American Mineralogist, Volume 96, pages 457–469, 2011

Roebling Medal Lecture

The three partners of metamorphic petrology

Robert C. Newton*

Department of Earth and Space Sciences, University of California at Los Angeles, Los Angeles, California 90095-1567, U.S.A.

Abstract

Study of the evolution of the Earth's crust advanced greatly in the last half-century through the dynamic collaboration of three equally contributing partners: field observations, together with microanalysis of mineral assemblages, experimental petrology, and stability calculations based on systematically measured and compiled thermodynamic properties of minerals.

In addition to providing the initial inspiration for experimental and theoretical studies of petrogenesis, quantitative field observations have had an important feedback relationship with the indoor approaches. It has been demonstrated that physico-chemical properties of mineral systems can, in favorable circumstances, be inferred from purely geologic criteria, and, in some cases, field criteria have been used to challenge the validity of existing experimental or thermodynamic data, leading to reinvestigations and revisions. The "geo-experimental" method may be particularly useful to infer phase equilibrium relations among minerals where experimental reactions are prohibitively slow at geologically reasonable temperatures or where fluid fluxing of mineral reactions is necessarily limited, as in investigations concerning the low-H_2O-activity deep-crustal rocks, the granulites.

Geo-experimental phase equilibrium diagrams, constructed largely from quantitative petrographic observations, have been successful in deducing polymorphism, order-disorder, and solid solution properties of such mineral systems as the aluminum silicate minerals, feldspars, epidote minerals, scapolites, and cordierite. The last minerals are particularly important in that they may retain a record of volatile components of an intergranular mineralizing fluid. Knowledge of the important effects of mixed volatile fluids has been inhibited by lack of experimental data on devolatilization, ion exchange, redox, sulfidation, and fluid-complexing reactions of the volatile-bearing minerals biotite, amphibole, apatite, scapolite, cordierite, carbonates, and sulfides with the major minerals of rocks of the deeper interior. A concerted approach among the experimental, thermodynamic, and petrographic disciplines is necessary to make progress on the still poorly understood role of volatiles in shaping the crust. The relatively young science of fluid inclusion analysis will have an increasingly important role in the interdisciplinary effort to interpret the evolution of the continental crust and its underpinnings.

Keywords: Experimental petrology, thermodynamics, geo-experimental, Earth crust, phase diagram, aluminosilicate