A Mesoproterozoic Sm-Nd age for the Oddanchatram anorthosite massif, south India: Evidence for ancient crustal contamination and significance to the regional terrane assembly

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Within the Southern Granulite Terrane (SGT), S. India, the margin of the Archaean Dharwar craton demarcates an apparent suture zone between Late Archaean and Proterozoic terranes. This zone was intensely reworked in a collisional tectonic regime during the Neoproterozoic and is presently manifest as the deep-section of a crustal-scale shear zone system, the Palghat Cauvery Shear Zone (PCSZ), which separates terrains with Late Archaean. (ca. 2.5 Ga) granulite facies metamorphism from those with Neoproterozoic (ca. 0.55 Ga) granulite metamorphism. Charnockites from the Neoproterozoic domains indicate a complex map pattern of Archaean and Mesoproterozoic Sm-Nd model-T_{DM} ages and Meso- to Neoproterozoic zircon and monazite U-Pb ages. However, there is no clear evidence for Mesoproterozoic juvenile crust in the region.

The Oddanchatram anorthosite massif, an elongated oval shaped body (~ 80 km^2) occurs within a steeply dipping shear zone that branches off from the PCSZ. It is composed largely of coarse grained metaanorthosite (avg. An=55%) in the core and deformed gabbroic anorthosite and norite along the margin. The suite is structurally concordant with deformed charnockite, garnet-sillimanite gneiss and granitoid units. A primary mineral assemblage of plagioclase (> 90 modal %), interstitial hornblende, pyroxene, zircon and titanite and a secondary assemblage of recrystalized high-calcic plagioclase with K-feldspar exsolution, garnet, biotite, and quartz characterize the anorthosites. Major and trace element compositions are consistent with plagioclase cumulates from a calc-alkaline mafic melt. Compared to model primitive mantle, the Oddanchatram suite is enriched in Sr, Eu and depleted in Nb, Ta, Zr and U. An Sm-Nd isochron gives an age of 1814±98 Ma (2 σ), εNd= -11.7. Nd (T_{DM}) model ages range between 2.7 and 3.2 Ga, similar to those of the spatially associated charnockites. The relationship between Nd abundance and Nd- isotopic compositions suggest a significant crustal-contamination of a differentiated mafic parental melt involving Mid- to Late Archaean crust. Implications of such Mesoproterozoic crustal components (a possible anorthosite-mangerite-charnockite-granite association) to the regional terrane assembly in an orogenic setting is discussed.

Proton/Calcium ion exchange behaviour of calcite: Implications for aqueous speciation and $CO_{2(g)}$ sequestration

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The quantitative characterization of the proton sorptive properties of calcite in aqueous solutions has represented a major experimental challenge. In this study, we introduce a headspace-free closed-system titration technique that can quantitatively resolve sorption equilibria from dissolution/precipitation reactions and allowed us to investigate the proton sorptive behaviour of calcite at 25 ± 1º over a relatively wide range of chemical conditions ($7.1 \leq pH \leq 9.5$; $4{\cdot}10^{-5}$ M $\leq \Sigma Ca^{2+} \leq 5.2{\cdot}10^{-3}$ M; $1.3{\cdot}10^{-4}$ M $\leq \Sigma CO_2 \leq 1.8{\cdot}10^{-2}$ M and available reactive area: solution ratios from 0.2 to 5.7 m^2/L) by means of acidimetric and calcium ion titrations.

A net proton uptake coupled with the incongruent release of Ca^{2+} over CO_3^{2-}ions, both largely exceeding the theoretical number of reactive sites available at the calcite surface, lead us to postulate that proton sorption extends beyond the calcite surface via a proton/calcium ion exchange mechanism with “labile exchangeable cation sites”:

$$\equiv CaCO_{3(exc)} + 2\,H^+ \Leftrightarrow \equiv H_2CO_{3(exc)} + Ca^{2+}$$

This reaction is represented by the empirical Langmuir-power exchange function:

$$K_{Exc} = \left(\frac{X_{\equiv H_2CO_{3(exc)}}}{X_{\equiv CaCO_{3(exc)}}}\right)^n \frac{(aCa^{2+})}{(aH^+)^2}$$

where n=1 and $\log_{10} K_{Exc} = 12.96 \pm 0.21$. The implications of the proposed mechanism on aqueous speciation (e.g. pH buffering, control of the calcite saturation state) and $CO_{2(g)}$ sequestration in carbonate-rock aquatic environments will be discussed.