. The Wildmahd sample All 1 is the youngest at 1.73 Ma with a probable uncertainty of 0.03 Ma allowing for unknown initial ^{234}U excess within a range of ± 40‰. The Wilder Mann samples range from 2.30±0.07 to 1.99±0.05 Ma on the same basis. One of the stalagmite samples shows significant variation along its length from 2.11±0.04 to 2.03±0.03; further analyses on the oldest parts are in progress.

The results demonstrate that these speleothems date from the late Pliocene/early Pleistocene interval and thus provide (a) a minimum age for these high-altitude caves (2450m asl), and (b) a continental record of environmental change at an early stage in the late Cenozoic glaciations.

Tectonic subduction erosion, arc magmatism and the maintenance of the continental crust

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Estimates of modern continental crustal recycling in subduction zones can be made from plate convergence velocities, the thicknesses of trench sediments, volumes and ages of accretionary complexes together with rates of trench retreat. Plate convergence rates appear to be the primary control on crustal subduction, with convergence >7.5 cm/yr associated with tectonic erosion. Collision of aseismic ridges with trenches drives around two thirds of forearc tectonic erosion over periods >10 m.y.. Globally material subduction at least as deep as the magmatic roots of arc systems is around 3.0 Armstrong Units (1 AU = 1 km^3/yr), of which 1.65 AU comprises subducted sediments, with 1.33 AU of eroded forearc crust. Recycling rates along a single margin may show strong temporal variation over 1 m.y. periods. Isotopic variations in Costa Rican tephra suggest that sediment accretion is the most common mode of tectonism, but this is separated by short periods of dramatic erosion that cause net crustal loss. Even where erosion is continuous this can operate in a fast steady-state mode or a slower temporary style. On the Central Andean margin tectonic erosion since 20 Ma has caused trench retreat, but slow subsidence under the coastal zone implies steepening of the forearc taper rather than large scale retreat. The Neogene mass loss rate of 13 km^3/m.y./km is 5-10 times lower than the long-term average. Since 2 Ma this rate has slowed further due to underplating under the coastal zone. A climatic role in driving continental erosion and moving the margin into a more accretionary state has been suggested but is hard to demonstrate. Average global mass loss requires that Cenozoic arc productivity lies close to 75 km^3/m.y./km if the volume of the continental crust is to be maintained. Efficient accretion of oceanic arc crust is essential in maintaining the total crustal volume. In the classic Taiwan-Luzon example local crustal mass balancing implies that ~90% of the igneous arc crust is accreted.