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Modelling the role of accessory minerals in the geochemical fractionation of granitic rock suites.

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Accessory minerals are the main repositories of many trace elements in granitic systems and they must strongly influence the trace element evolution during granitic differentiation in spite of the very low modal abundance. However, in order for accessory minerals to control the fractionation trends, the minerals must be liquidus phases. This is a reasonable assumption for zircon and apatite, but might be a contentious one for minerals such as monazite and allanite. In addition, the tiny accessory grains must be physically separated from the generally viscous residual melts. This is problematic for all accessory minerals, unless they separate as inclusions in heavier major mineral phases. Furthermore, it is difficult to arrive at reliable estimates of the effective crystallisation rate of accessories. Petrography learns that accessories are often present as clusters of minerals that crystallised from pockets of trapped interstitial melts. These accessory minerals crystallised too late to significantly affect fractionation trends. Moreover, these clusters frustrate efforts to estimate effective crystallisation rates from modal abundances.

Although straightforward Rayleigh-type fractional crystallisation models have merits to outline the main factors that caused geochemical evolutionary trends, the implied complete separation of mineral phases from residual liquid is at best a poor approximation of reality. A more elaborate crystallisation model of granitic ‘mushes’ will be presented, that aims to overcome this limitation. It tracks the trace element variation in two subsystems - a ‘congealed mush’ and a ‘residual mush’ that develop as crystallisation proceeds. The model also takes into account any separation of less-viscous, water-rich melts and fluid phases from the residual mush during the final stages of solidification. Emphasis is put on the role of accessory minerals on the evolution of the Rare Earth Element (REE) patterns.

The model calculations will be illustrated with results for two leuco-granitic series from the Variscan Northern Vosges (France) : the Natzwiller granite and the highly evolved Kagenfels granite. The variation trends of the Natzwiller granite can be modelled successfully. The calculations demonstrate the crucial role of the accessory minerals apatite, sphene, allanite and zircon. The Kagenfels granite presents a much more difficult case, because the pronounced decrease of the concentrations of the middle REE (relative to Light and Heavy REE), cannot be readily explained by models based on reasonable values of modal abundances of accessory minerals and of partition coefficients. It is argued that late stage separation of a water-rich silicate melt from the residual mush profoundly affected the trace element abundances of the granitic mush.