Field and Microstructure study of Transpressive Jogdadi shear zone near Ambaji, Aravalli- Delhi Mobile Belt, NW India and its tectonic implication on the exhumation of granulite

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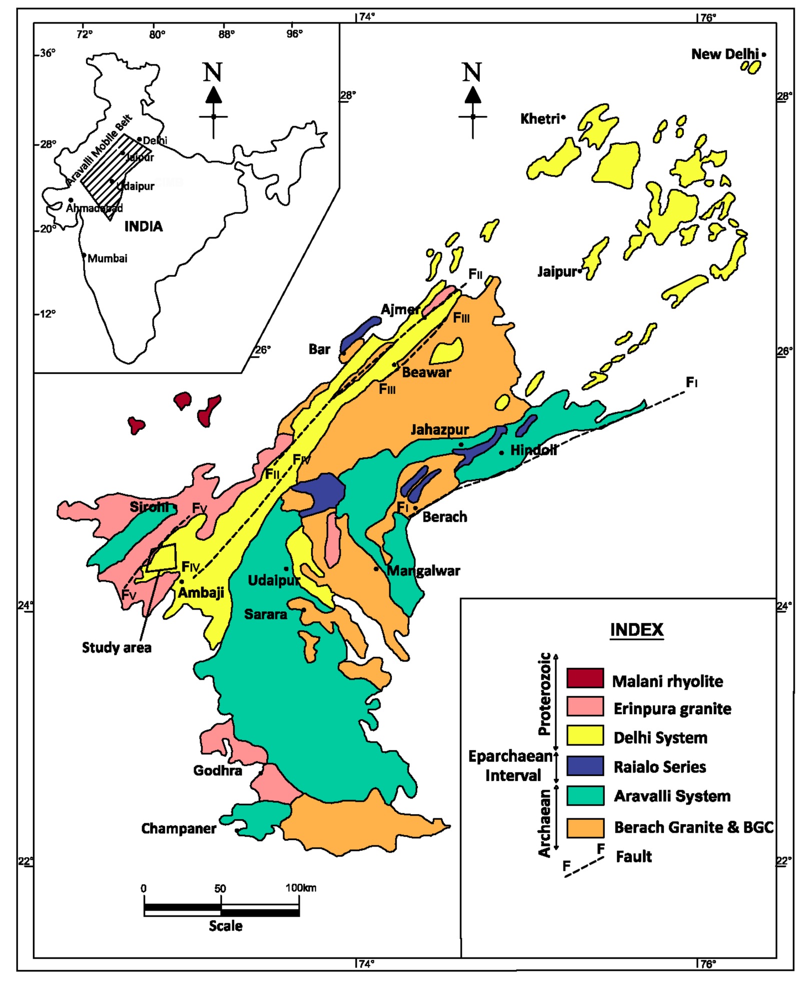
Abstract

Aravalli- Delhi mobile belt is situated in the nortwestern part of Indian shield. It comprises tectono- magmatic histories fromfrom Archean to neoproterozoic age. It possesses three tectono- magmatic metamorphic belts namely Bhilwara Supergroup (3000 Ma), Aravalli Supergorup (1800 Ma) and Delhi Supergroup (1100 -750Ma). The Delhi Supergroup is divided in two parts North Delhi and South Delhi; North Delhi (1100 Ma to 850 Ma) is older than South Delhi (850 Ma to 750 Ma). The study area falls in the South Delhi terrane; BKSK granulites are the major unit in this terrane. BKSK granulites comprise gabbro- norite-basic granulite, pelitic granulite, calcareous granulite and occur within the surrounding of low grade rocks as meta- rhyolite, quartzite, mica schist and amphibolites. The high grade and low grade terranes share a sheared margin. Granulites have undergone three phases of folding, intruded by three phases of granites and traversed by many shear zones. One of the shear zones is Jogdadi shear zone which consists of granitic mylonites and other sheared rocks. Jogdadi shear zone carries the evidence of both ductile as well as brittle shearing. It strikes NW – SE; the mylonitic foliation dip moderately to SW or NE and stretching lineations are oblique towards SE. The shear zone is folded and gabbro- norite – basic granulite occurs at the core. One limb of fold passes over coarse grained granite while other limb occurs over gabbro- norite- basic granulite. Presence of mylonitic foliation, asymmetric folding, S-C fabrics, porphyroclasts, mica fishes and book shelf- gliding are indicative of ductile deformation. Most of the porphyroclasts are sigmoidal and delta types but there are also some theta and phi type porphyroclasts. Book shelf-gliding structures are at low angle to the C plane. The shear zone successively shows protomylonite, mylonite and ultramylonites from margin to the centre. As the mylonitization increases recrystallized quartz grains appear. Porphyroclasts reduces in proportion and size. S fabric makes 13°-40° angle with C-plane. From shear fabric NW oblique vergence has been interpreted. The Rigid Grain Net analysis of porphyroclast suggests mean kinematic vorticity number (Wm) is 0.61. It suggests that this is transpressive shear zone. The mineral assemblages namely Qtz+ Flds+Grt+Bt in granite and Pla+ Hbl+Bt in basic granulites suggests amphibolite facies of metamorphism during mylonitisation.

