Phyllonites from Attur Shear Zone and its tectonic significance in Southern Granulite Terrain, South India

B. K. Bhadra

Department of Earth Sciences, Pondicherry University, Pondicherry 605 014, India

In the eastern part of the Southern Granulite Terrain, Attur Shear Zone (ASZ) is characterized by 1 to 1.5 km wide phyllonite zone which shows the maximum intensity of shearing. The foliation planes in this zone are sub-vertical ENE–WSW striking mylonitic foliation with dominant steeply plunging (70–80°) stretching lineations. The phyllonites show all gradations from protomylonite to ultramylonite and extensive biotitization of pyroxene/hornblende minerals. The microstructural studies of phyllonites indicate that ASZ has undergone extensive ductile shearing accompanied by fluid (H₂O) induced retrograde metamorphism. ASZ, probably formed at deep (10–15 km) continental crust, is exhumed at the present level of erosion by relative upliftment of adjacent blocks.

Among the three types of shear zones, ductile shear zone provides greater insight for deep-crustal deformation processes. At mid-crustal level, mylonites are commonly formed by ductile deformation through crystal-plastic grain size reduction and recrystallization. The mylonites have been observed in many crystalline terrains which have deformed under greenschist to granulite facies metamorphism. In southern Peninsula India, a number of Proterozoic shear zones divide the Archean Granulite Terrain into different crustal blocks (Figure 1a). Based on studies of LANDSAT images, Drury and Holt inferred that northern and southern granulite blocks have been displaced along E–W trending Moyar–Bhavani–Attur lineament by dextral shear.

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Generally, the term 'phylloite' is used for schist-
derived mylonite which is enriched with phyllosilicate minerals such as sericite/muscovite, biotite, chlorite, etc. Due to its fine-grained mineral constituents, phylloite sometimes resembles slate or phyllite. In ASZ, the phylloites are medium- to fine-grained, grey to pale green, dominantly composed of feldspar, quartz and phyllosilicate minerals. They often show spotty appearance given by circular to elliptical feldspar porphyroclasts embedded within fine-grained matrix and resemble typical mylonites. The foliation planes within the phylloite zone are essentially mylonitic foliation which are moderate to steeply dipping either north or south with steeply plunging (70-80°) mineral/stretching lineation. Stereoplotting of foliation and lineation data shows that the lineation maxima falls on the modal foliation plane (N78°/82°S) which indicates a dominant dip-slip shear movement (Figure 1c). The kinematic analysis of shear sense indicators such as S-C fabric, asymmetric folds, asymmetric augen, fractured and displaced grains, etc. indicates a dextral shearing event from west to east (communicated elsewhere).

Microstructural studies from phylloites of ASZ show all gradations from protomylonite to ultramylonite via the orthomylonite stage. At the initial stage of mylonitization, the rock is deformed by intracrystalline strain associated with elongation of grains and grain size reduction. Plagioclase and K-feldspar show deformation twinning, strongly undulant extinction and at places they are fractured and displaced. Quartz grains also get flattened showing undulose extinction with serrated boundaries and peripheral grain refinement. At this stage the protomylonite shows mortar texture. Among the quartz and feldspar porphyroclasts, quartz grains get more elongated than feldspar. Sometimes the development of sub-grains within elongated quartz may result in a crude banding structure. As the strained quartz grains begin recovery/recrystallize with the pace of increasing strain rate, the porphyroclasts ratio decreases less than 50% w.r.t. the matrix and the rock appears as orthomylonite (Figure 2). Here the rock has developed microscopic banding given by the quartz ribbons anastomosing the highly strained feldspar porphyroclasts. With increase in the shear strain the orthomylonite passes over to ultramylonite when most of the porphyroclasts diminished to equant grains of finer size. Quartz grains are completely recrystallized with the development of finer quartz ribbon.
In the fault zone model, Sibson\textsuperscript{16,17} has shown that brittle deformation at shallow depth grades into plastic or ductile deformation at 250–300°C and 10–15 km depth where mylonite form predominantly by the mechanism of crystal plastic deformation. The microstructural behaviour of phyllonites across the gneissic rocks in the area indicates that the mylonite probably formed at deep continental crust and is now exposed at the surface due to uplift and erosion. This upliftment of the adjacent blocks is manifested by the development of steeply plunging stretching lineations on steeply dipping mylonitic foliations. Also, a distinct pressure difference is found\textsuperscript{18} between the charnockite massifs of Shevroy (7.4 kb) and Kollimalai (8.6 kb) across the ASZ which indicates an uplifted Kollimalai w.r.t. Shevaroy. During the tectonic upliftment process, deep-seated fluids (H\textsubscript{2}O and CO\textsubscript{2}) conduits through the fractures of ASZ and causes widespread retrogression and metasomatism. The interaction of H\textsubscript{2}O influx with the granulites causes retrograde hydration during the initial stage of exhumation. It has been interpreted that the retrogression effect of phyllonites is syn- to late stage phenomena of progressive mylonitization.


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