Tectonic imprints within a granite exposed near Srinagar, Rajasthan, India

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Partial melting in the middle to lower crustal level produces melts of granitic composition during orogeny. Thrusts play a vital role in their exhumation after consolidation of these granitic melts. In this paper we focus on one such granite along the eastern margin of the Delhi Fold Belt (DFB) rocks near Srinagar, Rajasthan, India. This is the first report of granite within the area and holds a key stratigraphic position in the entire rock package. The said granite is found to be intrusive to the DFB metasediments as well as their basement popularly known as the Banded Gneissic Complex (BGC). We disentangle the deformation fabrics seen within the granite and associated DFB metasediments, suggesting that subsequent to emplacement and consolidation, the granite has co-folded along with the country rocks. Three deformational events could be identified within the DFB metasediments namely, D_{1D} , D_{2D} and D_{3D} . The peak metamorphism was achieved in the D_{1D} event. The granite magma is generated and emplaced late syn-kinematic to D_{1D} and thereafter is deformed by D_{2D} and D_{3D} producing D_{1G} and D_{2G} structural fabrics. These compressive deformations resulted in the collapse of the basin; the combined package of DFB rocks and the granite was thrust eastwards over the basement rocks. The tectonic transport direction during thrusting is suggested eastwards from our structural analysis. Transverse faults developed perpendicular to the length of the granite have led to partitioning of the strain thereby showing a heterogeneity in the development of fabric within it.

1. Introduction

The Delhi Fold Belt (DFB) rocks are exposed along the axial regions of the Aravalli fold mountain belt extending from Delhi in the north to Gujarat in the south through Rajasthan in an hourglass shaped outcrop pattern (Gupta and Bose 2000; Gupta 2004). The southern part of DFB rocks (often referred to as South DFB, SDFB; Sinha Roy 1984) is intruded by numerous granite bosses and stocks, a majority of which are concentrated within the western segment of the SDFB. The granitic injections found within the DFB rocks are mainly distributed in three time zones: around 1470 Ma (Gopalan *et al.* 1979; Choudhary *et al.* 1984;

Tobisch *et al.* 1994; Fareeduddin and Kroner 1998) followed by 1.0 Ga (Volpe and MacDougall 1990; Deb *et al.* 2001) and thereafter around 850 Ma (Choudhary *et al.* 1984; Volpe and MacDougall 1990). There are scanty evidences of granite/granitoid injections along the eastern boundary of the DFB rocks, especially within the SDFB. The only example of granite-pegmatite along the eastern margin of DFB south of Ajmer was reported by Dasgupta *et al.* (2009, 2011) from the vicinity of Bayalan, near Beawar about 100 km south from the present study area.

Heron (1953) described a thick sequence of meta-sedimentary rocks unconformably overlying the basement gneisses from the area. His succession

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included a basal conglomerate overlain by calc schists, argillites, and quartzite. He did not mention the occurrence of any granite from the area. The presence of thick conglomerate along the eastern margin is a rare feature in the DFB rocks unlike the western margin of DFB, where Heron (1953), Murthy and Bhargava (1972), Biswal (1993) and Dasgupta *et al.* (2012) have reported a thick persistent band of conglomerate known as the Barr conglomerate separating the DFB rocks from the basement gneisses to its west. There are scanty occurrences of conglomerate reported along the eastern margin of the DFB rocks, the only other being at Badnor ($74^{\circ}16'58.32''\text{E}$, $25^{\circ}50'2.48''\text{N}$, south of the present area), where the conglomerate at the base of DFB rocks lies unconformably over the basement gneisses (Mukhopadhyay and Dasgupta 1978).

It is the presence of the conglomerate that drew our attention and though we found bands of conglomerate within the high hills along the eastern margin near Srinagar ($74^{\circ}46'39.5''\text{E}$, $26^{\circ}26'03.5''\text{N}$), most of these high hills are of granite and is being reported for the first time. With this perspective we explore the granite, seen to have intruded into the basement and the cover DFB rocks, and subsequently co-folded with the DFB metasediments, around Srinagar. The only other occurrence of granite along the eastern margin of DFB south of Ajmer was reported by Dasgupta *et al.* (2009, 2011) from the vicinity of Bayalan, near Beawar about 100 km south from the present study area.

