Petrochronological appraisal on the timing and duration of ultrahigh-temperature metamorphism in southern India: Insights from charnockite and sapphirine bearing semipelitic granulite from the Madurai Block

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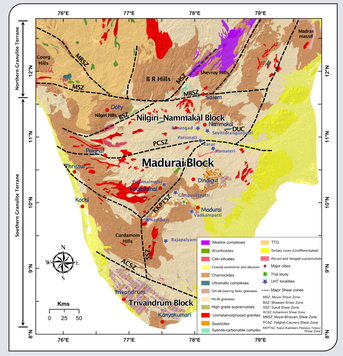
1. Introduction

- The Granulite Terrane of southern India is one of the world's largest exposed deep continental crustal sections, preserving rock record from Archean to Proterozoic, spanning 2900 Ma.
- The terrane is a mosaic of several crustal block with intervening suture/shear zones, broadly classified into Northern and Southern Granulite Terrane.
- The **Madurai Block** forms the largest crustal block of the Southern Granulite Terrane and has been extensively studied on account of Neoproterozoic-Cambrian (ca. 550 Ma) **ultra-high temperature (UHT) metamorphism**.
- Close temporal relationship between UHT events and supercontinent cycles has prompted authors to study UHT metamorphism in the Madurai Block in the context of Gondwana assembly.
- In light of the diverse PT paths and the ages obtained from different parts of the block, authors have envisaged varied geodynamic scenarios for the attainment of UHT. Such as:
  1. Post collisional thinning and associated magmatism in a subduction-collision setting (Santosh et al., 2009)
  2. Collision of Eastern Madurai Domain and Western Madurai Domain along the KKPTSZ and SSZ culminated into UHT metamorphism (Brandt et al., 2014).



Objective

- A precise P-T evolution of each crustal domain combined with detailed geochronological data must be known for a decisive interpretation of the geodynamic setting.

The specific objectives of this study are:

- ✓ **To constrain the P-T evolution through integrated petrography, mineral chemistry and pseudosection modelling.**
- ✓ **Constraining the timescale of metamorphism through texturally controlled in-situ monazite geochronology.**
- ✓ **Constrain the probable geodynamic setting for the attainment of UHT conditions**

2. Study area and field relationship

Study area: Usilampatti, Northwest of Madurai City

Rock Types: Charnockites, Enderbites, Migmatitic semipelitic gneisses and Leptynites

Charnockite is the most dominant lithology with **Migmatitic semipelites** occurring as enclaves within charnockite and leptynite.

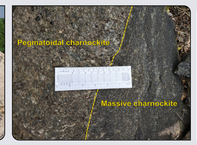
Charnockite: Garnet+Orthopyroxene+Plagioclase+K-feldspar+Quartz

Migmatitic semipelite:

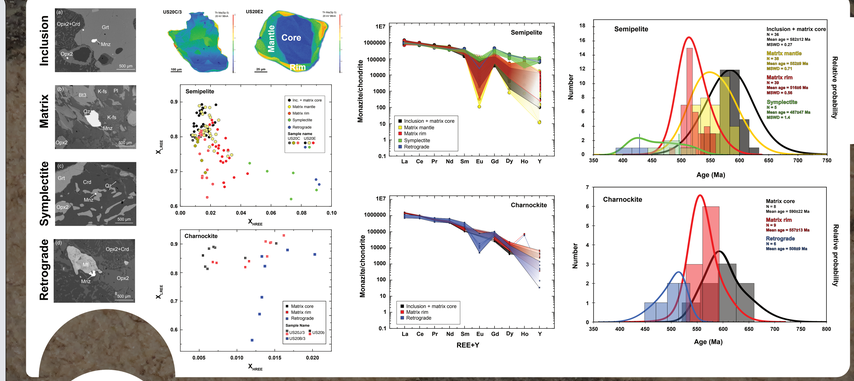
Melanosome → Garnet+Orthopyroxene+Cordierite±Biotite

Leucosome → Plagioclase+quartz+K-feldspar+garnet

Both the rock types preserve conspicuous reaction texture to constrain the PT evolution.



5. In-situ monazite geochronology



6. Pseudosection modelling

Program Used: Perple_X

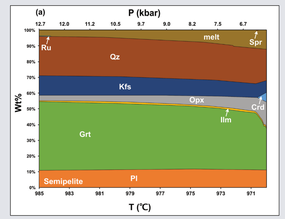
Compositions: From XRF and Local Bulk

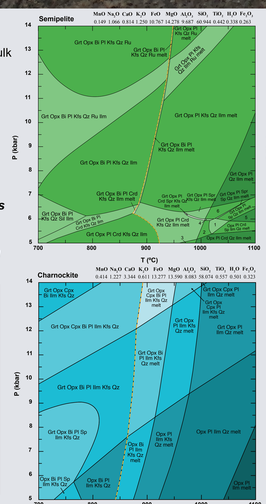
Peak P-T conditions

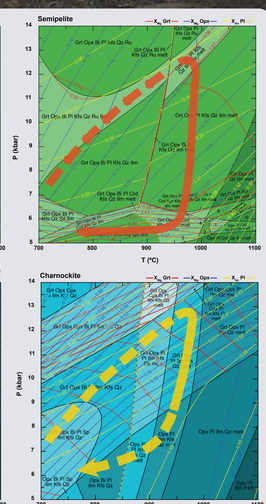
Semipelite	Charnockite
960-980°C	950-980°C
11-12.5 kbar	12-12.5 kbar

