

THE TRANSITION FROM AN ARCHEAN GRANITE-GREENSTONE TERRANE INTO A CHARNOKITE TERRANE IN SOUTHERN INDIA; Kent C. Condie and Philip Allen, Dept. of Geoscience, New Mexico Institute of Mining and Technology, Socorro, NM 87801

In southern India, it is possible to study the transition from an Archean granite-greenstone terrane (the Karnataka province) into high grade charnockites (Fig. 1). The transition occurs over an outcrop width of 20-35 km and appears to represent burial depths ranging from 15 to 20 km (1). Field and geochemical studies indicate that the charnockites have developed at the expense of tonalites, granites, and greenstones (1, 2, 3, 4). South of the transition zone, geobarometer studies indicate burial depths of 7-9 kb (5).

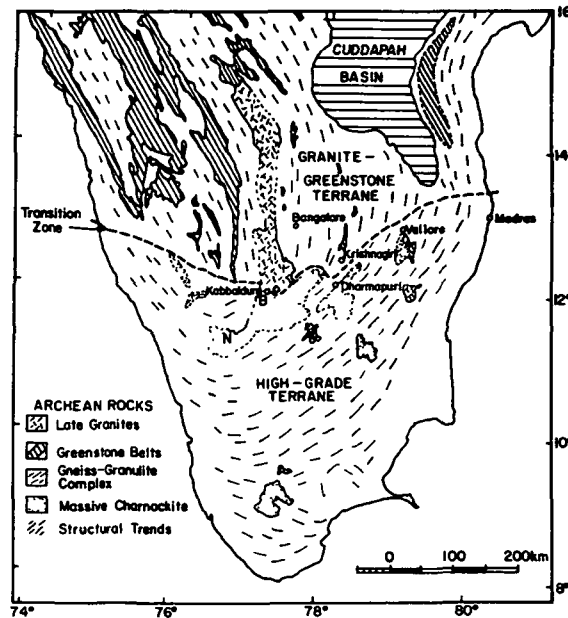


Figure 1. Geologic map of southern India showing the transition zone.

On most chemical variation diagrams, the charnockites, define igneous-like trends with a sparsity of intermediate compositions ( $\text{SiO}_2 = 55-65\%$ ) and a great majority of tonalitic compositions. As with other granulite-facies terranes, the Indian charnockites exhibit significant depletions in Rb, Cs, Th, and U (4). However, a well-defined correlation of degree of depletion and metamorphic grade is not apparent. Many of the low-grade charnockites exhibit as great of depletion as high-grade charnockites. Unlike most other high-pressure charnockites, however, Indian charnockites do not exhibit

depletion in K, and Rb depletion does not reach the 1-2 ppm level as observed in Lewisian granulites. Indian tonalites and charnockites do not exhibit significant differences in the contents of Ba, Sr, REE, high field strength elements or transition metals. Depletions in Rb, Cs, Th, and U appear to have occurred during the passage of a CO<sub>2</sub>-rich fluid phase.

Tonalitic and granitic charnockites (like their protoliths) have light-REE enriched patterns and generally exhibit an inverse correlation between SiO<sub>2</sub> and total REE content. Eu anomalies range from slightly negative to strongly positive, with Eu/Eu\* exhibiting an inverse correlation to REE content.

With exception of Rb, Cs, U, and Th, the major and trace element distributions in Indian charnockites reflect the composition of their protoliths. Geochemical modelling clearly indicates that the tonalitic charnockite protoliths (TCP) have been produced by partial melting of a mafic source rich in hornblende and/or garnet or by fractional crystallization of a wet basaltic magma (1, 4). A mafic source must be enriched in incompatible elements relative to N-MORB or TH1 (the major Archean basalt type) and depleted relative to continental rift basalts (Fig. 2). Such a source is similar in composition to TH2 (enriched Archean basalts). Archean tonalites, in general, demand the existence of an enriched mafic source and thus require a substantial volume of enriched mantle by the late Archean.