Figure 1. Geological map showing the broad lithostratigraphic subdivisions of south central Rajasthan, as envisaged by Heron (1953). The arrow marks the location of the study area near Ajmer.

The present area (figure 1) therefore, demanded a thorough geological mapping with the objective of unraveling the deformation style in the DFB rocks (and its correlation with reports elsewhere), timing of granite formation, and tectonic evolution of the rocks along the eastern margin of DFB. This part of our study highlights the Precambrian tectonics involved and discusses the nature of evolution of the eastern margin with the western margin of the DFB rocks. It is worth mentioning here that Sinha-Roy (1988, 2004) introduced the concept of plate tectonics which he thought was operative in the Precambrian rocks of this terrane.

2. The Srinagar granite and associated metasediments: the map pattern

The lithologic map of the area (figure 2) reveals that the metasedimentary rock package of DFB in the study area comprises a basal polymictic conglomerate overlain successively by calc-silicate gneiss, pelitic schist of diverse mineralogies (biotite schist, garnet schist, and staurolite schist, forming a partial Barrovian sequence of metamorphism), quartz-biotite schist and quartzite. The

Figure 2. Lithologic map of the study area. Note that the granite is subdivided into three sectors, namely I, II and III for structural analyses (refer text for details).

entire metasedimentary package is separated by granite from its basement composed of amphibolite gneiss and migmatite to the west.

The granite occupies the high hill ranges around Srinagar with a plano-convex outcrop pattern; straight western margin and a convex eastern margin. There are faults dipping 70° towards ENE, transverse to the length of the granite outcrop. The intrusive nature of the granite is established by the presence of conglomerate rafts (figure 3a) and apophyses (figure 3b) injected into the calc gneiss. Within the basement gneiss, tongues of granite are also observed (figure 3c).

West of the Srinagar granite, the metasediments of DFB occur as bands, folded into asymmetric dextral folds, whose long limbs trend NNE–SSW. This conforms to the regional structural grain of the DFB rocks (reported from the Ajmer

Beawar region) which is controlled by folds having NE–SW to NNE–SSW trending axial planes and generally shallow plunges with culminations and depressions (Sengupta 1988; Mukhopadhyay 1989; Mukhopadhyay and Matin 1991; Naha *et al.* 1984; Naha and Mohanty 1988). Bands of quartzite stand out from amidst the pelitic schist and form hill ranges, which facilitate as marker horizons for deciphering the regional structure. There are three generations of fold forms as we shall discuss in later sections. The basement rocks occupying the low-land regions to the east of the granite are biotite gneiss mostly with a few occurrences of quartzite and dark coloured hornblende biotite gneiss. These lithologies are complexly folded (the fold pattern completely different from the folds observed within DFB metasediments), often migmatized and have a very poor exposure quality compared to the well

Figure 3. (a) Meter scale raft of conglomerate (bounded by yellow coloured dotted line and marked Co) with quartzite pebbles (P), trapped within granite (G) west of Srinagar along a section looking from south. Note the thin tongues of granite intrusive along the schistosity planes within the matrix (marked by arrow). (b) Tongue of light coloured granite (G) emplaced in spaces within foliations of calc silicate gneiss (Cg), revealing the intrusive character of the granite. Hammer head points towards southwest. (c) Granite (G) intrusive into dark basement Banded Gneissic Complex (Bgc), in lit par lit fashion east of Srinagar, looking from south.

exposed DFB metasediments. It is evident from comparing the geometry of the folds within the basement gneisses and the DFB rocks that the basement gneisses remained unaffected by the DFB orogenies, at least in the present area. The separating surface of BGC and the DFB rocks acted as

a decollement surface during the Delhi orogeny. As the main focus of the present study is to bring out the tectonic imprints within the DFB rocks and the Srinagar granite and their interrelation, the detailed structural analysis of the BGC is not discussed.

