Geochemistry of granites from the Guarda-Sabugal area, Portugal

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Seven distinct phases of Variscan two-mica granite are recognized in the Guarda-Sabugal area. They intruded the Cambrian schist-metagraywacke complex, crystallized in the middle crust and are alkalic-calcic and strongly peraluminous. The oldest granite G1 is syn- to late-D3 (309.2±1.8 Ma), granites G2, G3, G4, G5 and G6 are late-D3 (304-300 Ma), whereas granite G7 is late- to post-D3 (299±3 Ma; ID-TIMS ages on zircon and monazite).

Granites G2 and G5 represent distinct pulses of magma and correspond to different degrees of partial melting of the same metasedimentary material. They have the same $(^{87}Sr/^{86}Sr)_{300}$ and similar εNd_{300} and $\delta^{18}O$ values, but G5 has a higher biotite/muscovite ratio, Ti, Fe, Mg, Ca, Zr, Ba, Ce contents and lower Si and Rb contents than G2. The granite G5 results from a higher degree of partial melting at a higher temperature than G2. Each granite magma G2 and G5 evolved by fractional crystallization. Granites G2, G3 and G7 define a series and granites G5 and G6 define another series. Both series have similar values of $(^{87}Sr/^{86}Sr)_{300}$ of 0.708, εNd_{300} from -3.5 to -3.8 and $\delta^{18}O$ of 10.43-11.02 ‰. In each series, the major and trace element contents of granites define fractionation trends; the REE patterns are subparallel and REE contents decrease from the oldest to the youngest granite; the whole-rock $\delta^{18}O$ defines a trend and only increases by up to 0.1 ‰ and 0.4 ‰ in the G2, G3 and G7 series and G5-G6 series, respectively. In each series, potash feldspar Ba and plagioclase Ca decrease, whereas Mg decreases and Li increases in biotite from the oldest to the youngest granite. Granites G3 and G7 are derived from granite G2 magma and granite G6 is derived from granite G5 magma by fractionation of quartz, potash feldspar, plagioclase, biotite and ilmenite. The two series define two distinct trends in the log Rb/Sr-log Sn diagram indicating that fractional crystallization increased the Sn content of magmas within each series and Sn-bearing granites G3, G6 and G7 do not represent a crust anomaly in Sn. G1 and G4 correspond to different pulses of granite magma and are distinct from those of granites G2 and G5, which is confirmed by the different $(^{87}Sr/^{86}Sr)_{300}$, εNd_{300} and $\delta^{18}O$ values.

The next generation of petrologic study of lunar compositions: Exploring the effects of water, Cl, F, S and the fluid exsolution processes that have affected their distribution

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The highly successful Apollo program launched a plethora of analytical and experimental petrologic investigations fundamental to our understanding of the origin and evolution of the Moon. Although it was recognized that carbon-bearing magmatic volatiles as well as S and Cl were present in lunar magmas (e.g. [1-3]), the effect of these on mineral stability and the implications for lunar evolution remain largely unknown, in part, because of the degassed nature of lunar glasses. The recent determination of volatile abundances in apatite has opened the door for a new paradigm of lunar evolution, since apatite has the potential to provide insight into the water, F, and Cl abundances of crystallizing lunar magmas. However, this can only be realized if the processes that affect magmatic volatile abundances are understood and the stage of apatite growth and stability can be determined.

Magmas reaching the lunar surface have likely undergone at least first boiling, and, if crystallized to the extent of mare basalts, second boiling. During these processes, the relative partitioning of halides and water into an exsolving fluid changes (e.g. [4]) and the apatite crystallizing may reflect changes induced by fluid loss. A set of experiments have been launched that involve investigating the effect of water, Cl, F and S on the phase equilibria of mare basalts and apatite stability, which simulate isobaric crystallization, decompression-induced first boiling, and low pressure crystallization-induced second boiling. The results will be coupled with assessment of the petrogenetic history of Apollos samples for which we have already determined the volatile abundances through SIMS and microprobe analysis.

[1] Fogel & Rutherford (1995) *GCA* **59**, 201–216. [2] Delano *et al*. (1994) *LPS* **XXV**, 325–326. [3] Shearer *et al*. (1989) *LPS* **XX**. 996–997. [4] Aiuppa *et al*. (2009) *Chem Geol*. **263**, 1–18.