Very high exhumation rates in the central Swiss Alps, revealed by the (U-Th)/He and fission track analyses

A. ARAMOWICZ[1], M.A. COSCA[1], K.A. FARLEY[2], D. SEWARD[3] AND D.F. STÖCKLI[4]

[1]Institute of Mineralogy and Geochemistry, University of Lausanne. CH-1015 Lausanne, Switzerland (Aleksander.Aramowicz@unil.ch)
[2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, USA.
[3]Geological Institute, ETH Zürich, Switzerland.
[4]Department of Geology, University of Kansas, Lawrence, USA.

Apatite and zircon (U-Th)/He thermochronological data together with apatite fission track analyses from near the Lötschen valley and subsurface samples from the NEAT tunnel are used to constrain the exhumation and thermal history of the western part of the Aar crystalline massif in the central Swiss Alps. This region is undergoing active deformation as geodetic measurements indicate current uplift at a rate of 1 mm/a. Samples for this study have been collected over an overall elevation range of 3 km. Exhumation rates calculated from both age-elevation profiles and from cooling curves constructed using multiple systems agree with each other and suggest that a geothermal gradient of ~30°C/km has likely remained stable over the last 7 Ma. Zircon (U-Th)/He and apatite fission track data indicate that a period of relatively fast exhumation (~3 mm/a) occurred at 5.5-6.5 Ma. This episode of rapid exhumation, previously undetected in past studies, correlates well with a contemporaneous, high erosional flux in the internal parts of the Alps (Messinian salinity crisis). The rate of exhumation in the western Aar massif, although relatively high, is in agreement with Pliocene exhumation rates described recently from the nearby Mt. Blanc massif. Because of high spatial resolution and three dimensional sampling in this area we have identified a significant role of localized heat advection by hot fluid circulation in the crystalline rocks, postdating initial cooling registered by the applied methods. The northern part of our study area appears to have been severely affected, as evidenced by young apatite (U-Th)/He ages. Similarly, some zircon (U-Th)/He ages suggest considerable resetting in the lowest elevation, axial part of the valley. The average exhumation rate calculated for the period between closure to helium diffusion in apatite (U-Th)/He and the present day from the tunnel samples is ~0.3 mm/a while current surface uplift is 2-3 times faster. This discordance can be explained by either recent acceleration in uplift of the Aar massif or, more likely, by transient changes in the thermal structure within the massif due to fluid circulation and associated heat advection. Exhumation rates calculated with the reset ages represent minimum values. These results underscore the caution that must be taken when interpreting low temperature geochronological data from Alpine regions.

Magma generation and transport in subduction zones: Numerical simulations of chemical, thermal and mechanical coupling during magma ascent by porous flow

D. ARCAY, T. GERYA AND P. TACKLEY

ETH-Zürich, Swiss Federal Institute of Technology, Institute of Geophysics, Hönggerberg, Schaffmatstr. 30, CH-8093 Zürich, Switzerland (diane.arcay@erdw.ethz.ch, taras.gerya@erdw.ethz.ch, ptackley@ethz.ch)

Most subduction zones are characterized by significant magmatic activity responsible for building trench-parallel volcanic arcs above descending slabs. High magma production rates observed within the arcs result from infiltration of water-reach fluids released by slab dehydration. The released water triggers hydrous melting of hot mantle wedges located above the cold slabs. However, the process of magma transport from the melt generation region located above the hydrated slab surface at 100-300 km depth to the magma extraction zone at the volcanic arc surface, and its influence on mantle wedge deformation, are not well known. In particular, during basaltic liquid ascent through the mantle wedge, decreasing pressure and temperature changes are likely to induce significant compositional variations, especially in terms of dissolved water content. Relationships between melt transport and mantle wedge deformation are also not clearly understood. We present a numerical model of magma generation and transport in subduction zones, that simulates chemical, thermal, and mechanical interactions between fluids and solid rocks along the magma ascent pathway. Magma migration is modelled by a porous flow across a constant permeability matrix, while the solid downward current associated with subduction in the mantle wedge, is included. The heat advected by the percolating liquid phase as well as latent heat effect associated with melting will be included. Water exchanges between the molten rock and the solid matrix are computed as a function of pressure, temperature, and solubilities laws in melt. We will first present benchmark results to validate the porous flow modelling as well as the ernery equation resolution for a two-phase flow. The aqueous and magmatic fluid repartition within the mantle wedge will then be presented. Magma productivity rates, varying along the magma ascent pathway, will be discussed as a function of magma viscosity.