Figure 4. Characteristics of sheared granite in sectors I and III. (a) Laminated and mylonitised granite observed north of Srinagar within sector I, on plan. The mylonitic banding is developed due to intense shearing the rock has been subjected to. Diameter of the coin is 1.1 inches. (b) Elongated K-feldspar megacryst having irregular outlines but oriented parallel to the mylonitic foliation observed in (a). Patches of septa of dark coloured biotite aligned parallel to it represents primary foliation preserved as relicts within the rock (K stands for K-feldspar). (c) Photomicrograph of mylonitic foliation seen within the granite in (a) (Q – quartz and M – muscovite). (d) Anastomosing pressure solution seams (marked by arrow) composed of secondary fine grained phyllosilicates and opaque minerals, within the granite mimicking the mylonitic foliation, seen in the deformed granite. (e) S–C fabric defined by muscovite grains, showing a dextral asymmetry. (f) Equal area projection of 49 poles to mylonitic banding showing a point concentration. (g) Mineral lineations defined by stretched quartz grains seen on the mylonitic foliation plunging northeasterly. Note that the northeastern strike end of the foliation surface is marked. (h) Equal area projection of 54 shallow plunging lineations of stretched quartz coeval to D_{1G} and D_{2G} (refer text for description).

Table 1. Statistical analysis of orientation data. Cones of confidence are drawn at 95% confidence limit.

Type	N	Nature of distribution	Eigen values			Angular measure of cone of confidence at 95% level (measured in degrees)		
			λ_1	λ_2	λ_3	$\lambda_1 - \lambda_3$	$\lambda_2 - \lambda_3$	$\lambda_1 - \lambda_2$
Delhi Fold Belt rocks								
Poles to compositional planes	135	Girdle distribution (307/82 NE)	83.30	37.13	14.58	6.93	9.94	—
Mineral lineation and fold axes of D _{1D} generation	61	Point concentration (84 → 129) ⁺	45.51	10.92	4.58	6.83	—	6.28
Undifferentiated fold and pucker axes of D _{2D} and D _{3D} generations	81	Point concentration (9 → 23)	54.43	17.25	9.32	8.08	—	7.33
Poles to schistosity planes	145	Girdle distribution (310/79 NE)	87.29	44.81	12.91	6.55	7.56	—
Granite in sectors I and III								
Poles to foliation surfaces	49	Point concentration (219/53 NW)	42.09	4.07	2.84	5.78	—	5.69
Quartz stretching lineation and fold axes of undifferentiated D _{1G} and D _{2G} generations	54	Point concentration (4 → 15)	50.54	2.27	1.19	3.15	—	3.11
Granite in sector II								
Poles to foliation surfaces	164	Girdle distribution (305/90)	107.91	52.32	3.77	2.90	3.10	—
Quartz stretching lineation and fold axes of undifferentiated D _{1G} and D _{2G} generations	168	Point concentration (?)	126.34	22.68	18.98	4.71	—	4.62

⁺Statistically linear distribution.

3. Detailed structural analysis

It has been shown that within the western segment of the SDFB, near Sendra, the intrusion of Chang granite within the metasediments has reoriented the foliations within the meta-sediments in its immediate vicinity (Gangopadhyay and Mukhopadhyay 1984), but away from the intrusion the sediments retain their structural grain. Following the same algorithm, structural geology investigations were carried out in the granite as well as in the associated DFB rocks of the area. The structural pattern of DFB rocks was worked out from areas away from the granite, where the minimal effect of emplacement is experienced. Alongside, the structural pattern within the granite was studied to have an idea of the deformations recorded within the granite. A systematic comparison of structural styles and time relationship of the deformation episodes observed within the metasediments and the granite was thereafter established. This led to the building up of a tectono-stratigraphic evolution of the rocks of the area.

In the following account, we describe the granite first and then the DFB rocks.

