5.5.13

Differentiation vs. magma mixing in A-type granites (Wangrah Suite, Australia): An experimental study

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Crystallization experiments were performed at 200 MPa, 900-700 °C, various aH_2O, at Ni-NiO buffer on four natural A-type granite compositions from the Wangrah Suite, Lachlan Fold Belt, SE Australia to constrain differentiation and crystallization processes. The compositions are representative for the Danswell Creek, Wangrah, Eastwood and Dunskeig granites (from "most mafic" to "most felsic"). The chemical variations of these granites (i.e., decrease of FeO, MgO, CaO, Ba and Sr with increasing SiO_2) reflect different stages of differentiation. Experimental results were compared to the natural phase compositions to constrain the water contents of the melts and the phases involved in fractionation processes in the Wangrah Suite. The Danswell Creek granite could represent the primary water-undersaturated magma with 2.5 ± 0.5 wt.% H_2O from which the more evolved Eastwood and Dunskeig granites were derived by crystal fractionation. Although orthopyroxene is not observed in the natural assemblages of the Wangrah Suite, it has influenced the early fractionation of the Wangrah Suite granites. The Eastwood granite composition can be obtained after fractionation of magnetite, orthopyroxene and plagioclase (~20 wt.%) from the Danswell Creek composition and the water content in the melt increases to ~3 wt.% H_2O. Further fractionation of plagioclase, quartz, K-feldspar and biotite (~40 wt.%) from a composition similar to the Eastwood can lead to the Dunskeig granite (H_2O in melt ~4.7 wt.%). The Dunskeig composition is close to the minimum composition in the system Qz-Ab-Or-An-H_2O at a aH_2O between 0.5-0.7. Consequently, the crystallization of this composition is characterised by a rapid decrease of melt fraction over a small temperature interval of ~30 °C. At 750 °C the magma is composed of ~50% crystals. Such a magma will become immobile at relatively high temperatures (~70 °C above the water saturated solidus). In contrast, the viscosity of the residual melt decrases over this temperature interval (water content up to 4-5 wt.% H_2O). The most abundant Wangrah granite which is rich in K_2O can not be derived from Danswell Creek by crystal fractionation. A magma mixing process of highly crystalline low temperature magma containing substantial amounts of K-feldspar with primary high temperature felsic melts (similar to the Danswell Creek granite) can explain the high K_2O content of this rock and the occurrence of rapakivi texture. The formation of rapakivi texture does not need necessarily bimodal (mafic/felsic) magmatism or decompression but can result from injection of felsic water-undersaturated melts into crystallizing evolved magma chambers (replenishment).

5.5.14

Source diversity in Cretaceous anorogenic granites from Namibia raises doubt on A-type classifications

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A classic example of anorogenic magmatism is the Early Cretaceous breakup-related volcanic and intrusive complexes in Namibia. The silicic complexes have trace element characteristics typical for "A-type" granites as currently defined, but major differences in alkali/aluminum ratios and isotopic compositions require diverse magma sources for these rocks. In particular, Nd and O isotope data provide constraints on the nature and relative proportions of crustal and mantle sources involved.

With one exception, the silicic complexes have isotope variations ($\delta^{18}O$ from +8.1 to +10.7‰ and εNd from -1 to -9) that can be explained by a surprisingly simple binary mixing of mantle and crustal components. Furthermore, this same mixing line fits the Nd-O isotope variations of nearby mafic-alkaline complexes and silicic volcanic units associated with the regional Etendeka flood basalts. We interpret the crustal component to be lower crustal metasediments that were dehydrated and perhaps melt-depleted by generation of the widespread Cambrian S-type granites in the Damara Belt. The mantle component appears to be dominated by the Tristan mantle plume, but some involvement of depleted mantle material is needed to explain all of the isotope data. The data rule out any significant role for enriched, subcontinental mantle lithosphere.

Despite demonstrably different sources, the granitic complexes and silicic volcanics classify chemically as A-type granites. Instead of depending on particular source characteristics, the "A-type signature" is likely related to the high temperatures involved, which allow partial melting of even refractory and melt-depleted, lower crustal lithologies.