Obtained P-T ranges are in line with conventional thermobarometric calculations

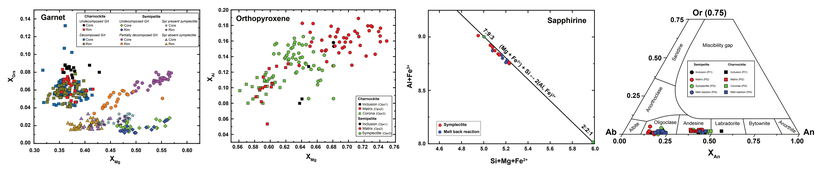
Both the rock types shows clockwise P-T evolution with decompression-cum-cooling





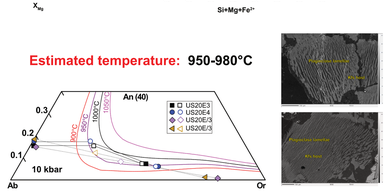


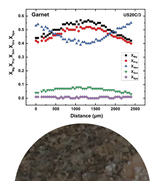
4. Mineral chemistry and thermobarometry



Texture	Conventional Thermobarometry	
	Semipelite	Charnockite
	Fe-Mg exchange thermometer	
Core	950±30°C	970±20°C
Symplectite	850±20°C	880±20°C
	Al-in Opx thermometer	
Core	980±25°C	990±10°C
Symplectite	920±35°C	905±15°C
	Grt-Opx-Pl-Qz barometer	
Core	10.1±0.7 kbar	9.5±1 kbar
Symplectite	7.5±0.5 kbar	7±0.5 kbar

Estimated temperature: 950-980°C





3. Petrography and reaction history

	Semipelite	Charnockite
Coarse grained assemblage	Grt + Opx2 + Pl2 + Kfs + Qz	Grt + Opx2 + Pl2 + Kfs + Qz
Inclusion assemblage	Opx1 + Pl1 + Bt1 + Qz + Rt + Ilm	Opx1 + Pl1 + Bt1 + Sp + Ilm + Qz
Symplectic assemblage	Opx3 + Crd ± Spr ± Pl3 ± Bt2 ± Ilm	Opx3 + Pl3 ± Bt2 ± Qz
Replacement at grain edges	Grt and Opx replaced by Bt	Grt and Opx replaced by Bt

Prograde to peak stage

Bt1 + Qz ± Pl1 → Grt + Opx2 + Kfs + melt (✓ ✓)

Symplectic Stage

Grt + Qz → Opx3 + Crd ± Spr ± Pl3 (✓)

Grt + Qz → Opx3 + Pl3 (✓)

Melt back reaction

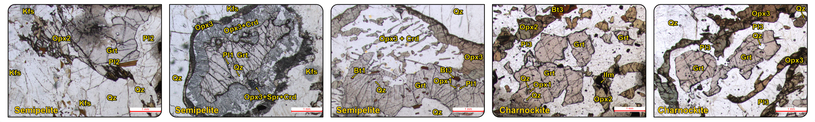
Grt + melt ± Opx2 → Bt2 + Pl4 + Qz (✓ ✓)

Grt + melt → Spr + Bt2 + Pl4 (✓)

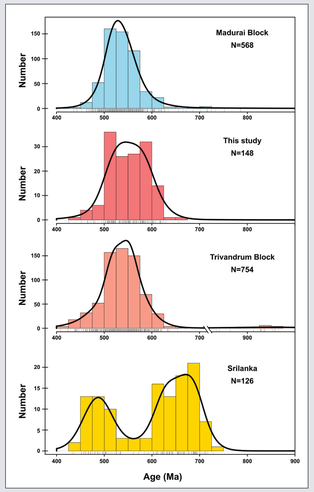
Retrograde Bt growth

Grt/Opx1 + Kfs + V/H2O → Bt3 + Pl4 + Qz (✓ ✓)

Opx2 + Crd2 + Kfs + V/H2O → Bt3 + Pl4 + Qz (✓ ✓)

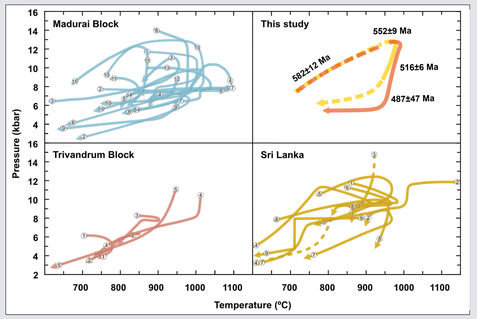


7. Discussion and conclusion



- ✓ **Prolonged duration of monazite growth in different crustal blocks from Late-Neoproterozoic to Cambrian**
- ✓ **Dominantly clockwise P-T paths obtained from Madurai and Trivandrum Block in SGT, Srilanka and other eastern Gondwana fragments.**

Existence of a regional scale, late-Neoproterozoic to Cambrian, long-lived Hot orogen in eastern Gondwana.



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