The role of thermal constraints in extreme fractionation of felsic magmatic systems: examination of critical controls to protore and (or) ore formation

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Extreme fractionation is evident in many magmatic systems including evolved felsic magmatic systems. Although considerable focus in the literature has been on volatile complexing (alone) in explaining metal enrichment in magmatic systems, only a few researchers conduct experiments and highlight field studies presenting primary magmatic processes as responsible for generation oreforming systems in various granitoid magmas. The behavior of incompatible elements during partial melting and (or) fractional crystallization is well known, although the effects of the duration of a magmatic system from a thermal perspective is very rarely considered. It is postulated that the efficiency of crystal-melt partitioning and crystalmelt separation is very much a function of the duration of a cooling system. Using thermal modeling techniques, various magma injection scenarios were examined, in particular mafic magmas cogenetically emplaced with felsic magmas, to illustrate the range in cooling times for fractionating magmatic systems. The thermal energy modeling was done using the program HEAT by Ken Wohletz (Kware). This program is versatile and enables input of variable thermal gradients, and emplacement of different timing of intrusions into any package of rocks. It is easily shown that the duration of crystallization of felsic magmatic bodies can be easily extended by >> 10 times, such that crystallization from a typical granitoid solidus temperature of 700°C to << 600°C could be over 1 million years, which could overcome the viscosity issues with crystal fractionation at very low temperatures. If correct, any system can now be geochronologically constrained by dating each phase of a magmatic system, and associated ores formed, i.e., the importance of thermal models can be tested in ore systems. The specific purpose of which is to determine the lengths of times that specific magmatic systems were above their liquidi through to their lowermost solidus and in terms of extreme fractionation to very evolved magmatic systems like Li-Cs-Ta (LCT-type), Nb-Y-F (NYF-type), Sn, Mo, U, and LREE apogranitic to granitic pegmatite systems to extremely low T's consistent with each of their solidi, i.e., well below 600°C. Partitioning of elements between crystal and melt thus approaches ideal distribution coefficients for incompatible elements. As well efficient crystal – melt separation (Rayleigh fractionation and partial melting) in increasingly viscous magmas has time to separate and migrate promoting fractionation and concentration of fluxing volatiles in those derivative melts. Furthermore, prediction of economic potential of a particular felsic magmatic system is possible by appropriate thermal modeling of these magmatic systems.

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