Thus the exhumation of granulites is primarily accomplished through several parallel thrusts with Jogdadi shear zone which are transpressive in nature. Subsequently extensional condition and normal faulting have removed the cover rocks.

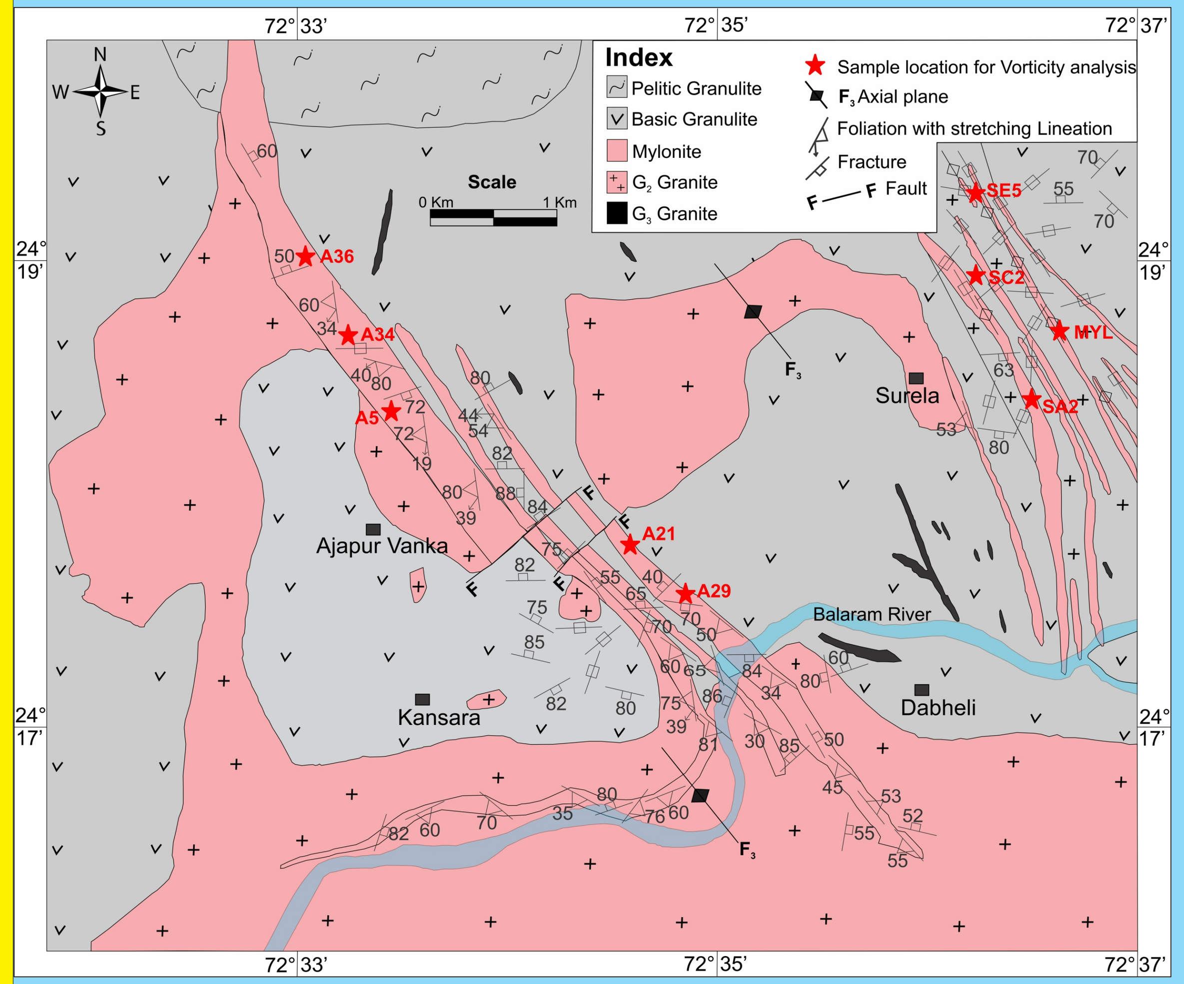
1. Introduction



The study area is located at southwestern end of Ambaji basin of South Delhi terrane. Balaram- Kui- Surpagla- Kengora (BKSK) granulite are the major rock unit in this terrane. The rocks of Ambaji basin posses three phases of folding F_1, F_2 and F_3. The Ambaji granites have also been identified to consist of three phases of granitic intrusion G_1, G_2 and G_3. The age of G_1, G_2 and G_3 granites are 885 to 826 Ma, 793 to 780 Ma and 758 to 750 Ma respectively (Tiwari et al., 2015; Singh et.al. 2010).

