Fold-thrust belt and synkinematic alkali magmatism along terrane boundary shear zone of the Eastern Ghats Mobile Belt: Does the Rayner-Napier boundary of East Antarctica reflect that?

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Abstract: The terrane margin of the Eastern Ghats Mobile Belt (EGMB) with the surrounding cratons of Indian Peninsula is considered to abut against the Rayner-Napier boundary of Enderby Land in the East Gondwanaland assembly. In this paper, a detailed structural analysis of NW part of the Eastern Ghats terrane margin is attempted. The NW front shows fold-thrust belt structure consisting of Sinapalli, Lathore and Turekela nappes. The basal decollement is exposed as a terrane boundary shear zone that demarcates the high grade Eastern Ghats belt from the surrounding craton. It shows splay thrusts forming schuppen or imbricate structure. Further, the decollement passes over a lateral ramp across which a variation in the rock association is noticed. Nepheline syenite plutons are emplaced along the terrane boundary shear zone. The plutons show transitional fabric from magmatic to solid state, thus ascribing the compressional origin of the alkaline melt and synkinematic emplacement of the pluton with thrusting. The fold-thrust belt development and synkinematic alkaline magmatism characterising the NW margin of the EGMB should also be looked into the tectonic correlative Rayner-Napier boundary.

Keywords: Eastern Ghats Mobile Belt, fold-thrust belt, nepheline syenite pluton, synkinematic emplacement, Rayner-Napier boundary

Introduction

The Eastern Ghats Mobile Belt (EGMB) of the east coast of India represents a regional granulite belt, comprising a host of granulitic supracrustals such as khondalites (garnet - sillimanite - graphite gneiss), charnockitic gneisses, eclogites, quartzites and banded iron formations that have been intruded by mantle derived intrusive suites such as charnockites, basic granulites, enderbyites, I type of granites, anorthosites and alkali granites and also rocks derived from the partial melting of the supracrustals such as leptynites, S-type granites and migmatites. These rocks have been grouped into four zones namely the western basic charnockite zone, the western khondalite zone, the central migmatite and charnockite zone and the eastern khondalite zone (Fig.1: Ramakrishnan et al., 1998). Linear transition zone consisting of amphibolite-facies rocks occurs along the western margin of the belt, derived from the retrogression of the granulites. The belt is juxtaposed against the low-grade cratonic rocks along shear zones which have been designated as Terrane Boundary Shear Zone (TBSZ; Biswal et al., 2000). The TBSZ shows a curvilinear geometry with a NNW-SSE strike and a strike-slip character in the north, and NNE-SSW strike with a thrust character in the west. However, it shows dip towards the mobile belt. Number of alkaline plutons occur close to the terrane margin (Leealanadham, 1993). The NW margin of the mobile belt near Khariar shows fold-thrust belt (FTB) structure consisting of a stack of thrust sheets overlying the cratonic foreland. The FTB shows a salient geometry as it protrudes into the Bastar craton (Biswal and Sinha, 2004). This paper presents a detailed structural analysis of this part of the terrane margin with a view to comparing with its tectonic correlative, the Rayner-Napier Complex margin of the East Antarctica. It is well established in the literature that India and Antarctica constituted a contiguous terrane in East Gondwanaland assembly, and the western margin of the EGMB once joined up with Rayner-Napier Complex margin in such correlation (Biswal et al., 2002). The EGMB were compared with Rayner Complex while the Napier Complex was matched with Bastar Craton.