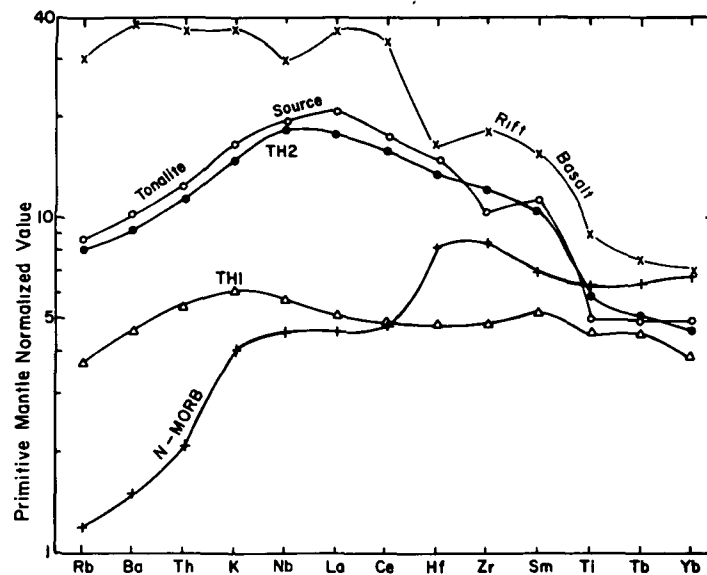


Figure 2. Primitive mantle normalized incompatible element distributions in the Indian TCP source compared to other mafic compositions (modified from 1). Rb and Th contents of TCP from Indian tonalites.

Most Indian charnockites cannot represent the residue left after extraction of granitic magma as indicated by the contrasting incompatible element contents (Fig. 3B). One sample from the transition zone (NCl), however, does match the calculated residue. This suggests that although the charnockite terrane as a whole cannot be considered as residue, portions of the terrane in the transition zone may represent residue.

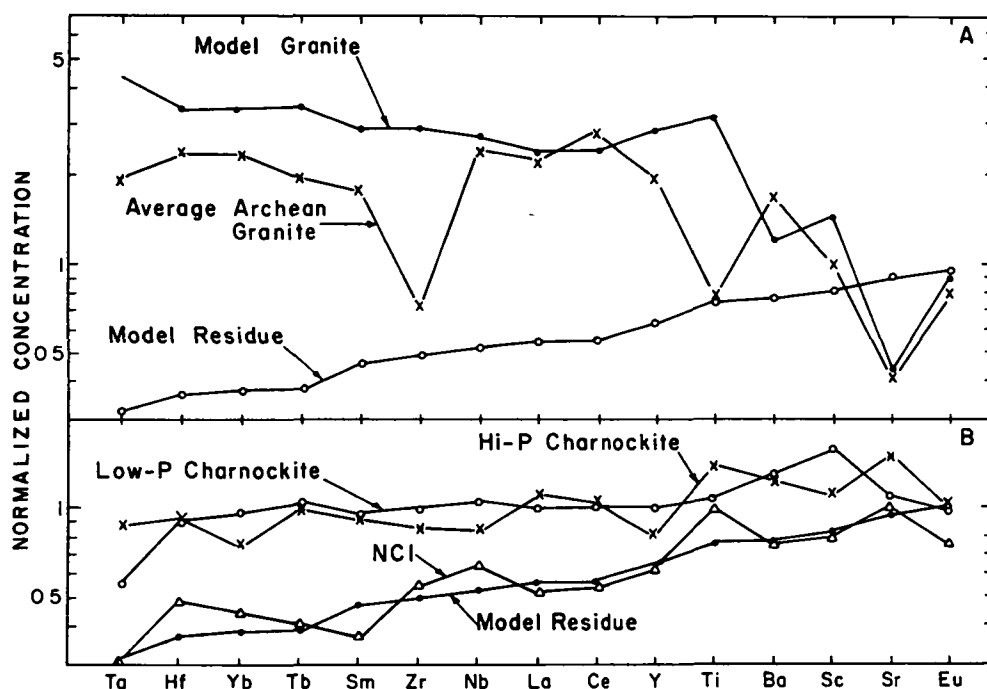


Figure 3, Tonalite-normalized element distributions of relatively incompatible elements in granite and charnockites. Model granite and residue are produced by 20% batch melting of tonalite. Mode and melt fractions given in (4).

Although field and geochemical data clearly indicate that some granites in the transition zone are of metasomatic origin (1), others may be partial melts and still others, involve both processes (6). Field relationships along the transition zone strongly suggest that a fluid phase relatively rich in  $\text{CO}_2$  purged  $\text{H}_2\text{O}$  from the lower crust and concentrated it in a relatively narrow region at mid-crustal levels where partial melting produced migmatites with granite leucosomes (1, 3, 6). In some areas along the transition zone, major plutons may have formed by such a mechanism. Thus, granite formation in the Archean crust of India is closely related to charnockitization and is localized, for the most part, at intermediate crustal levels (20-25 km) along a metasomatic front. Deep crustal charnockites represent tonalites in which large amounts of Rb, Cs, Th, and U have been

removed by fluids with variable, but on the whole, high  $\text{CO}_2/\text{H}_2\text{O}$  ratios. High  $\text{CO}_2/\text{H}_2\text{O}$  ratios in fluids also raise solidus temperatures and thus prevent partial melting of the lower crust. If this model is correct, it is the middle and not the lower crust where we should look for the residues left after granite extraction.

#### References

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