Compositional zoning in an aluminous A-type granite from South India: Major, trace and *REE* signatures

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The Proterozoic granulite facies terrain of the southern part of the Indian Peninsula is intruded by a suite of alkali granite and syenite plutons preserving evidence for a prominent Pan-African felsic magmatic event (Santosh and Drury, 1988; Rajesh *et al.*, 1996). The Pan-African Ambalavayal (AL) granite intrude into the high grade metamorphic terrain of northern Kerala, South India, (Fig. 1) and is spatially associated to the Moyar and Calicut fault lineaments. The comparison of the pluton distribution with these map-scale lineaments show that the pluton was aligned nearly parallel to the NE-SW and E-W faults in the basement, consistent with magma ascent along pre-existing deep fault lineaments. It is a pink to red granite, owing to abundant brick red K-feldspar, but cream white feldspar is also present particularly towards the margin of the pluton. In contention with the colour change there appears to be a slight variation in the mafic mineral (hornblende and biotite) contents from margin (appears to be more than the interior) to the interior of the pluton, although it was very difficult to delineate.

Modal analyses of representative granitic samples plotted on a Quartz-Alkali feldspar-Plagioclase plot indicate that they range in composition from syenogranite to monzogranite. This is further supported by the R1-R2 multication diagram. CIPW norms for all the samples analysed by XRF, when projected onto the Quartz-Albite-Orthoclase phase diagram, indicate that granite compositions do not correspond to those of minimum melts in the pure quartz-albite-orthoclase system, but fall below the anhydrous ternary minima reflecting the effect of H_2O undersaturation in the magma. Modal analysis and textural analysis indicate probable trends with slight overlaps and forms the basis of delineating two probable compositional zones within the pluton; outer and inner (Fig. 2). Modal proportion of plagioclase, K-feldspar and hornblende are more towards the outer zone of the pluton in comparison to

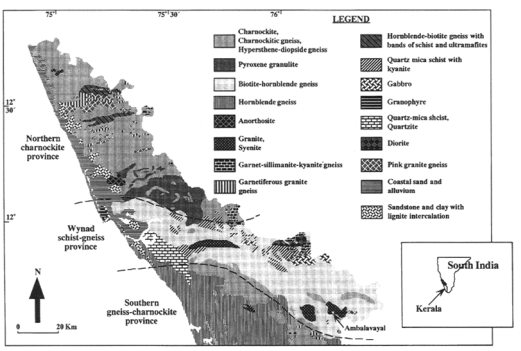

FIG. 1. Generalized geologic map of northern Kerala, South India, showing the distribution of various lithologies and the Ambalavayal granite (*cf.* GSI, 1995). The broad division of northern Kerala into four petrologic provinces is also shown. Inset shows the general outline of South India showing the location of northern Kerala.

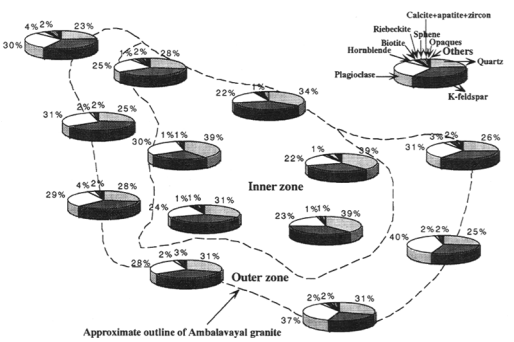

FIG. 2. A comparison of the average modal abundance of the major mineral phases between the outer and inner zone of the Ambalavayal granite. Modal abundance was determined by point counting of thin sections and whole-rock XRD analysis of powdered samples. The decimal places have been approximated.

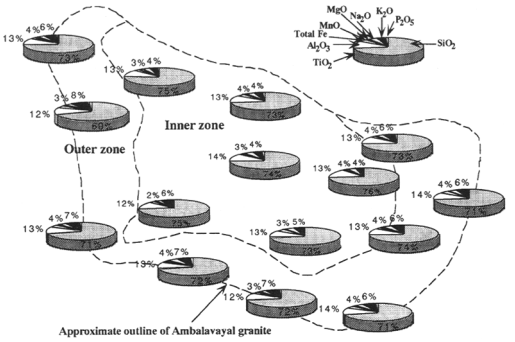

FIG. 3. A comparison of the average major element trends between the outer and inner zone of the Ambalavayal granite. Only weight percentages of SiO_2, Al_2O_3, Na_2O and K_2O are shown. The decimal places have been approximated.