The inset in Fig.1 shows the detailed view of the study area wherein the western khondalite zone is shown spreading to the margin of the belt. But towards south the western basic charnockite zone appears along with transition zone. Besides, a narrow hook-type outcrop occurs to the west of the Transition zone. A detailed structure is much more complicated than what is shown in the above map. Figure 2 shows the structural map of the area.
Rock Types and Small Scale Structure

The study area shows three nappes namely Sinapalli, Lathore, Turekela nappes (Fig. 2). These nappes are mutually separated by thrusts and separated from the cratonic basement by decollement which is exposed on the surface in form of 2-3-km wide thrust. The thrust forms a part of the larger Terrane Boundary Shear Zone and hence it has been hereafter referred to as TBSZ. Various units of the study area are described below:

Basal Decollement or TBSZ

The TBSZ is the surface expression of the basal decollement of the FTB and is represented by 2-3-km-wide ductile to ductile-brittle thrust exposed between the granulites of the Sinapalli nappe and granites of the Bastar Craton. It includes the mylonitised granites and granite gneisses of the Bastar Craton, amphibolites and quartzofeldspathic gneisses of the Sinapalli nappe. The granitic mylonites show the presence of various mylonitic fabric namely S-C fabric (Fig. 3a), sigma (Fig. 3b) and delta porphyroclasts (Fig. 3c) that unequivocally suggest NW vergence of the thrust. This indicates overthrusting of Sinapalli nappe over the craton.

The TBSZ shows more or less straight nature due to its moderate dip. However, near Boran and Babebir it shows kinks which are attributed to the large lateral ramp structure present on the basal decollement. The ramp is E-W trending and is named as Khariar lateral ramp. At the kinks, the slip is oblique suggesting the northern block has been shifted towards west. The presence of lateral ramp has brought variation in the
Computation of shear strain along TBSZ

The TBSZ is marked by protomylonites, mylonites and ultramylonites from margin to the centre of the thrust. These are characterised by various types of mylonitic fabrics amongst which the S-C fabric is the most important as it not only gives the sense of shear but also used to compute the amount of displacement. In this computation plane strain situation has been assumed. Based on the measure of S-C angles of the samples collected from one margin to the other, shear strain is computed (Ramsay and Huber, 1987) to be approximately 5.5 and displacement is about 3 km (Fig. 4).

Sinapalli Nappe

Rock types

The Sinapalli nappe is represented by alternate basic granulites/amphibolites and quartzofeldspathic gneisses with a few charnockite bands. Basic granulites are well-banded rocks consisting of alternate pyroxene-hornblende-garnet bands and plagioclase-rich bands. These are considered to be flow layers-cum-gneissosity. Relict cumulus texture is observed in the above layers due to the segregation of magmatic pyroxene grains. Thin-section study reveals micro-layering. Within the layer, the minerals show granoblastic texture with triple junction between the grains. Orthopyroxene (opx), clinopyroxene (cpx), garnet, plagioclase and hornblende are the main constituents of the basic granulites. In some of the sections the garnet is found to encircle the orthopyroxene grain suggesting conversion of orthopyroxene into garnet indicating compression (Fig. 3d). In some other rocks, a decomposition reaction is observed in the form of symplectic intergrowth between garnet and plagioclase and cpx forming opx rims around garnet (Fig. 3e). These two reactions belong to two different stages, one is

distribution of rock types on either side. To the north, charnockites belonging to Lathore nappe are exposed while to the south the alternate sequence of basic granulites and quartzofeldspathic gneisses of Sinapalli nappe are exposed. Further tectonic window of basement granites are exposed to south.
developed at much deeper level of the crust and the other after thrusting to shallower levels. However, both belong to the granulite facies.

Intimately associated with basic granulites (BG) are the quartz-feldspathic gneisses (QFG) which are leucocratic rocks with band width varying from a few mm to tens of metres. In some outcrops they appear as alternate flows of basic and acid lavas which have been metamorphosed to BG and QFG, respectively. The QFG shows granoblastic texture with bimodal size distribution of quartz and alkali feldspar grains. Plagioclase is in subordinate amount. Garnet porphyroblasts are scattered in the rock and the grain margins are serrated. Gneissosity is defined by alternate quartz-feldspar layers and biotite-hornblende-rich layer. In some of the sections, perthite-antiperthites are observed with spindle-shaped solid solution structures and feldspars are relatively euclidean and lath-shaped. At places, khondalites occur in association with QFG. Khondalites contain garnet, sillimanite and graphites. Garnet enclosed within feldspars contains inclusions of sillimanite. Along the lateral ramp shear zone the khondalites are extremely sheared producing garnet porphyroblasts. Biotites are grown in the pressure-shadow areas of these clasts. The garnets are fractured due to shearing and the feldspars are stretched into ribbon.

