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# New developments in two-feldspar thermometry

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## ABSTRACT

The thermodynamic model of the two-feldspar thermometer has been revised. From recent enthalpy and volume measurements in the (Na,Ca)- and (K,Ca)-feldspar binaries, new interaction parameters have been derived and previous ones have been updated. Entropy parameters have been fitted to the phase equilibrium data of Seck (1971) and Elkins and Grove (1990). The two data sets could be suitably combined into one. Ideal Ab, Or, and An activities have been expressed in terms of both the molecular mixing and Al-avoidance models.

Two-feldspar pairs from high-grade metamorphic rocks that cooled slowly under dry conditions suffer from a distinct type of retrograde resetting. Whereas the original An content in both the plagioclase and the alkali feldspar is preserved because the intercrystalline Ca + Al ↔ (Na,K) + Si diffusion is sluggish, Na and K may be freely exchanged between phases. Mathematical reversal of the Na-K exchange at constant An yields the temperature at which the two feldspars originally coexisted. The shifts in Ab and Or contents obtained from the reversal reflect the relative plagioclase/alkali feldspar proportions observed in thin sections. Good agreement between calculated and measured ratios was found for feldspar pairs from Sri Lankan granulites. This observation represents a successful test of the reliability of the calculated Ab-Or shifts.

In contrast to dry metamorphic rocks, similar application of chemical constraints is not indicated in the case of volcanic rocks. Then the two-feldspar thermometer delivers three, usually incongruent temperatures: *T*(Ab), *T*(Or), and *T*(An). From the abundance of temperatures, Fuhrman and Lindsley (1988) suggested adjusting compositions within assumed chemical uncertainties (e.g., ±2 mol%) so that congruent temperatures could be obtained. However, the result is not unique. Depending on minute variations in the starting compositions, the temperatures may vary by several tens of degrees. In addition, temperatures vary to a similar extent depending on the type of search algorithm. Therefore, we advise users to completely abandon this practice. Instead, a statistical procedure is suggested: Two-feldspar compositions are randomly generated according to Gaussian distributions with their means at the observed compositions and standard errors chosen according to the quality of the chemical analysis. This procedure returns normally distributed temperatures [*T*(Ab), *T*(Or), *T*(An)] together with means and standard deviations. From the overlap of the three Gaussian curves the question of equilibrium or non-equilibrium crystallization of feldspar pairs may be addressed.