Figure: Regional map of Aravalli Regional geological map of the Aravalli Craton, adapted from Heron (1953), Sharma (1994), Roy and Jakhar (2002), and maps published by the Geological Survey of India (Gupta et al., 1980).

2. Geological map of study area



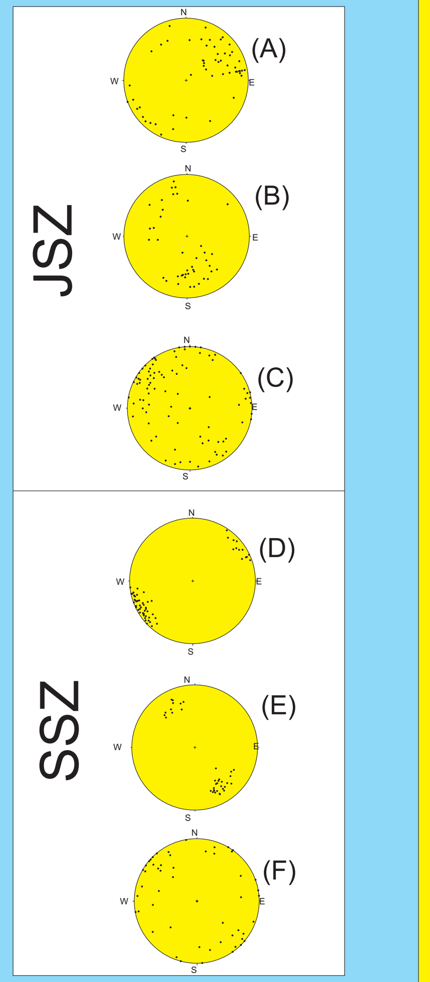


Figure: Lithological and structural map of Jogdadi and Surela shear zone (Modified after Biswal et. al., 1998). Pole plot of foliation, lineation and fracture are plotted; (A)to (C) plots are from Jogdadi shear zone and (D) to (F) are from Surela shear zone. (A) 67 foliation are NW- SE trendind with steep dip. (B) 47 stretching lineation planes measured on foliation plane, dominantly plunging SSE from towards NNW. (C) 98 fracture plane with three dominant directions N-S, N110°, N050°. (D) 58 foliation planes with NW- SE trending with steep dip. (E) 37 Stretching lineations dominantly plunging towards SEand also towards NW. (F) 95 fracture plane with two dominant directions N050° and N140°.