Structure

The Sinapalli nappe shows an alternation between BG and QFG in a very minor scale. These are assumed to be the primary foliation (flow layers). They show F1 recumbent fold which is sheared along the limb. The folds are overturned to NW (Fig. 3f). These are coaxially refolded by NW-vergent F2 fold. Axial plane shears are also developed parallel to the F2 axial plane (Fig. 3g). F2 sheath folds are developed by axial-planar flow during thrusting.

Lathore Nappe

Rock type

Lathore nappe is dominated by charnockitic gneiss which is a light-coloured, medium-grained and well-banded rock composed of quartz, feldspar-rich layers alternating with layers of thin pyroxene-biotite-garnet that define gneissosity in the rock. The rock is marked by pencil structure in many instances where feldspars are segregated forming augens or pockets which show a circular cross-section normal to the gneissosity plane and stretching parallel to the gneissosity surface. Myrmekitic structures are prominent at the margins of feldspar grains, suggesting post-crystalline strain. The individual minerals show undulose extinction. Charnockitic country rock shows the presence of isolated calc-granulite which consists of sphene, calcite, plagioclase and pyroxenes.

Structure

The charnockitic gneisses along with the interbanded calc-granulites show re-folding. The folds include tight isoclinal F1 folds that have been coaxially refolded by upright F2 folds (Fig. 3h). The F2 folds have turned into sheath due to axial planar flow. Sporadic dome-and-basin interference structures are found due to superimposition of F3 folds on F2 folds. F1-F2 axes are in NE-SW trend while F3 is in NW-SE trend. Lathore nappe is affected by brittle deformation in the form of sinistral NE-SW and dextral NW-SE faults. Traced towards east, the NE-SW faults truncate against the Turekela nappe while NW-SE ones cut across it. This suggests two generations of faults (Biswal and Sahoo, 1998).

Turekela Nappe

Rock types

The Turekela nappe represents the topmost nappe that was thrust upon the craton to the NW. It occurs as a klippe surrounded by the rocks of the Lathore nappe. The root zone of the klippe lies further towards east. The klippe is dominated by khondalites followed by calc-granulites. Mineralogically, khondalites consist of sillimanite, graphite, feldspar, garnet and quartz. Leptynite derived from the melting of the above assemblage occurs as concordant veins.

Structure

Turekela nappe exhibits multiple stages of folding consisting of coaxial folding between first three folds namely F1', F1 and F2 along NNE-SSW axis. These are followed by NW-SE-trending F3 folds which have produced mirror image pattern with F2 fold. Thin sections of the khondalites show preferred orientation of sillimanite. Garnet and quartz occur in chains parallel to it. This defines the gneissosity in the rock. Quartz grains are distinctly lensoidal and the size analysis of these grains shows constructional type of strain in the Turekela klippe. The Turekela klippe has been traversed by many close-spaced NW-SE-trending brittle dextral faults, cutting across the Lathore nappe.

Dharamgarh Window

To the east of Sinapalli nappe, covering the areas around Brundabahal, Golamunda and Dharamgarh, vast low-lying terrain exists with sporadic occurrences of pink granites, interlayered with amphibolite bands. This is called Dharamgarh window. There are sporadic occurrences of basic granulites which could be remnants of the Sinapalli nappe or may be high-grade rocks of the craton. Amphibolites are thin while pink
Fig. 3. a. S-C fabric in mylonites, b. Sigma type porphyroclasts in mylonites showing NW vergence, d. Delta type porphyroclasts in mylonites showing NW vergence, d. Opx rimmed by garnet in basic granulites suggesting compression, e. Symplectitic structure between garnet and plagioclase producing opx, suggesting decompression, f. F1 fold in QFG, g. F2 fold in QFG, with axial plane shear, h. F2 fold in calc-granulites.
granites are larger in extension. The granites are characteristically pink due to their feldspar and garnet content. Mineral lineations are parallel to the axis of the folds which are represented by tight isoclinal F1 fold and coaxial open F2 fold.