3.1 Structural geometry of Srinagar granite

The entire granite exposure was divided into three sectors on the basis of homogeneity in the development of the planar fabric within the granite (figure 2). The granite exposed in the central sector II, is more coarse grained with a weakly developed foliation and has maximum outcrop width. The two other sectors I and III within the granite, are wedge-shaped, located north and south of sector II respectively, show cleavage, and are sheared.

3.1.1 Granite in sectors I and III

The granite is strongly foliated and lineated and is relatively fine grained in these sectors (figure 4a). The foliation is composite in nature, mostly secondary but retains its magmatic nature at places, as some of the megacrysts (which are rare in

Figure 5. Petrographic features of the granite exposed in sector II. Note the bars in b, c and d represent a length of 500 microns. (a) Megacrysts of K-feldspar within the granite. Note that some of the megacrysts are aligned either parallel or are athwart to the foliation. (b) Coarse-grained granite showing relict interlocking texture between the grains. (c) The foliation seen in (a) under the microscope is formed by parallel alignment of muscovite flakes. Some of these flakes may depict the primary foliation now transposed to the deformation induced fabric. (d) Protomylonitic fabric visible in the granite along narrow zones (one such zone encircled). Note that the larger muscovite grains are parallel to this foliation.

occurrence) are aligned parallel to it showing a directional affinity in plan and in section (figure 4b). This foliation is a mylonitic banding (figure 4a), steeply dipping towards WNW, the fabric even visible under the optical microscope (figure 4c). A protomylonitic fabric is noticeable in thin sections with percolation of pressure solution

seams (filled with opaques and secondary mica, figure 4d) along two orientations; arrangement of muscovite grains hint to a development of a S-C fabric in the rock (figure 4e), which in turn reflect shearing and associated dynamic recrystallization within quartz. A stretching lineation of quartz on this mylonitic foliation has a shallow

Figure 6. Structural styles within granite in sector II. (a) Asymmetric D_{1G} antiform and synform within granite having an easterly vergent axial plane along a section looking from north. (b) Hand sketch showing the geometry of the trains of folds of D_{1G} generations with a steep easterly dipping limb and gently westerly dipping limb in an outcrop scale. (c) Upright folds of D_{2G} generation developed on the gentle limbs of D_{1G} folds, axial planes of D_{2G} are marked as AP_{2G} . (d) Equal area projection of 164 poles to foliation planes of the granite showing girdle distribution. (e) Equal area projection of 168 fold axes and mineral lineations within granite showing variable plunges, giving a domal geometry at the central region of sector II. The inner circle is the best fit small circle representing a right circular cone and apical angle of 75° . (f) The arched up foliation plane within the granite in the central region of this sector giving the dome viewed from south. The traces of foliation are shown by solid lines.

plunge either to the NNE or SSW. Poles to foliation when plotted on an equal area projection diagram show a statistical point concentration with a mean orientation of $219^{\circ}/53^{\circ}$ northwesterly (figure 4f, table 1). The equal area projection of the quartz stretching lineations (figure 4g) seen on the mylonitic foliation surface also shows a statistical cluster about a mean orientation of 4° towards 15° (figure 4h, table 1).

3.1.2 Granite in sector II

The granite in this sector is foliated only along its margins but otherwise it is massive. As one moves towards the core of the granite from marginal parts in more massive variety of granite in this sector, xenoblastic to subidioblastic crystals of pinkish K-feldspar are seen having dimensions varying from a few to tens of centimeters (figure 5a). The feldspar megacrysts are generally a collection of large grains of K-feldspar, quartz, and plagioclase having a relict interlocking texture (figure 5b) indicative of its igneous parentage. From a distance these grains look like pebbles (figure 5a) embedded within a fine grained quartzo-feldspathic matrix, the rock resembling a conglomerate. The foliation is a spaced cleavage, composite in nature as it retains its primary magmatic nature locally, which gets accentuated by subsequent metamorphism. The fabric is generally recrystallized with some domainal mylonitisation effects (figure 5c). There are a few narrow brittle shear bands which are mostly westerly dipping, along which the granite has been transformed into a very fine grained non-cohesive gouge type mass.