3. Field Structures

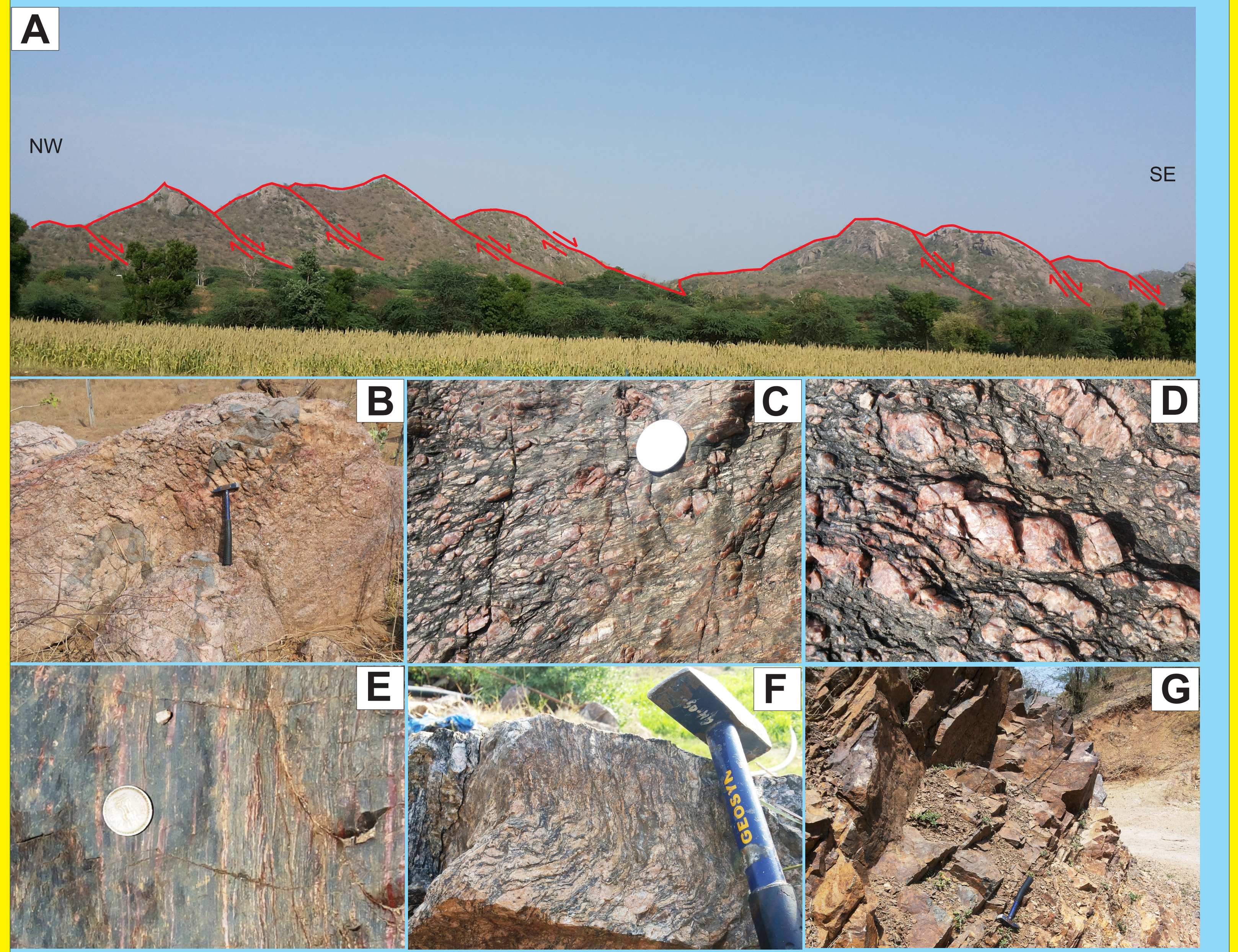


Figure: (A) Regional view of Jogdadi shear zone (B) Granite shows intrusive relationship with basic granulite (C) Feldspar porphyroclast wrapped by quartzo feldspathic and micaceous foliation in mylonite (D) Feldspar grains showing bookself structure in the mylonite (E) Feldspar mineral lineations are observed in the high strained shear zone (F) Fold axis observed on folded mylonite (G) Highly jointed cataclasite showing Earthy appearance

