

The leptynitic gneisses of the Kerala Khondalite Belt, southern India: phenomena and mechanism of dehydration/melting at granulite facies conditions

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Introduction

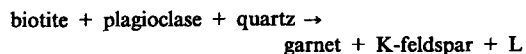
Within the late-Proterozoic Kerala Khondalite Belt in southern India, the widespread biotite-bearing granitic gneisses have been subjected to in-situ dehydration and melting at upper amphibolite to granulite facies conditions (Srikantappa *et al.* 1985, Chacko *et al.* 1987). Segregation of melts occurred in the centimetre to metre scale as well as over outcrop distances and gave rise to a complete sequence of garnet-bearing leucosome types. This ensemble (leptynitic gneiss) was formed under essentially static conditions and fortunately has not been overprinted by subsequent ductile shear deformation. Several active quarries have been selected to study three major aspects of crustal anatexis: (1) the generation of granitic melts at conditions of a fluid-absent granulite facies regime, (2) the mechanisms of melt segregation and melt migration and (3) the geochemical affinity of these melts with granites from distinct geotectonic settings. Here we report the field relations, describe the phenomena of dehydration/melting and give first results of the petrological and geochemical investigation.

Results and discussion

The gneisses before migmatization, as inferred from the petrographic and geochemical features, had a granodioritic composition and the mineral assemblage mesoperthite, quartz, oligoclase (An₂₀₋₂₅) and biotite. Accessory phases are zircon and apatite, ilmenite is the only opaque mineral.

At the onset of dehydration/melting, post-dating the penetrative deformation of the gneiss, in-situ leucosomes (L1) were formed either as isolated and equally distributed lenticular domains or combining to a network. Garnet always occurs in the centre of the leucosomes where it often forms large clusters. The grains exhibit strongly embayed boundaries, host numerous quartz inclusions and are often rimmed by quartz. The matrix consists of quartz, mesoperthite and

coarse-grained graphic intergrowths of plagioclase and alkali-feldspar. Plagioclase as single matrix phase is rare. The graphic intergrowths often surround the mesoperthite grains from which they may have been formed either through fluid-enhanced recrystallization or crystallization of an intergranular melt at subsolvus conditions. The in-situ leucosomes (L1) and the gneiss domains have similar granodioritic compositions, although some complementary features are obvious: significantly higher concentrations of FeO, MgO, Y and the HREE characterize the leucosomes, whereas the gneiss domains are moderately enriched in CaO, Na₂O, K₂O, Rb, Sr and Ba. These chemical characteristics document small-scale element transfer between the two domains, which was mainly controlled by the continuous biotite breakdown in the gneiss domains and the simultaneous growth of garnet in the centre of the leucosomes. It is suggested that the leucosomes (L1) were formed through fluid-absent biotite dehydration-melting according to the model reaction



at 750–800°C, 5–6 kbar and $X_{\text{H}_2\text{O}} \approx 0.3-0.5$, as inferred from oxygen isotope-thermometry and mineralogical thermobarohyrometry (Srikantappa *et al.* 1985, Chacko *et al.* 1988, Hoernes, pers.comm.). The proportion of melt generated at these conditions possibly was too low (< 2 vol.%) to allow segregation.

With the progress of migmatization, when melting and segregation became more important, thin veins of garnet-bearing leucosomes (L2) developed parallel and discordant to the foliation. The field relations and microstructures indicate that the segregation of the melts occurred over small distances synchronous or after development of the *in-situ* leucosomes (L1). The leucosomes are coarse-grained and show a graphic intergrowth texture of quartz and feldspar. Garnet has a smaller grain size than in

the *in-situ* leucosomes, an euhedral shape and is almost free of inclusions. Compositional zoning, typical for garnets of *in-situ* leucosomes, is absent. These observations suggest its crystallization in a melt. The quartzofeldspathic matrix still resembles that of the *in-situ* leucosomes, the abundance of graphic two-feldspar intergrowths, however, decreased at the expense of mesoperthite grains.

At the most advanced stage of migmatization leucogranitic melts were injected from greater distances into the leptynitic gneiss subparallel to its foliation, where they now form dykes (L3) of up to fifty metres thickness. The medium-grained rocks have a granoblastic texture and are made up of mesoperthite, quartz and euhedral garnet.

The leucosomes L2 and L3, in contrast to the *in-situ* leucosomes (L1) and the gneiss domains, have a chemical composition which is typical for leucogranites (Inger & Harris 1993). They are depleted in FeO, MgO and CaO and markedly enriched in K₂O, which is reflected by the high modal abundance of K-feldspar. Trace element data show a moderate enrichment in Rb and Ba, whereas Sr, Zr and REE are moderately (L2) to strongly depleted (L3). The chemical characteristics suggest that melting and segregation of L3 has left a residue enriched in Fe-Mg-bearing phases, plagioclase and accessories like zircon and apatite.

The leucosomes L2 and L3 most likely were formed through a biotite dehydration-melting-reaction, similar to that inferred for L1, but involving intense melt segregation and possibly a

higher degree of melting. With the assumption, that the leucogranitic veins L2 and L3 essentially represent melts of near-eutectic composition, as indicated by the graphic intergrowth textures and their compositions, for a given temperature (750–800°C), the water activity of the melts and the pressure conditions can be inferred from the experimental data of Johannes & Holtz (1990) for the haplogranitic system. Accordingly, the melts were water-undersaturated ($a_{\text{H}_2\text{O}} \approx 0.4$) and formed at pressures around 5 kbar.

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