

Rates of metamorphism in collisional orogeny

M. ENGI^{1*}, E. JANOTS¹, D. RUBATTO², A. BERGER,
C. GREGORY², J. ALLAZ¹ AND J.-O. SCHWARZ¹

¹Institute of Geological Sciences, University of Bern,
Switzerland (*correspondence: engi@geo.unibe.ch)

²Research School of Earth Sciences, Australian National
University, Canberra (daniela.rubatto@anu.edu.au)

Scope and Methods

Understanding the processes that operate over a range of temporal and spatial scales, as a belt of regional metamorphism develops, is at the root of many key problems in geodynamics. Progress requires studies combining petrology and geochronology in orogens where the tectonic evolution is well known. Samples from a section across the low- and medium-grade northern part of the Central Alps were studied [1] with the aim of unravelling the dynamics of the Barrovian metamorphic evolution. Detailed petrological work, aided by thermodynamic modeling, allow us to recognize the prograde sequence of assemblages involving REE-minerals, and to obtain specific P-T conditions for each stage. By dating several of these stages (SHRIMP U-Th-Pb on monazite and allanite, Ar-Ar on micas), using exceptionally well characterized samples, a very robust P-T-t path emerges. This yields well constrained regional heating and cooling rates and, when combined with quantitative textural data obtained from the same sample sequence, growth rates of prograde metamorphic minerals, as well as fluid production rates.

Results

Prograde allanite dated at 31.5-29 Ma grew from a (detrital) monazite precursor at 430-450°C (ctd-in); monazite appeared at 18-19 Ma in the garnet-zone (560-580°, near ctd-out). The average heating rate of 10-12 deg/My pertains to a T-interval in which major reaction progress occurs in meta-clastic rocks, for which rates of metamorphic growth can be determined. Growth-zoned porphyroblasts of chloritoid, garnet, and staurolite record the P-T conditions precisely. The spacing of isopleths ($\partial X_C/\partial T$) and isomodes ($\partial n_i/\partial T$) directly monitors the advance of continuous silicate reactions in response to heating at the rate ($\partial T/\partial t$), hence absolute reaction progress rates ($\partial \xi/\partial t$) are determined. Similarly, crystal size distributions measured for garnet populations in the same metasediments yield estimated rates of nucleation and growth ($\partial N/\partial t$) for these P-T conditions. As growth of the porphyroblasts studied is related to specific dehydration reactions, the spacing of the isomodes also yields minimum rates of devolatilization. These rates appear characteristic up to ~650 °C.

[1] Janots *et al.* (2008, in press) *Jour. Metam. Geology*.

Mercury and other trace elements in coastal South Carolina aerosols

MARK A. ENGLE^{1*}, ALLAN KOLKER¹, DAVID P.
KRABBENHOFT², MARK L. OLSON², MICHAEL T. TATE²
AND CASEY SONEIRA¹

¹U.S. Geological Survey, Reston, Virginia
(*correspondence: engle@usgs.gov)

²U.S. Geological Survey, Middleton, Wisconsin

As part of a USGS study to investigate sources of mercury (Hg) deposition in coastal areas, aerosol samples were collected between Awendaw and Georgetown, South Carolina, USA, from April, 2006 to May, 2007, together with Hg speciation measurements, air quality parameters, and meteorological data. Intensive sampling of aerosols for Hg and other trace elements was conducted at three sites in May and July, 2006 and at one site in May, 2007.

Twelve-hour integrated total suspended particulate (TSP) Hg concentrations determined in this study are typical of background areas ($7.8 \pm 3.6 \text{ pg m}^{-3}$, $n=85$), except for the industrial city of Georgetown (Hg-TSP as high as 43.2 pg m^{-3}). Enrichment factor calculations suggest that contributions from anthropogenic sources account for more than 90% of Se, S, Sb, Bi, Pb, and Hg in TSP samples during the sampling periods. Principal component analysis suggests that primary trace element aerosol sources in the study area include crustal input, coal-fired power plants and other anthropogenic emitters, and sea salt. Mercury was identified as its own component, suggesting its geochemical behavior is unlike other trace elements analyzed. Statistical comparison of individual trace element TSP concentrations showed that all sites exhibited similar concentrations of elements derived from crustal (Ce, Cs, La, Pr, Sn, Sr, Th, and Mg) and coal combustion sources (S, Sb, Se). The Georgetown site exhibited elevated Hg and Pb TSP concentrations relative to the other two sites, indicating greater contribution from local sources (i.e. a coal-fired power plant, a paper mill, and/or a steel production plant).

Comparison of Hg-TSP and fine particulate ($\text{PM}_{2.5}$) Hg concentrations between adjacent samplers demonstrates that $71 \pm 17\%$ of particulate-bound Hg was associated with coarse ($>2.5 \text{ }\mu\text{m}$) particles, possibly sea salt aerosols. Modeled rates of dry deposition for coarse and fine particulate Hg are compared with reactive gaseous Hg during the sampling periods. Findings from this study suggest that atmospheric particulate matter is an important transport mode for Hg in the South Carolina coastal environment and that Hg exhibits a complex and dynamic behavior relative to other trace elements.