4. Microstructures

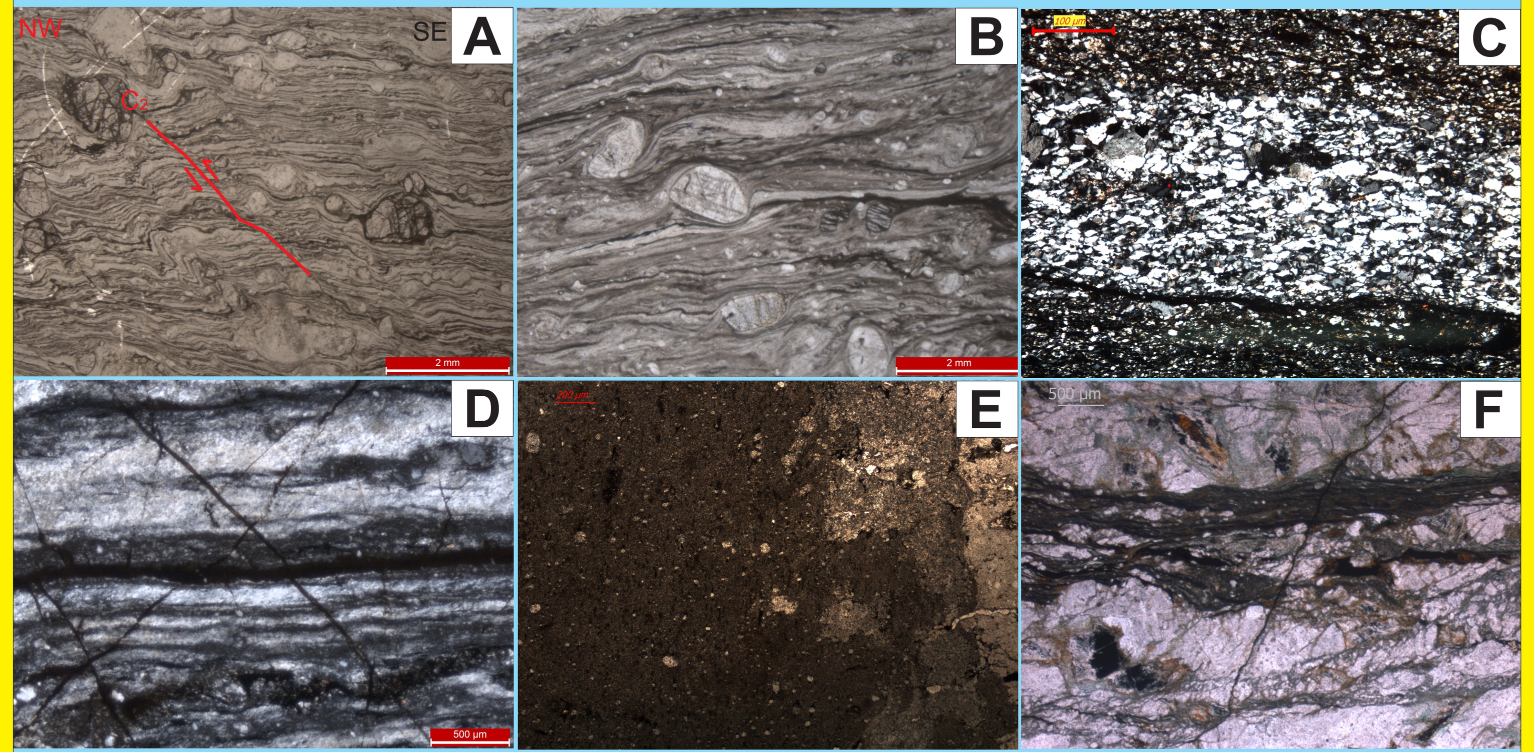


Figure: (A) Feldspar and fractured garnet grains are wrapped by quartzo- feldspathic and micaceous matrix in mylonite, porphyroclasts and asymmetrical folds are showing sinistral sense of shearing from top to NW and shear bands are also displaced by synthetic C_2 brittle fractures (Ramssey and lisley 2000). The material has exposed to the surface by this traspressive manner shear (B) Forward and backword rotated feldspar porphyroclast observed in the section of quartzo- feldspathic mylonite showing sinistral sense of shear. (C) Ultramylonite containing recrystallized foliation bands. The light colored band is quartz rich while dark grey colored bands contain fine grained mica. The quartz rich band making S surfaces with respect to dark colored mica C bands. In this section S- C fabric is clearly observed. (D) Alternate quartzo- feldspathic and mica rich layer are fractured by late stage brittle shearing in conjugate manner with the mylonitic thin section. (E) Light colored rounded to subrounded porphyroclast are present in dark grey colored groundmass with ultrafine grain matrix. Mostly grains are randomly oriented in the thin section. (F) Thin section of sheared basic granulite showing mylonitic structure.

