In step with time: *In situ* geochronology meets microscale records of geologic processes

MARY R. REID

Department of Geology, Northern Arizona University, Flagstaff, AZ 86011; mary.reid@nau.edu

The profound record of geologic phenomena at sub-millimeter scales can be revealed by in situ geochronology and geochemistry in the context of key textural relationships. Complementary in situ geochemical and isotopic analyses reveal, for example, fluid evolution during cementation, the evolution of low as well as high grade metamorphism, subduction and exhumation, and the nature and duration of crustal growth. The improved accuracy and precision of U-Pb dating at <50 µm by LA-ICP-MS is increasing use of this method for in situ dating, especially for provenance studies and reconnaissance geochronology. Efforts to develop more matrix-matched reference materials will continue to improve the accuracy of *in situ* dating and geochemistry.

Dating of igneous and environmental samples by $^{234}U/^{238}U$ and $^{230}Th/^{234}U$ disequilibria is also possible at a spatial resolution of <100 µm on. Vazquez and Reid (2004) coupled in situ U-series geochronology with crystal-scale allanite chemistry to reveal a t-T-X record for heterogeneous accumulation of the voluminous Toba rhyolite. The advent of the Ti-in-zircon geothermometer (Watson and Harrison, 2005) will ensure further crystal-scale insights into magmatic processes. In situ ^{235}U-^{231}Pa zircon ages may augment ^{238}U-^{230}Th geochronology (Schmitt, 2006). For environmental samples that contain ≥1 ppm U, dating by LA-ICP-MS affords high-resolution reconnaissance studies that can cope with open systems like bones, teeth, and possibly molluscs without chemical preparation (e.g., Eggins *et al*., 2005). Fluctuations in initial ($^{234}U/^{238}U$) and trace element concentrations, such as those found in 2-200 µm thick opal layers in soils, can be linked to glacial-interglacial transitions by ionprobe $^{230}Th/^{238}U$ dating (Maher *et al*., in prep.).

Finally, extension of in situ laser analyses to (U–Th)/He geochronology enables dating of 25 µm domains for provenance and unroofing studies (Boyce *et al*., 2006).

References

Boyce, J.W., Hodges, K.V., Olszewski, W.J., Jercinovic, M.J., Carpenter, B.D., and Reiners, P.W., (2006). *Geochim. Cosmochim. Acta* **70**, *3031-3039.*

Eggins, S.M., Grun, R., McCulloch, M.T., Pike, A.W.G., Chappell, J., Kinsley, L., Mortimer, G., Shelley, M., Murray-Wallace, C.V., Spotl, C., and Taylor, L., (2005). *Quat. Sci. Rev.* **24**, 2523-2538.

Maher, K., Redwine, J., Wooden J.W., Paces J.B., and Miller, D. M., (in prep.). *Earth Planet. Sci. Letts.*

Schmitt, A.K., (2006). *Eos Trans. AGU* **87**, *Abst. V53E-08.*

Watson, E.B. and Harrison, T.M., (2005). *Science* **308**, 841-844.

Vazquez, J.A. and Reid, M.R., (2004). *Science* **305**, 991-994.

Continental scale geochemical mapping and the geochemical background

C. REIMANN

Geological Survey of Norway, 7491 Trondheim, Norway, (Clemens.Reimann@ngu.no)

Since 1995, large domains in Northern Europe have been mapped at ever decreasing sample densities: 1 site/300 km^2 in the Kola Project, 1 site/1000 km^2 in the Barents Project and 1 site/2500 km^2 in the Baltic Soil Survey. The geochemical atlas of Europe, based on a sample density of 1 site/5000 km^2, was published in 2005 (see www.gtk.fi/publ/foregsatlas). Results demonstrate that such low-density geochemical mapping allows for the construction of robust geochemical maps of large areas at reasonable cost. The maps contain important new information and politically vital reference data about the varying levels of chemical elements in the surface environment at the continental scale.

The data demonstrate that there exist a number of natural processes that influence the regional distributrion of chemical elements in the surface environment at a variety of scales. Many of the displayed large-scale patterns are surprising and unpredictable based on geological reasoning alone. The distribution of chemical elements at the earth surface has an important impact on animal and human health. Continental scale geochemical maps of a variety of sample media, reflecting different compartments of the ecosystem, are thus urgently needed.

The anthropogenic impact on the natural environment cannot be reliably judged and interpreted without continental-scale geochemical maps and sound knowledge and documentation of the geochemical background. The observed natural variation of element concentrations in all sample materials collected so far covers several orders of magnitude. The statistical definition of a geochemical background or action levels for, for example, metals in soils of Europe, is thus fraught with problems. Obviously there is no single "natural" background value that is valid for a large area. Rather background will change from area to area within a region and between regions. The inherent connections between scale and background variation are key features for understanding environmental processes.