**Nepheline Syenite Plutons**

The nepheline syenite plutons are emplaced within the TBSZ and occur as three NS-trending en echelon bodies extending from Kalimati in north to Babebir in south. The northern pluton lies within the granite mylonite while the southern one is flanked by granite mylonite in the west and by quartzo-feldspathic gneiss in the east. The middle body is flanked by amphibolites on either side.

Nepheline syenites can be classified into five categories viz. (i) fine-grained, dark-coloured magmatic variety (Fig. 5a), (ii) coarse-grained, leucocratic magmatic variety (Fig. 5a), (iii) pegmatoidal variety (Fig. 5b), (iv) transitional variety (Fig. 5c) and (v) mylonitic variety (Fig. 5d). The first three show
predominant magmatic foliation defined by parallel orientation of alkali feldspar laths and hornblende grains. The transitional variety shows both magmatic as well as solid-state deformational fabric. These are marked by distinct compositional layers and almost down-dip mineral lineations. The compositional layers are defined by thin, dark hornblende, pyroxene- or biotite-rich layers, alternating with coarse white or pinkish feldspar- and nepheline-rich layers. In many instances, the compositional layers are folded into symmetrical, isoclinal to open, steeply plunging to reclined folds with nearly Class 2 geometry (Ramsay, 1967). The hinge zone of the fold exhibits an axial-planar arrangement of biotite, hornblende and feldspar grains (Fig. 5c). Mineral lineations parallel to the hinge line of the folds are developed due to linear arrangement of biotite, hornblende and feldspar grains. They appear almost down dip on the compositional layers.

Microscopic study indicates that in the magmatic variety the feldspar laths are very long, prismatic and invariably twinned. They show preferred orientation indicating flow direction. This defines the magmatic C-fabric in the rock. Oblique to this, S-fabric is developed along which some of the feldspar laths are arranged (Fig. 5f). The magmatic S-C fabric develops when the melt is emplaced in a non-coaxial strain. In the magmatic variety, corona texture is prominent due to hornblende rims around pyroxene, sphere rims around ilmenite and nepheline rims around alkali feldspar. This suggests inequilibrium condition during crystallisation of magma. In the transitional variety, hypidiomorphic granular texture is present (Fig. 5g). Occasionally, porphyritic texture is observed due to the presence of small microcline and other minerals around microcline phenocrysts and poikilitic texture is seen in hornblende phenocrysts enclosing smaller grains of feldspars. Perthitic structure is very common in the rock defined by flamelike albite lamellae inside K-feldspars. In addition, albite rims occur around feldspar grains in many instances which show optical continuity with the internal albite lamellae. Though the feldspar grains are commonly straight, in sections they show arcuate geometry and are tilted up in an imbricate fashion. Mylonitic variety shows superimposition of solid state deformation on magmatic foliation. Dynamic recrystallisation of nepheline and feldspar grains occur along mylonitic foliation nearly parallel to the magmatic foliation (Fig. 5h). This suggests high-temperature deformation of the pluton (Simpson and Wintsch, 1989).

The mylonitic foliation of the host rock is concordant with the magmatic foliation of the nepheline syenite pluton. This is called coupling and is attributed to the synkinematic emplacement of melt with thrusting (Paterson et al., 1998). Hence it is interpreted that the alkaline melt was emplaced in a non-coaxial strain regime (Biswal et al., 2004). As a result the minerals in the crystal- melt mush tend to align parallel to the C-fabric of the host rock. Furthermore, rotation of elliptical particles in a viscous medium indicates that all particles irrespective of their initial orientation will assume a near parallel attitude with the shear plane at a shear strain value of 5.24 (Ramsay and Lisley, 2000). This will develop magmatic foliation in the intrusive. The TBSZ hosting the nepheline syenite plutons show average shear strain of 5.2 (Fig. 4). It is therefore, suggested that the magmatic fabric in the plutons is developed due to high values of shear strain.