Within the foliated granite near the margins, the secondary planar fabric resulting out of this deformation is more conspicuous and pervasive, defined by parallel alignment of biotite and muscovite flakes (figure 5d).

The foliation plane in granite is folded into a train of broad hinged non-plunging antiforms and synforms. Two deformation regimes are identified within the granite, namely D_{1G} and D_{2G} , the former responsible for development of the foliation while the latter folds it. The second deformation D_{2G} has produced a series of upright to inclined open antiformal and synformal folds often with an easterly vergence (figure 6a, b and c). At different outcrops within the granite in this sector, one finds folds congruous to this geometry in a mesoscopic scale with a spaced schistosity, developed axial planar to these folds. The D_{2G} folds are either gently plunging NNE or SSW. The equal area projection of poles to foliation planes within the granite show a girdle distribution, with a horizontal β trending 35° – 215° (figure 6d, table 1). The

plots of lineations are variable (figure 6e). At the central portion of this sector, the granite is seen to be arched up into a domal shape (figure 6f) with traceable major axial surfaces of D_{2G} generation in this sector (figure 7).

3.2 Structural geometry of DFB rocks

The DFB rocks exposed in the area are multiply deformed by three phases of deformations, namely D_{1D} , D_{2D} , and D_{3D} . The dominant planar fabric of the area is a schistosity (that has developed within the quartzite, pelitic schists, hornblende-biotite schist and conglomerate) and a gneissosity (seen within the calc gneiss), which are the result of the first deformation episode D_{1D} . The grade of metamorphism during this deformation has reached up to amphibolite facies, indicated by the presence of staurolite in the pelitic rocks (figure 8a). During this deformation-metamorphism event, the granitic magma could be generated by partial melting (Pitcher 1993 and references therein; Rutter and Neumann 1995; Misra *et al.* 2009, 2011) and intruded the DFB rocks along with the basement gneiss; though such a statement is purely conjectural and needs to be proved with proper

Figure 7. Trend map of the foliation surfaces within granite in sector II, revealing the major mappable axial surfaces.

Figure 8. (a) Staurolite porphyroblast showing multi-stage deformation signature. The internal trail of inclusions of quartz are oblique to the crenulated foliation of biotite warping the staurolite porphyroblasts. Note that there are flakes of biotite within the staurolite grain that are approximately parallel to the crenulations cleavage in the rock. (b) The first generation tight folds of bedding in quartzite seen 5 km west of Srinagar. (c) Equal area projection diagram of 135 poles to compositional planes within quartzite showing a girdle distribution. (d) Equal area projection of 61 lineations syn-kinematic with D_{1D} folds within quartzite of DFB.

geochemical studies, which is not the aim of this paper.

The D_{1D} has produced folds of diverse geometries. Away from the Srinagar granite, within the quartzite the D_{1D} folds are close to tight (figure 8b) and have moderate to gentle plunges due N or S on a NNE–SSW trending axial plane. The poles to the compositional planes seen within the quartzite, thought to represent bedding planes, transposed by D_{1D} , show a great circle distribution on an equal area projection diagram, whose pole has an attitude of 8° towards 217° (figure 8c, table 1). The mineral lineations and the fold axes belonging to the D_{1D} generation, when plotted on an equal area projection diagram, show a scatter distribution (figure 8d). The fold axes are more variable in their orientations than the mineral lineations with an overall point concentration, plunging 84° towards 129° (table 1).

As one moves from west to east, the D_{1D} folds become tighter (nearly isoclinal) and get more inclined. This is attributed to the physical rotation of the D_{1D} folds in response to the continuous compressive stress regime that outlasted the associated metamorphism of the DFB metasediments.

The D_{2D} folds are the result of this continued collision, with a time lag from D_{1D} . The geometry

of these folds do not predict a drastic change in the stress regime of the deformation. These folds have folded the D_{1D} schistosity surfaces. The D_{2D} has produced a spaced cleavage within the quartzite and calc gneiss (figure 9a) overprinting the D_1 foliation surface and a zonal crenulation cleavage within the pelitic-schist (figure 9b). Equal area projections of poles to schistosity/gneissosity planes of D_{1D} generation show that they are distributed along a girdle whose pole has an attitude of 11° towards 220° (figure 9c, table 1).

