Detrital mineral thermochronology in active fluvial systems and the evolution of modern orogenic landscapes

K. HODGES, K. RUHL, C. WOBUS AND J. BOYCE

Department of Earth, Atmospheric, and Planetary Sciences, 54-1120, Massachusetts Institute of Technology, Cambridge, MA 02139, USA (kvhodges@mit.edu)

In order to explore the relationship between tectonics and climate in active orogenic systems, it is important to establish short-term erosional histories. At present, some of the most powerful tools available for such studies are the $^{40}Ar/^{39}Ar$, (U-Th)/He, and fission-track cooling ages that can be obtained for detrital minerals in stream channels and young river terraces. The $^{40}Ar/^{39}Ar$ method is well-suited to such studies; the micas (particularly muscovite) are relatively resistant to grain-size comminution and alteration during erosion and transport and yield information pertaining to the cooling of source regions through the ~375-325˚C temperature range. Modern laser microprobe systems permit the routine determination of 100 single-grain $^{40}Ar/^{39}Ar$ dates – enough for statistically significant characterization of the age population in most detrital samples – in 24-36 hours. Himalayan case studies will be presented to show how such data may be used to model both catchment-wide and regional erosion rates, and to monitor the kinematics of recent deformation.

Unlike most $^{40}Ar/^{39}Ar$ thermochronometers, the (U-Th)/He and fission-track thermochronometers – zircon, monazite, xenotime, titanite, and apatite – have closure temperature ranges (~225-65˚C) sufficintly low that that the geometry of their closure isotherms mimic surface topography in rapidly eroding orogens. As a consequence, these low-temperature thermochronometers can be extremely valuable indicators of changes in the landscape during orogenesis. Unfortunately, most detrital fission-track and (U-Th)/He studies involve analytical protocols that are much more time consuming than those used for laser microprobe $^{40}Ar/^{39}Ar$ studies. As a consequence, generating a sufficient number of single-grains dates to achieve a representative sampling of the total population in a detrital sample is a major undertaking. For (U-Th)/He work, laser microprobe technologies offer great promise for improving sample throughput. Early applications of this emerging tool will be reviewed at the presentation.

UV-laser ablation $^{40}Ar/^{39}Ar$ geochronology of tectonic processes

M. A. COSCA[1], A. MULCH[2] AND B. PUTLITZ[1]

[1]University of Lausanne, Institute of Mineralogy and Geochemistry (mcosca@unil.ch)
[2]Stanford University, Geological and Environmental Sciences (mulch@pangea.stanford.edu)

One way that $^{40}Ar/^{39}Ar$ geochronology can be applied to understand better the temporal evolution of tectonic processes of both local and regional scale is through the identification and *in situ* dating of K-bearing mineral growth ages. In some cases, documenting mineral growth is relatively straightforward such as during near-surface pseudotachylyte formation. For example, pseudotachylyte associated with exhumation of UHP rocks in the Dora Maira massif, Italy, contain microcrystallites of K-feldspar and biotite neocrystallized from the frictional melt generated during a seismogenic event. *In situ* ultraviolet (UV) laser ablation $^{40}Ar/^{39}Ar$ geochronology of the pseudotachylyte yields an age of 20.1 ± 0.5 Ma for this event, consistent with field observations and other geochronological data. Geological examples of tectonic processes from deeper levels in the crust yield geochronological results reflecting longer, and sometimes divisable, time scales. Muscovite fish in greenschist facies extensional mylonites in southern Norway show textural, compositional, and $^{40}Ar/^{39}Ar$ evidence for distinct growth histories. UV-laser $^{40}Ar/^{39}Ar$ ablation ages of muscovite cores interpreted to have formed during high-grade metamorphism record $^{40}Ar/^{39}Ar$ cooling ages approximately 10 to 12 m.y. older than compositionally distinct muscovite overgrowths. The muscovite overgrowth ages are interpreted to record a subsequent regional extensional event. Even deeper levels within the crust can yield meaningful $^{40}Ar/^{39}Ar$ growth histories. Phengitic white mica from blueschist and eclogitic rocks from the Greek island of Syros, have subtle and irregular compositional zoning barely resolvable with X-ray mapping. Such compositional variations are interpreted to reflect the response of white mica to changes in external changes in pressure, temperature, and fluid conditions. *In situ* UV laser ablation $^{40}Ar/^{39}Ar$ geochronology of individual white micas reveals a distribution of ages not only consistent with the observed compositional variations but also spanning a time range that is interpreted to record mica growth during blueschist and eclogite metamorphism *including* the period of subduction. While such an interpretation is predicated upon the assumption that these mica ages record mineral growth and not cooling, additional geochronological data from other systems including Lu-Hf support such an interpretation.