**Large-Scale Structures**

The study area is divided into seven sectors. While sectors 2, 3, 4, 7 lie within the TBSZ, the Sector 1 lies in Lathore nappe, sector 5 in Dharamgarh window and sector 6 in Sinapalli nappe. The corresponding stereoplots for foliation and lineation are given in Fig. 6. Part of the Turekela klippe is included in Sector-1.

**Sector - 1:** The sector shows curving of gneissosity from NW to E which is reflected in the stereoplots where the gneissosity shows a girdle distribution around NE-plunging axis. The girdle axis (a axis) coincides with the maximum obtained in the lineation plot. The lineations are intersection lineations between S0 and S2. The curving of the gneissosity is due to the lateral ramp structure. However, the small-scale structure suggests that the gneissosity is also folded by F2 folds. Hence it is interpreted that the F2 folding and lateral ramp development are probably coeval.

**Sector - 2:** This sector covers the northern part of the TBSZ. Besides mylonites, there are amphibolites which are inferred to have formed from retrogression of basic granulites of the EGMB. One of the amphibolite bands, occurring to the extreme west, shows sulphide mineralisation. The retrogression as well as mineralisation are attributed to the mineralising fluid passing through the TBSZ. The amphibolites have been folded during thrusting, producing F3 isoclinal fold and F3 crenulations. The stereo-plots show N-S concentration of the mylonitic foliations and easterly concentration of down-dip stretching lineations characterising the thrust.

**Sector - 3:** This is comparatively a small sector. But it shows the presence of a flexure produced due to change in the trend of the nepheline syenite pluton and surrounding mylonites. This change is reflected in foliation and lineation plots and is attributed to lateral ramp structure.

**Sector - 4:** In this sector the lithological units show N-S trend. However, towards south, there is curving to NW near Barbebri. There is variation in the plunge of the stretching lineation as well as intersection lineation. This variation is attributed to ramp structure. As near the ramp, the displacement is an oblique slip, and the lineations show moderate plunge towards E to SE and NE.

**Sector - 5:** The sector represents the window of the craton that has been exposed due to thrusting followed by erosion.
Fig. 5. a. Nepheline syenite, fine dark-coloured variety and leucocratic medium-grained variety. b. Pegmatoidal variety of nepheline syenite. c. Transitional variety showing magmatic foliation. d. Mylonitic variety showing stretching lineation. e. Open fold in nepheline syenite. f. Magmatic S-C fabric. g. Transitional variety of nepheline syenite showing serrated grain margin. h. Solid state deformation superimposed over magmatic foliation.
Fig. 6. Stereoplots showing foliation and lineation of seven sectors.
Pink granites are the dominating rock types in the sector with a few amphibolite/basic granulite bands. The contact with the surrounding rocks of the Sinapalli nappe is marked by thrust. Within the window, there are isolated outcrops of basic granulites which have been considered to be the klippe of Sinapalli nappe. But it is not sure whether these basic granulites are same or different from those basic granulites that alternate with pink granites. The contact of the isolated patches of basic granulites is not well marked. To the north of the window, around Golamunda, there are E-W trending F3 folds. The E-W folding is reflected in the stereoplot where the girdle shows easterly plunging β-axis. This variation in trend from NE to E is interpreted to be due to shearing along lateral ramp.

Sector-6: The sector shows alternate bands of basic granulites and quartzofeldspathic gneiss. The amphibolites are included in Sector-7. In many instances the basic granulites show hagbog structures with westerly inclined steep face and easterly inclined gentle face. The westerly steep face is the thrust line scarp and the eastern face is the dip slope. It has been interpreted that the basic granulite bands are repeated not only due to coaxial folding but due to imbricate thrusting. The stereoplot suggests the N-S-trending gneissosity plane and down-dip stretching lineation.

