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Trends in Phosphate and Silicate Mineral Chemistry Across a Section of Archean Crust, Tamil Nadu, South India: The Role of Fluids In Regional Granulite-Facies Metamorphism

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Fluorapatite, monazite, allanite, titanite, biotite, orthopyroxene and amphibole distributions, textures, and mineral compositions as well as whole rock trace element chemistry have been documented in felsic and intermediate orthogneisses as a function of distance across a 95 km traverse of lower Achaean crust, Tamil Nadu, south India. The traverse ranges from a northern amphibolite-facies zone (NAF) to a central lower grade granulite-facies zone (CGF), which grades into a higher-grade southern granulite-facies zone (SGF). Going from north (lower grade) to south (higher grade), trends in mineral and whole rock chemistry include a marked depletion of Rb, Th, and U in the whole rock analyses, a small depletion in LREE in the whole rock and monazite analyses, an enrichment in Ti and F and depletion in Fe and Mn, in biotite and amphibole, increases in Al and decreases in Mn in orthopyroxene, and enrichment of fluorapatite in F. K-feldspar micro-veins, usually at quartz-plagioclase grain boundaries, and replacement antiperthite occur throughout the traverse. In the SGF and southern half of the CGF roughly 80 to 90 % of the fluorapatite contains monazite inclusions and rim grains: these appear to be the principle hosts for REE. Monazite associated with fluorapatite appears to have formed by the reaction of fluorapatite (with 1.6 to 4.4 wt% REE) with a fluid. Large, often complexly zoned, monazite grains independent of fluorapatite occur in the majority of the samples from the northern CGF and southernmost NAF. The southern boundary of this area is marked by a reaction by which independent monazite grains were replaced by a REE enriched fluorapatite.

This reaction was accompanied by a loss of Th and may also have been accompanied by a small depletion in LREE. Monazite is completely absent and the principle REE bearing accessory minerals are allanite and titanite in the northern NAF. The Fe trends in the Fe-Mg silicates appear to indicate a buffering of H_2O activities to slightly lower levels northwards in the granulite-facies terrain. Other features of the traverse can be explained by increasing temperature (Al in orthopyroxene), progressive mineral reactions (southward increase in F in fluorapatite, biotite, and, amphibole and a southward decrease of Mn in orthopyroxene, biotite and amphibole), or either partial melting or metasomatic reactions (K-feldspar micro-veins). However trace element depletion and monazite-fluorapatite reaction relationships are best explained by the action of an externally derived, low a_{H2O} brine migrating through the rocks from a (possibly mafic) source at greater depth.