5. Results

(1)Rigid Grain Net: Mean kinematic vorticity analysis (W_M)

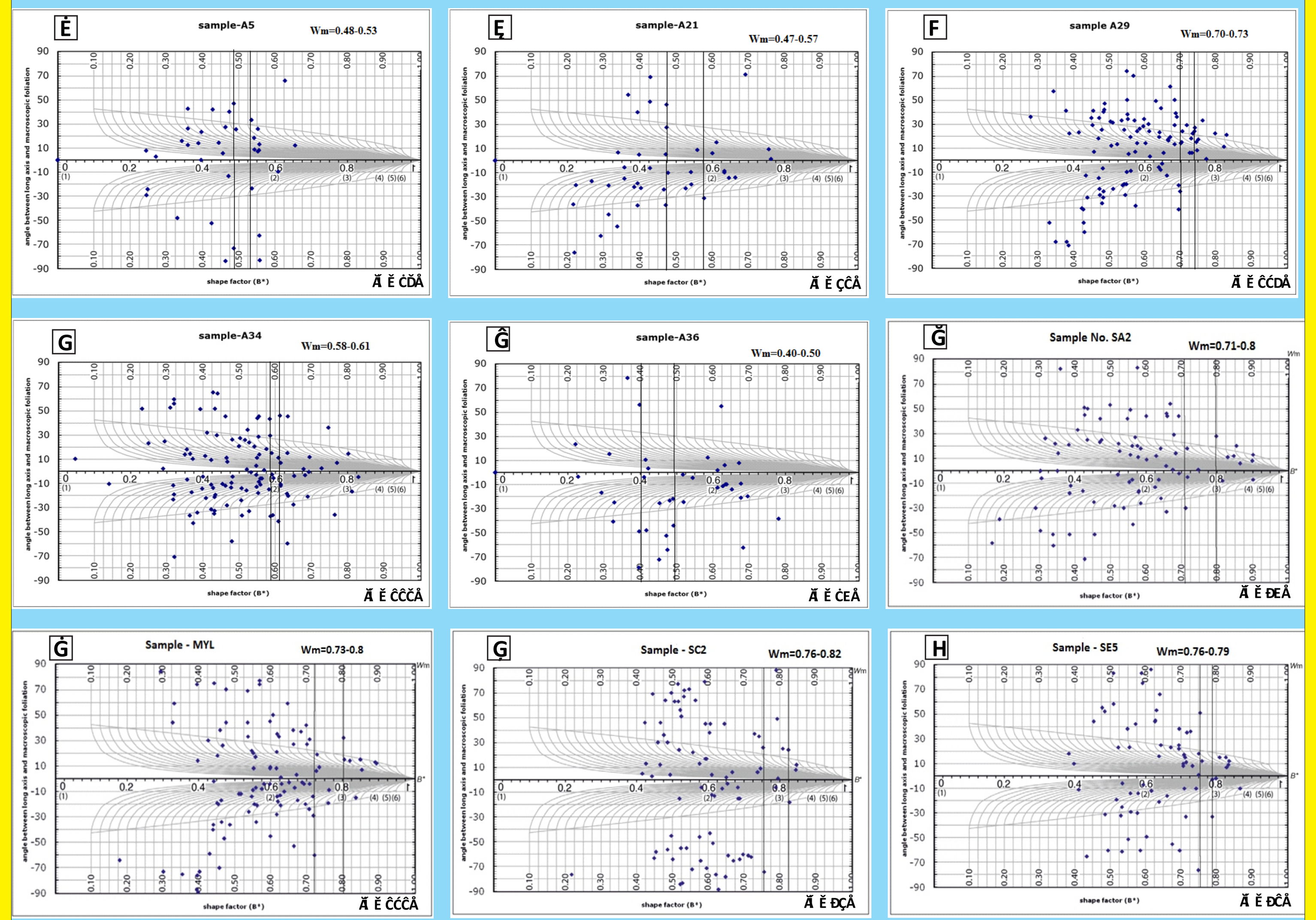


Figure: Rigid Grain Net (RGN) analysis is carried out in mylonitic thin sections cut perpendicular to foliation and parallel to lineation (on 2D L Sections). Thin sections are processed by ImageJ software to calculate long axis, short axis of rigid porphyroclast and angle between long axis and microscopic foliation (θ) value by best ellipse fit tool. Total 9 mylonitic samples; 5 samples from (A) to (E) are from Jogdadi shear zone and 4 samples From (F) to (I) are from Surela shear zone are analyzed to calculate mean kinematic vorticity number and % of pure shear (After Jessup et al., 2007). Values are give in table1.

Table1: Mean kinematic vorticity (WM) and percentage(%) of Pure shear for (A) Jogdadi and Surela shear zone

(A)

Sample No.	Range of W_M	Percentage (%) of Pure shear
A5	0.48- 0.53	65- 70
A21	0.47- 0.57	63- 71
A29	0.70- 0.73	48- 52
A34	0.58- 0.61	59- 62
A36	0.40- 0.50	65- 75

(B)