The D_{3D} deformation episode has produced open upright folds, developed on gentle limbs of D_{2D} folds; similar in geometry to the D_{2G} folds of the granite within the area. The undifferentiated D_{2D} and D_{3D} fold axes along with congruent puckers when plotted on an equal area projection diagram show that they have low plunges either NNE or SSW directions with a statistical mean orientation of 9° towards 23° (figure 9d, table 1).

3.3 Structural correlation between granite and DFB metasediments

It can therefore be concluded from the present study that the DFB sediments preserve the imprint

Figure 9. (a) Upright folds of D_{3D} generation folding the gneissic banding within the calc silicate gneiss of DFB, on a section viewed from south. (b) Crenulation cleavage developed within the pelitic schist. These cleavages are parallel to the D_{2D} axial structures. (c) Equal area projection of 145 poles to the D_{1D} generation foliations showing a predominantly girdle distribution. (d) Equal area projection of 81 undifferentiated D_{2D} and D_{3D} fold and pucker axes lineations showing a point concentration.

of one more deformation regime than that of the granite. In fact, the D_{3D} is similar in style and orientation with D_{2G} . A look at the orientation figures of the structural elements plotted on equal area projection diagrams also reveals the same. The modal orientation of the axes of D_{2D} and D_{3D} folds taken together is 9° towards 23° (figure 9d), which is comparable to the average orientation of the axes of D_{2G} folds within the granite, which is 4° towards 15° , in sectors I and III (table 1). There is similarity in the distribution pattern of the foliation planes in the granite in sector II and the schistosity of the DFB rocks folded by D_{1G}/D_{2G} and D_{2D}/D_{3D} respectively. The pole for the former is 11° towards 220° and for the latter is almost horizontal trending 35° – 215° (table 1). It is only within the sectors I and III in the granite, one finds a statistical orientation of planar fabric having an attitude of $219^\circ/53^\circ$ NW, along which mylonitisation has taken place and hence is suggested to be the plane of shear. Statistically the orientations of D_{2D}/D_{3D} generation fold axes match (within the statistical error limits; table 1) to the D_{2G} generation fold axes; both together lie close to the shear

plane described above. With these considerations it can be reasonably concluded that the granite must have been emplaced prior to D_{2D} deformation episode. We further suggest from the composite nature of foliation planes within the granite (which was initially a magmatic fabric but later altered to a diastrophic one) the timing of granite emplacement must be late syn- to post-kinematic with D_{1D} deformation (figure 10).

The shape of the granite exposure reveals a maximum thickness at the central regions compared to the southern and northern tips. This enhanced thickness and hence the differential volume of granite could be a reason for a differential expression of strain in response to the same stress regime to which it was subjected. To compensate for the differential strain pattern, lateral faults developed (some of mappable dimensions, figure 2), similar to lateral ramps with horizontal slickenlines on their surfaces indicating a shallow west-to-east transport direction (figure 11a).

Equal area projections of joints and other fractures (figure 11b) reveal that there are three modal distributions of fracture surfaces: two of those

Figure 10. Sequence of emplacement and folding of Srinagar granite along with the DFB rocks. **Stage I:** Folding of DFB rocks due to E–W compression giving rise to the formation of D_{1D} folds in them with the development of a schistosity and/or gneissosity. This is accompanied by emplacement and consolidation of granite. **Stage II:** Deformation under the continued stress regime resulted in folding of the D_{1D} foliation (within the DFB rocks) along with the magmatic foliation (within the granite) into asymmetric folds of D_{2D}/D_{1G} generation, with easterly vergent axial planes. The contact with BGC acted as a decollement surface and later on as a detachment plane. Continued deformation resulted in exhumation of the granite and its associated metasediments along this detachment plane. **Stage III:** The upward transport of the rock package resulted in the folding of the gentle limbs of the D_{2D}/D_{1G} folds into upright of D_{3D}/D_{2G} folds, riding piggy back against the detachment plane. The continued E–W stress produced lateral ramps during the tectonic transport of the DFB rocks over the basement. Note that the fault being parallel to the sectional view does not show up in the figure.

belong to a single conjugate joint set, with their intersection plunging 27° towards 218° , similar to the orientations of the later fold axes. The other set is EW trending correlatable with the lateral ramps and transverse faults.