Sector-7: The sector shows the mylonites and amphibolites with granites. The amphibolite bands may be the original basic granulites which have been retrograded to amphibolites during shearing. There is a single band of charnockite that shows almost horizontal attitude. The eastern edge of the charnockite has been dragged to easterly dip due to thrusting. The stereoplot shows N-S trend of the foliation and southeastern plunge of the stretching lineation.

Large-Scale fracture lineaments

The study area is traversed by at least eight major fracture lineaments (I-VIII) which have been picked up from FCC. Definite sign of shearing along these fractures has been noticed at many places. The maximum length of the lineaments is 13.99 km while minimum is nearly 0.50 km. The lineaments show two definite trends: N-S and E-W. The lineaments are interpreted belonging to two different age groups. The lineaments trending N-S are believed to be older and are thought as probable representatives of the deep-seated cratonic weak zones. On the other hand, the E-W trending lineaments are younger and related to the lateral ramp. This is borne out from the fact that all the N-S trending major lineaments are cut and bent towards the east near the lateral ramp. The emplacement of nepheline syenites and kimerildites are controlled by N-S lineaments.

To show the structure at depth, three E-W profiles namely AA, BB, CC and one N-S profile namely DD are drawn (Fig. 7). The location of the profile lines are shown in Fig. 2.

Profile A-A: A-A shows the Lathore and Turekela nappes resting successively over the craton with thick sole thrust at the base. The sole thrust is exposed as TBSZ on the surface. The basement is made up of late tectonic granites wherein the sole thrust is developed. Splay thrusts branch out from the sole thrust, forming leading imbricate thrust structure. The nepheline syenite pluton is emplaced within sole thrust. The basement is marked by mantle reaching faults which truncate against the sole thrust. The nepheline syenite magma is considered to have been supplied through these fractures and emplaced along the TBSZ.

Profile B-B: B-B shows the Sinapalli nappe juxtaposed against the sole thrust. It underlies the Lathore nappe. Turekela nappe does not occur along this section. Sinapalli nappe is exposed close to the TBSZ in the west. The sole thrust is developed partly on the late-tectonic granites and partly on granite gneiss. The nepheline syenite pluton is enclosed within Sinapalli nappe. Imbricate thrusts giving rise to a schuppen zone are found within Sinapalli nappe. Mantle reaching fractures which are responsible for intrusion of nepheline syenites are present in the basement.

Profile C-C: C-C profile shows the occurrence of Sinapalli nappe and klippe on the basement. The Lathore nappe is absent. On the surface, basic granulites and quartzofeldspathic bands alternate due to imbricate splay. Basement is represented by granite gneisses intruded by late tectonic granites. The granite gneiss has been thrust up along the imbricate thrust to produce the window.

Profile D-D: D-D is the longitudinal profile in N-S direction. It shows Khariar lateral ramp that divides the area into two parts. In the northern part the Lathore and Turekela nappes are exposed while in the south is Sinapalli nappe. The Sinapalli nappe pinches out at depth, below the lateral ramp. This suggests that Sinapalli assemblages represented crustally lower level rocks and they are exposed at higher level due to lateral ramp structure.

Discussion and Conclusion

The northwestern front of the EGMB represents the salient part of the FTB consisting of three nappes that were successively thrust upon the craton to NW. The basal decollement of the FTB is exposed as moderately inclined thrust designated as TBSZ as it demarcates the boundary between high-grade EGMB terrane and low-grade Bastar craton. The basal decollement passes over a lateral ramp that is responsible for the termination of Lathore nappe and dominance of Sinapalli nappe and exposure of cratonic window in the south. Kinks are observed on the TBSZ due to the lateral ramp structure. Detailed structural analysis of the area reveals that individual nappes are distinct in their deformational history and lithological assemblage. Observing the alternate basic granulite and quartzofeldspathic units being repeated several times in
stratigraphic horizon, a leading imbricate splay structure like a schuppen zone is suggested for Sinapalli nappe. Similar structures are also inferred for Lathore and Turekela nappes. The cratonic window shows reactivation and upliftment along these splay thrusts. Folding in the Sinapalli nappe and thrusting are synchronous. This inference is borne out from the fact that the $F_1$ limbs are invariably marked by axial-planar thrusts. $F_1$ may be pre-thrusting. Both $F_1$ and $F_2$ are coeval with a prolonged period of granulite-facies metamorphism. $F_1$ is correlated with compressional-stage granulite metamorphism while $F_2$ to decompressional granulite-facies metamorphism. This indicates that the rocks were exhumed from a much deeper level of the crust.