Sample No.	Range of W_M	Percentage (%) of Pure shear
SA2	0.71- 0.80	42- 50
MYL	0.73- 0.80	42- 49
SC2	0.76- 0.82	40- 47
SE5	0.76- 0.79	44- 47

(2)Relationship between W_M and the angle θ between the maximum instantaneous streching axis and the shear zone

Table2: Mean kinematic vorticity (WM) and percentage(%) of Pure shear for (A) Jogdadi and (B) Surela shear zone

(A)

Sample No.	Mean W_M	Mean θ
A5	0.505	09.6°
A21	0.715	25.0°
A29	0.520	31.6°
A34	0.595	28.6°
A36	0.450	27.2°

(B)

Sample No.	Mean W_M	Mean θ
SA2	0.755	08.8°
MYL	0.765	18.6°
SC2	0.790	39.2°
SE5	0.775	23.0°

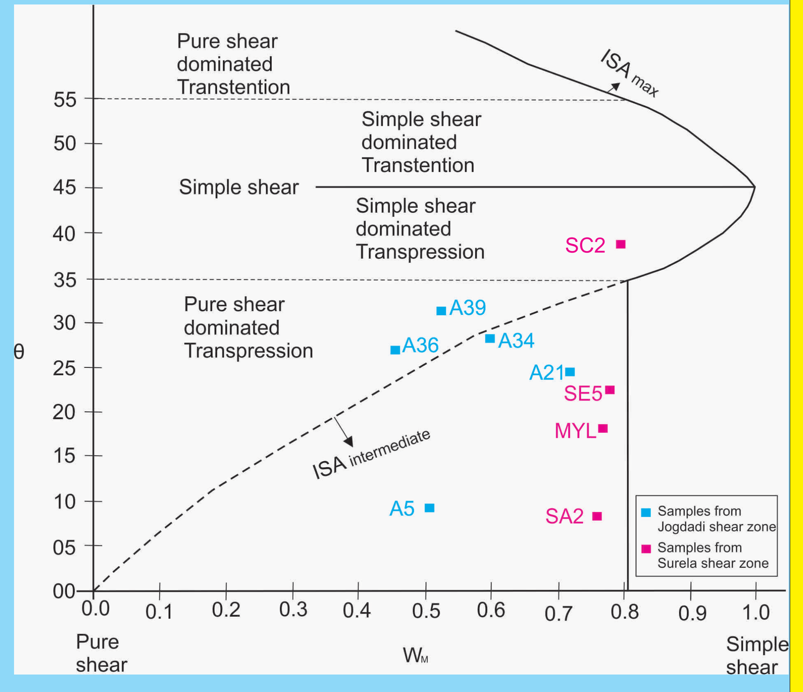


Figure: Graph between W_M and the angle θ between the maximum instantaneous streching axis and the shear zone (After Fossen and Tikoff 1993)

6. Conclusion

The exhumation of granulite is primary accomplished through several parallel thrusts with Jogdadi and Surela shear zone which are transpressive in nature. Subsequently extensional condition and normal faulting have removed the cover rocks.

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