4. Discussion

Our work shows that the Srinagar granite is syn-tectonically emplaced along fracture zones during the deformation-metamorphism of DFB metasediments. Subsequent to its emplacement, the granite exhumed along thrust bringing together the

Delhi metasedimentary rock sequences over the basement BGC. A comprehensive account of the metamorphic evolution of the rocks along with geochronology of the thermal events needs to be addressed. The area thus awaits a more comprehensive study of the P - T - t history of the rocks along with geochronology to supplement our structural evolutionary model.

The present study shows an example of Precambrian collisional tectonism, where the major collapse direction is east west, with an orogenic core immediate west of Srinagar. The granite, exhumed along subduction-related-faults, has been later co-folded with the DFB metasediments and the entire

Figure 11. (a) Horizontal slickenlines seen on the E–W vertical fault surfaces looking from south. These lines indicate the tectonic transport direction along the westerly dipping thrusts. (b) Equal area projection of three sets of fracture planes seen in sector II. The great circles represent the average fracture orientation for each set. The fractures plotted by red dots are southeasterly dipping and their average orientation is given by red great circle. The blue squares represent northwesterly dipping fractures with an average orientation given by the blue coloured great circle. These two form a conjugate set with their point of intersection (the green dot at P) matching the fold axis. The black crosses represent the measured fault planes which are transverse to the length of the granite. These are WNW–ESE trending with a subvertical dip due SSW, represented by the black coloured great circle.

package carried over the basement gneisses. The separating surface acted as a décollement surface, thereby keeping the basement unaffected by the deformation regime; much alike to thin skinned tectonism. The development of the fabric reveals that the same tectonic stress regime persisted throughout Delhi orogeny, producing folds of diverse generations but taken together representing a single spectrum of progressive deformation. This is in contrast to the deformation regime seen along the western margin of the SDFB, where two episodes of finite strains have been reported (Dasgupta *et al.* 2012). We therefore like to conclude that the collapse of the different segments of Delhi basins had a different tectono-evolutionary history. The time period between 1470 and 850 Ma is generally taken to be the time frame of the Delhi orogeny. However, Roy and Kroner (1996) and Pandit *et al.* (2003) consider the age of termination of Delhi orogeny at 750 Ma from the charnockites which occur within and are younger to the DFB rocks.

Several proposals have been put forward by geoscientists through ages regarding granite emplacement models like diking, ballooning, sheeting, and stopping (see Hutton 1982, 1988; Castro 1987; Guineberteau *et al.* 1987; Hutton *et al.* 1990; Clarke 1992; Pitcher 1993; Ingram and Hutton 1994; Vigneresse 1995; Bouchez 1997; Castro *et al.* 1999; Paterson and Schmidt 1999; Schmidt and Paterson 2000; Richards 2001 and Paterson 2006 for a complete review). Granite magma ascent and emplacement have also been controlled by crustal scale shear zones (D’Lemos *et al.* 1992; Hutton and Reavy 1992; Brown 1994; Vigneresse 1995; Roma’n-Berdiel *et al.* 1997; Rosenberg 2004) and have been modelled by Corti *et al.* (2005). Ferre’ *et al.* (2012) (with a good compilation of references

therein) provide a detailed discussion on how thrusts act as magma propagation pathways. We present a natural example of the model construed by Ferre’ *et al.* (2012) showing the granite exhumed along a thrust. We also discuss that in such a condition, formation of lateral ramps has resulted in partitioning of strain within the granite.

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