Sinapalli nappe represents a sequence of alternate basic granulites and quartzofeldspathic gneisses. These two units are intermingled on millimeter to tens of metre scale. Basic granulites show preservation of cumulus texture which indicates igneous parentage, possibly a tholeite. Considering its intimate association with basic granulite, the quartzofeldspathic gneiss is interpreted to be rhyolitic-andesitic flow. Rare embayed quartz grains are observed in it. If this interpretation is correct, then the association of basic granulites and quartzofeldspathic gneisses represent volcanism in rift setting. Thus, Sinapalli nappe probably represents a rift.

Nepheline syenite plutons are emplaced along the TBSZ synkinematically with thrusting. The age of emplacement constrains the age of thrusting. Based on zircon ages (Aftalion et al., 2000) the thrusting was inferred to be $\sim 1.5$ Ga. Alkaline rocks are generally produced in rift setting. But the Khariar alkaline rocks are considered to be the result of compressional origin. A shear heating model has been suggested for the origin and emplacement of the pluton, in line with that of African alkaline rocks (Black et al., 1985). The formation of FTB on the western margin of the EGMB generated extreme compression on the adjoining cratonic foreland. This led to the reactivation of the ancient mantle reaching fractures which were either underlying the FTB or close to it. The compression was transmitted to the base of the lithosphere through this reactivation and the lithosphere was heated up. It is believed that lithosphere was melted due to shear heating and produced alkali magma. The alkali magma was transported upward through the conduit of these deep-seated fractures and was emplaced along the network of thrust planes within the FTB. The rise in thermal activity on the EGMB front may be attributed to lithospheric

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**Fig. 7.** A-A. B-B. C-C are east-west profiles and D-D is the north-south profile across the study area. The profiles depict the leading imbricate structure and lateral ramp structure of the fold-thrust belt.
mantle delamination beneath Peninsular Craton similar to Tibet plateau (Black and Liegeois, 1993).

The other alkali plutons of the EGMB are also associated with large-scale crustal fractures (Fig.1). The Rairakhhol and Baradangua plutons are emplaced along the Mahanadi rift and a group of NE-SW- trending lineaments. Kunavaram complex is also thought to be emplaced at the junction of Godavari rift and Siluru Shear Zone. Koraput (Bhattacharya and Kar, 2005) and Elcheru alkaline complexes are emplaced at the junction of the Siluru Shear Zone with cross-cutting fracture (Chetty et al., 2003). Hence shear heating may be attributed to the origin of all these alkaline rocks.

In view of the importance attached to the occurrence of nepheline syenite plutons along terrane margins, it is logical to define the boundary of juxtaposing terranes based on such magmatism. In a different context, Burke et al. (2003) emphasised the importance of alkali magmatism in defining the ancient sutures. Though we do not totally agree with them regarding the deformed nature of the Khariar alkali plutons, it is definitely useful to consider such a feature for identifying the terrane margins.

From the above discussion it is clear that the terrane margin of the EGMB shows the development of FTB consisting of number of thrust sheets that have been thrust above the cratonic foreland. Simultaneously, alkaline magmatism has taken place along the shear zones. The above finding has large implication in building a correlation between India and Antarctica. In the East Gondwana land assembly, India and Antarctica are juxtaposed to form a contiguous terrain. The EGMB continues into the Rayner Complex and the Bastar-Dharwar craton links with Napier Complex. The western margin of the EGMB is considered to be merging with the Rayner-Napier boundary making it significant from correlation point of view. However, neither FTB nor alkali magmatism is reported from Rayner-Napier boundary.

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