Experimental evidence of the role of liquid immiscibility in evolution of granitic pegmatites and Li-F granites

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Recent studies of melt and fluid inclusions in pegmatites of Ehrenfriedersdorf, Germany (Thomas et al., 2000), demonstrated extreme enrichment of the evolved granitic melts in B, F and P. Other examples of evolved granitic systems show large variations in absolute concentrations and relative proportions of the volatiles and fluxes. For instance, quartz-hosted melt inclusions from the Malkhan tourmaline-rich pegmatites in Russia show extreme enrichment in B (up to 6.7 wt% B_2O_3), but low F contents (about 0.1 wt%). High B contents, around 2 wt%, were also found in melt inclusions from highly evolved rocks of the Orlovka massif (Russia), which is a classical example of strongly differentiated intrusion of Li-F granites. Inclusions in the Orlovka contain up to 1.8 wt% F and differ from those in Malhan not only in F, but in proportions of major oxide components as well.

In all the three cases represented by the Orlovka, Malkhan and Ehrenfriedersdorf, we find in melt inclusions evidence of three distinct coexisting fluids operating at final stages of magmatic evolution. They are: (1) aluminosilicate melt of granitic composition; (2) a second melt, composed mostly of borates, or fluorides, or both; and (3) H_2O-CO_2 low-density fluid with variable amounts of NaCl, H_3BO_3 and other solutes. The coexistence of three immiscible fluid phases was recently confirmed by hydrothermal experiments in diamond cells and rapid-quench pressure vessels using a synthetic granitic composition spiked with B, P and F (Veksler et al., 2002). Our results are in good agreement with previous studies of liquid immiscibility between aluminosilicate and fluoride (cryolitic) melts (Gramenitskiy and Schekina 1994). In on-going experiments we find evidence of silicate-borate liquid immiscibility in granitic systems doped with $Li_2B_4O_7$. Thus, liquid immiscibility appears to cover a broad range of bulk compositions from B-rich to F-rich melts and is likely to be common in the highly evolved granitic systems. It should strongly affect the behaviour of trace elements and major components and may be responsible for a number of characteristic chemical features of pegmatites and Li-F granites.

References

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Numerical modelling of competitive nucleation pathways

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The development of numerical models for the description of nucleation processes is an important step to model the sequence of phase reactions that takes place in sediments during the early diagenetic transformations, in particular, when reaction-speciation codes are employed.

In this work a numerical model based in nucleation and growth algorithms has been designed to compute the temporal sequences of precipitation and phase transformation kinetics in metastable solutions of polymorphic or hydrated substances. This model has been designed for the treatment of kinetic data, both for nucleation and crystal growth following experimental results of various macroscopic techniques, sensitives to some macroscopic property variable related to mass crystallized on time or given a density population distribution in crystal size (i.e. calorimetry, dynamic-XRD, etc.). It allows, furthermore, for the analysis of the influence of nucleation algorithms based on different thermodynamic considerations (referring mainly to the surface tension and the grain size distribution) of the parameters involved in the process.

The main part of the program consists of a sequence of algorithms that describe the crystalline growth kinetics by applying the balance equations to the usual expressions for the growth and supersaturation rate.

The initial growth conditions are made dependent on a subroutine containing nucleation algorithms that includes several thermodynamic approximations to the metastable interval, mainly connected with the estimation of the free Gibbs surface energy [1].

Fits to experimental values are obtained by optimizing the adjustable parameters introduced in the nucleation equations by the Marquardt algorithm.

The use of an analytical optimization model, alongside the program, facilitates the search for a better compromise between the kinetic nucleation parameters and said macroscopic effects experimentally observed both in one single phase precipitation systems as well as polymorphic or hydrated substances, in which the sequential precipitation of different phases takes place.

Since it is possible to use nucleation algorithms based on different thermodynamic considerations, the model is at the same time useful in the discussion of the viability of different nucleation mechanisms in natural systems.

References

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