Geobarometers for igneous rocks with ±1.0 kbar uncertainty?

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The value of a geobarometer for igneous rocks depends on its uncertainties and on the petrological problem being addressed. Many attempts have been made to decrease the model errors of phase equilibrium geobarometers by calibrating individual reactions on subsets of experimental data. However, the quantification of the actual uncertainties when such geobarometers are applied to natural samples is difficult or impossible. In addition, it is often necessary to apply a variety of single-reaction geobarometers to different mineral assemblages in the same rock suite, when these geobarometers have not been calibrated in an internally consistent way.

A multiple-reaction approach uses internally consistent thermodynamic models, potentially using all the phases present in an assemblage to constrain pressure (P). Correlated uncertainties on the thermodynamic model parameters, as well as in the measured mineral compositions, can be formally propagated into the pressure estimate, generating diagnostics that characterise the goodness of fit [1]. The method can be applied consistently to multiple assemblages within the same suite. However, its actual accuracy has never been tested against phase equilibrium experiments.

In this work we tested the accuracy of the average P method (avP, a multiple-reaction approach developed by [1]) using a database of phase equilibrium experiments in basaltic and peridotitic systems. We then refined the thermodynamic models used for avP calculations on assemblages containing at least olivine, plagioclase and clinopyroxene. After refinement, calculated 1σ uncertainties for each experimental sample vary in the range 0.9–2.6 kbar. Pressures are correctly predicted, within the 1σ uncertainties, for 68 % of the database, which attests the high accuracy of the method. The precision for natural samples was then evaluated by applying avP to gabbroic and ultramafic rocks from different geodynamic settings. This showed that for well equilibrated igneous rocks, 1σ uncertainties in P of 1.0 kbar can be achieved, along with satisfactory fit diagnostics.

[1] Powell & Holland (1994) Am. Mineral. 79, 120-133.