SUPPLEMENTAL MATERIAL

COMPILATION OF AVAILABLE EXPERIMENTAL PETROLOGICAL DATA ON THE SOLUBILITY OF ACCESSORY MINERALS IN GRANITIC MELTS

Apatite Solubility

Harrison and Watson (1984) performed basic work on apatite solubility in granitic melts for peralkaline and metaluminous melts (A/CNK values up to 1.0), and Pichavant et al. (1992) expanded this work for A/CNK values up to 1.27. The low apatite solubility at A/CNK $\leq$ 1 increases significantly with increasing peraluminous character of the melt. Lowering the fO$_2$ of these melts under otherwise identical conditions yields again to a slight decrease of apatite solubility (Richard et al., 1992). Wolf and London (1994) showed a linear relationship between A/CNK value and P$_2$O$_5$ content of the melts.

However, it is not easy to transfer the results of the experiments on haplogranitic melts, or natural Macusani glasses, to natural peraluminous granitic rocks. Pichavant et al. (1992) refer to the complexity of the solution equation for apatite and the commonly significant differences between the model and the measured P$_2$O$_5$ contents. The model systematically overestimates the whole-rock phosphorus content (Pichavant et al., 1992). Helpful for our considerations is the fact that those authors used data from granites of the SMB, which are similar to the chemical data of the monzogranites of our study in terms of A/CNK values and SiO$_2$ contents (Ham et al., 1990; Ham et al., 1989). Again, it is clear that the measured whole-rock P$_2$O$_5$ contents (~0.19 wt%) are significantly below the model assumptions of 0.87 wt% (Table 2 in Pichavant et al., 1992).

Despite these uncertainties, the high apatite solubility in the peraluminous granite melts suggests that any xenocrystic apatite would dissolve, and later crystallize again in the magma after reaching the solubility limit. However, petrographic observations in the boundary region between xenoliths and granitic magma (Figure 8) suggest that small country-rock apatite grains dissolved as large ones grew simultaneously (Ostwald ripening). In addition, some apatite xenocrysts may have been preserved as a result of the kinetics of the dissolution processes, or as inclusions in biotite crystals.

Monazite and Xenotime Solubility

Solubility models for monazite and xenotime in granitic melts were developed by Rapp and Watson (1986), Montel (1986, 1993), Keppler (1993), Wolf and London (1995), Stepanov et al. (2012), Skora and Blundy (2012), Duc-Tin and Keppler (2015), and Rusiecka and Baker (2019). In accordance with the experimental results and considerations of Duc-Tin and Keppler (2015) we assume that the phosphate content of the melt and not the content of a hypothetical $CePO_4$ or YPO_4 molecule regulates the solubility of both minerals.

The solubility of monazite and xenotime decreases with increasing phosphate content of the melt. Compared to apatite, the solubility of xenotime and monazite is significantly lower. It also decreases with increasing A/CNK value, but then remains relatively constant in peraluminous melts. The solubility increases with rising temperature.

Even if we do not have exact data on the respective REE contents of the melt and the precise compositions of the monazite and xenotime grains, we can assume that the monzogranitic melts of the SMB were always close to, or above, the saturation limit of one or both minerals. This condition means that any xenocrystic monazite and xenotime grains may have not dissolved. The development of new crystals in this case depended exclusively on the availability of LREE and Y, as sufficient phosphate was always available for crystallization.

Zircon Solubility

Watson and Harrison (1983) proposed a zircon saturation model, slightly modified by Boehnke et al. (2013). Gervasoni et al. (2016) extended this model to a wider range of rock compositions. Following this saturation model, using the mean chemical composition of the SMB monzogranite and an estimated temperature of the magma of 700°C (about the haplogranite solidus) we get a saturation level of a SMB monzogranite melt of 340 µg/g Zr. This value is higher than the average Zr content of these rocks. This condition means that, under the unrealistic assumption that the composition of the monzogranite represents a pure melt, the zirconium saturation had not yet been reached and therefore all xenocrystic zircons would have to dissolve and no new zircons could crystallize. However, the presence of zircons of different morphology indicates that the composition of the melt fraction in the monzogranitic magma of the SMB was above the saturation limit. Therefore, it cannot be excluded that zircons from the country rock were incorporated into the magma, especially if they were already enclosed in xenocrystic biotite (Fig. 6F).