Title: "Petrological evolution of the Neoproterozoic meta-supracrustal rocks from parts of the Indian shield"

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ABSTRACT

The metamorphic rocks of the Indian shield record a protracted geological history that span for more than ca.3500 Ma. Tracing the Neoproterozoic tectonothermal pulses in the Indian shield has paramount importance in understanding the formation of the two Neoproterozoic supercontinents (the Rodinia and the Gondwanaland). In view of this, two intercalated calc-silicate and pelitic granulites have been studied from the Chotanagpur Granite Gneissic Complex (CGGC) and the Granulite Terrane of South India (GTSI).

The calc-silicate and pelitic granulites in the CGGC occurs as map scale enclaves within the ca.1450 Ma (protolith age) felsic orthogneisses. Two types of calc-silicate granulite enclaves, having distinct mineralogy are studied. These are: (1) plagioclase+ titanite+ garnet+ clinopyroxene+ amphibole+ ilmenite+ spinel± calcite+ zircon± apatite ± magnetite. The mineral assemblages are asymmetrically distributed in plagioclase, clinopyroxene and garnet-rich bands. This rock develops rare symplectite of highly aluminous clinopyroxene (Al_2O_3>11.5 wt%), ilmenite and spinel. Interpretation of reaction textures and phase equilibrium modelling in the system Na_2O-CaO-FeO-MgO-Al_2O_3-SiO_2-TiO_2-H_2O-CO_2-O_2 attest to the reaction: garnet+ titanite+ amphibole= clinopyroxene+ ilmenite+ spinel+ plagioclase (Pl_2)+ vapour, triggered by a steeply decompressive P-T path from ~790-890°C, ~8.4-9.5 kbar to ~780-860°C and ~5-5.8 kbar. U-Pb ages of metamorphic zircon overgrowth over the detrital core, dates the timing of the dominant metamorphism at 1060-970 Ma (with a ca.1480 Ma old spot age). The $^{207}Pb/^{206}Pb$ ages of the detrital zircon core suggest that the protolith sediments were sourced from rocks of diverse age populations (~2470 Ma, 2190-2000 Ma and 1790 Ma) from hinterland. The low $\delta^{18}O$ (4±1.2 ‰) values of the whole rock suggest that the protolith sediments were altered via interaction with low $\delta^{18}O$ fluid (meteoric water). (2) This type of calc-silicate granulite comprises clinopyroxene + plagioclase + titanite + amphibole ± apatite. Millimeter thick compositional bands that are rich in clinopyroxene and plagioclase are seen. This rock develops garnet-vesuvianite and epidote bearing veins (clinopyroxene+ plagioclase+ titanite+ vesuvianite+ garnet+ epidote ± apatite ± calcite), proximal to undeformed pegmatite bodies that dissect the host calc silicate granulite. Reaction textures and the activity corrected topologies in P-T-X(fluid) topologies suggest that the infiltration of F-rich aqueous fluid, presumably derived from pegmatites, was responsible for the formation of vesuvianite and garnet by the reactions (a) clinopyroxene+ quartz+ plagioclase± calcite+ fluid (H_2O + F) ± O_2 → Vesuvianite + CO_2 and (b) clinopyroxene+ plagioclase± quartz± calcite→ garnet+ CO_2 at ~6kbar and ~600-620°C and X_{CO2}≤0.40. Epidote formed later at more H_2O-rich conditions (≤0.1 X_{CO2} and lower X_F) and lower temperatures <600°C. Titanite in some domains is unusually rich in Al_2O_3 (up to 11.5 wt%) and F (up to 3.8 wt%). The dominant substitution that explains the abnormally high Al-F titanite is $Ti^{+4} + O^{2-} \rightarrow Al^{+3} + (F+OH)^-$. f_{F2} in the coexisting fluid controlled the coupled substitution. The mineralogical evolution of the pelitic granulite enclaves show P-T conditions at the culmination of metamorphism (~9.8-10.5 kbar and ~850-880°C) that is similar to the peak P-T conditions recorded from the first type of calc silicate granulite.

contd.

Abstract

The Madukkarai Supracrustal Unit (MSU) within the GTSI is chiefly composed of an interlayered sequence of pelitic granulites (locally with arenaceous components) and calc-silicate granulites. The gneissic fabric of the pelitic granulite of the MSU is defined by centimeter thick laterally discontinuous garnet bearing leucosome. The mineral assemblages of the pelitic granulites include: garnet+ biotite+ sillimanite (locally pseudomorphs after kyanite)+ K-feldspar+ plagioclase+ quartz+ ilmenite ± cordierite± orthopyroxene. Rutile, zircon and monazite occur as accessory minerals. Interpretation of the reaction texture, pseudosection modelling and conventional geothermobarometry recovered maximum temperature and pressure of metamorphism in the realm of ~730–790 °C, ~5.5–7 kbar (relict kyanite indicates pre-peak pressures ≥8 kbar). These P-T values correspond to a transient geothermal gradient of ~37°C/km, at crustal depth of ~25 km. Subsequently, the pelitic granulite ascended (corresponding to a shallower crustal depth of ~15km) along a steeply decompressive retrograde P-T path that was followed by cooling up to ~630°C and ~4 kbar. The attainment of high-pressure condition prior to peak metamorphism, and geometry of the retrograde P-T path are consistent with a continent-continent collisional tectonic setting. The calc silicate granulites preserve clinopyroxene+ plagioclase + scapolite (±titanite ±magnetite) as the earliest assemblages. These minerals sequentially develop garnet (up to 75 mol% andradite) + amphibole and epidote through a number of infiltration driven mineral reactions. The observed mineralogical changes are interpreted in the P-T and T-X_{CO_2} topologies in the CaO-MgO-Al_2O_3-SiO_2-H_2O-CO_2 (CMASV) system. The effects of Fe^{2+}, Fe^{3+} and Na on the CMASV topologies are analysed. Interpretation of the 'frozen in' reaction textures in the activity adjusted CMASV topologies supports the view that the infiltration of an aqueous fluid triggered the metamorphic reactions (X_{CO_2} =0.4-0.6, ~440-640°C, ~440°C; at ~4.5-6kbar) in the calc silicate granulites. LA-ICP-MS U–Pb zircon and chemical age of monazite in the pelitic granulite, dates the timing of metamorphism in the range of 550-520 Ma with vestiges of ~600 Ma event. The petro-chronological history of the MSU resembles that of the meta-supracrustal rocks lying north and south of the study area. Observations from this study supports the view that the GTSI behaved as a coherent block during the Ediacaran-Cambrian orogenesis and does not support the view that the Palghat Cauvery Shear Zone is a Neoproterozoic suture zone. The timing and style of tectonothermal events being deduced in this study supports the view that the Indian shield and the Precambrian basements of the east Antarctica and Madagascar behaved as a coherent block in the Rodinia and Gondwanaland supercontinents.

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