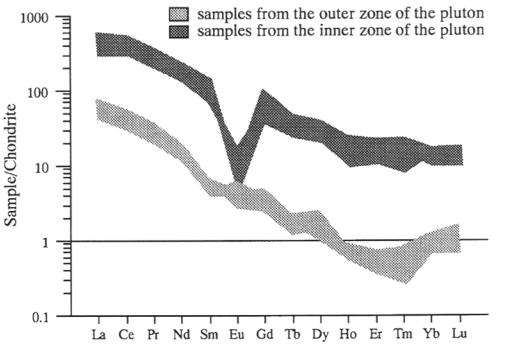

FIG. 4. Chondrite normalized *REE* patterns of samples from the outer and inner zone of the Ambalavayal granite.

the inner. In contrast quartz is enriched towards the inner zone. Biotite show slight variation with more modal proportions towards the outer zone, although in most samples they remain more or less constant. Riebeckite and sphene also show slight variation with more modal proportions towards the outer zone, while the rest of the accessory minerals show an uneven distribution.

On the geochemical table AL granite is a high-K granite with typical high-K calc-alkaline trend. The rock composition significantly vary from slightly peralkaline to metaluminous to slightly peraluminous. Strongly peraluminous compositions are absent. Major element trends indicate features like higher total alkalis, high total Fe, low CaO and MgO, and low *mg*-number, typical of A-type granites (Collins *et al.*, 1982; Whalen *et al.*, 1987; Eby, 1992). From the outer zone towards the inner zone of the pluton, distinct trends were observed with occasional overlaps (as summarized in Fig. 3). All the major elements, except Na_2O, show decreasing trends from outer zone to the inner zone. Na_2O contents show an increasing trend for the outer zone and decreases with increase in the degree of fractionation towards the inner zone. Al_2O_3 trends are more or less uniform with slight increment toward the outer zone. The use of various multicationic diagrams like Q-B, A-B, B-F and Q-F, where Q = Si/3 − (K+Na+2Ca/3), F = K − (Na+Ca), A = Al − (K+Na+2Ca) and B = Fe+Mg+Ti, characterize the geochemical variation noticed.

Trace elements show good correlations with SiO_2 for some elements such as Zr and Zn but diffuse trends for Sr, Ba and Rb. Trace element variation diagrams of the nature of X/Y *vs* X/V and X/Y *vs* Y, where X, Y and V are any three trace elements, clearly illustrates the compositional zoning within the AL granite samples. When total Fe/MgO is plotted against Zr+Nb+Ce+Y, the outer zone samples plot in A-type granite field of Whalen *et al.* (1987), while the inner zone samples plot in the fractionated felsic granite field. Similar trends were observed in other typical A-type granite differentiation diagrams of Whalen *et al.* (1987) and Eby (1992). Chondrite normalized *REE* plots of AL granite samples reveal two distinct almost parallel patterns, consistent with the geochemical zones recognized (Fig. 4). The samples from the inner zone have higher *REE* contents than the outer ones. When the variation in the pluton as a whole is considered, the fractional removal of the various mineral phases (although limited) supported adequately by major, trace and *REE* variations might have made a significant contribution to the overall evolution of the magma.

References

Collins, W.J., Beams, S.D., White, A.J.R. and Chappell, B.W. (1982) *Contrib. Mineral. Petrol.*, **80**, 189–200.

Eby, N.G. (1992) *Geology*, **20**, 641–4.

Geological Survey of India (1995) Geological and Mineral map of Kerala on the scale 1:500,000. published by *GSI*, India.

Rajesh, H.M., Santosh, M. and Yoshida, M. (1996) *J. Southeast Asian Earth Sci.*, **14**, 275–91.

Santosh, M. & Drury, S.A. (1988) *J. Geol.*, **96**, 616–22.

Whalen, J.B., Currie, K.L. and Chappell, B.W. (1987) *Contrib. Mineral. Petrol.*, **87**, 319–27.