DISCUSSION

Comment (1)

[Comment on the paper "**The Sandur schist belt and its adjacent plutonic rocks: Implications for Late-Archaean crustal evolution in Karnataka**" by Brian Chadwick, V.N. Vasudev and Nazeer Ahmed published in the Journal of the Geological Society of India, v.47, No.1, 1996, pp.37-57].

We congratulate the authors for their important contribution on the geology of the Sandur schist belt, though there appear to be some lacunae in the structural interpretations. We shall confine our comments on their observations in the Hospet-Sandur-Deogiri region which we have studied in some detail.

1. The authors' statement, "Matin and Mukhopadhyay (1987) and Mukhopadhyay and Matin (1993) reported that most of the small-scale folds in the cherts have an S asymmetry with a consistent sinistral sense of vergence" is a misrepresentation of our observations. We had clearly stated in our paper that it is the D_2 folds which have a consistent sinistral sense of vergence; D_1 folds have S, Z and M shapes. Dextral D_1 folds were illustrated in Fig.9 of our paper (Mukhopadhyay and Matin, 1993).

2. The authors have questioned our views on the presence of the mappable isoclinal folds in the region. It is to be noted that apart from the D_1 closures in the northwestern termination (Matin and Mukhopadhyay, 1987) other mappable isoclinal folds are present in the Donimalai range (north of Donimalai peak - Figs.1a and b). A mappable fold pair northeast of Vyasankere Railway station in the Raman Mala range is also shown in Fig.5

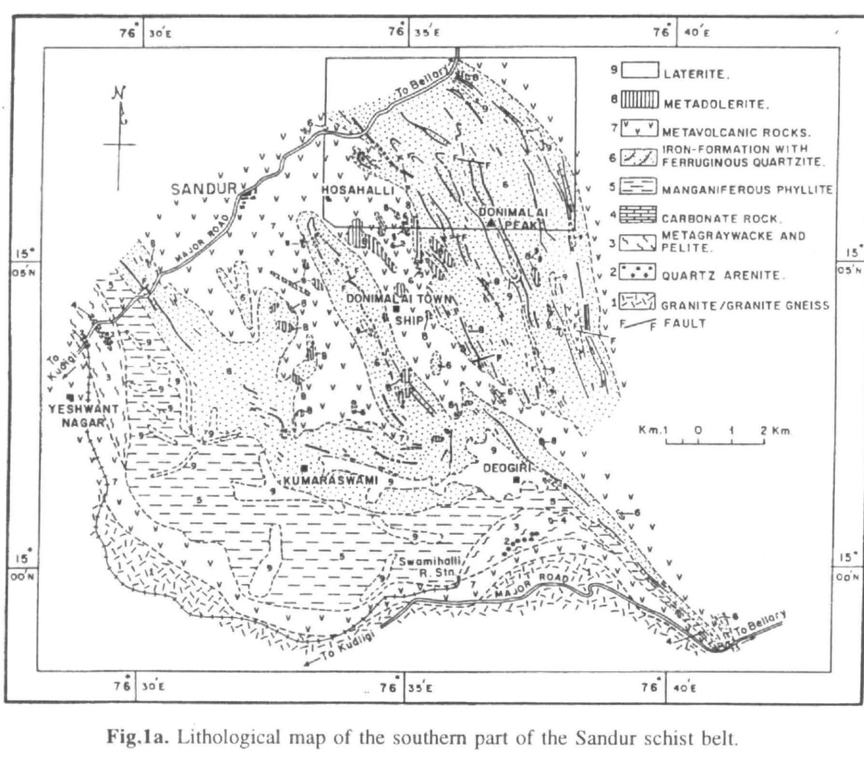

Fig.1a. Lithological map of the southern part of the Sandur schist belt.

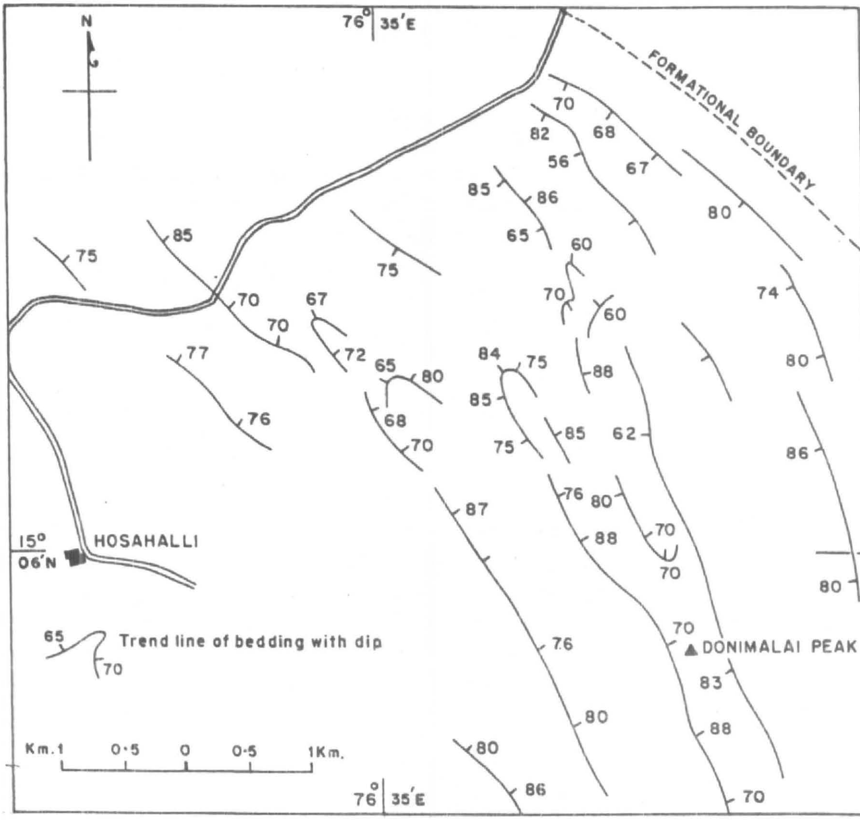

Fig.1b. Detailed structural map of the area shown in box in Fig.1a.

of our earlier paper (Mukhopadhyay and Matin, 1993). A large number of D_1 isoclinal folds extending for tens of meters are present in the Donimalai range near the Jambunath Konda temple north of Kallahalli. This zone with prolific D_1 folds can be traced for nearly a kilometer and possibly represents the core of a major fold.

3. The authors' interpretation about the regional synclinal sheath fold within the Raman Mala Formation is untenable and is poorly constrained by the structural data presented. Neither the northern closure nor the southern closure of any sheath fold is visible in the map. Chadwick *et al.* (1996) have themselves stated that both the southeasterly and northwesterly hinge areas as also the eastern limb are cut out by shearing and granite emplacement. It is not clear to us why the authors infer the existence of a major sheath fold when neither the NW and SE closures nor the eastern limb are observed. The minor fold axes show large variation within small sub-areas (Mukhopadhyay and Matin, 1993, Fig.11) and there is no systematic regional variation from SE to NW as would be expected on a major sheath fold.

4. The Sandur valley discontinuity is erected by the authors on rather tenuous evidence. Mylonitization and tectonic interleaving of granite and supracrustal rocks were earlier reported by us at the southeastern extremity of the schist belt (Mukhopadhyay and Matin, 1993; Fig.4). However, structures indicative of intense deformation are present only sporadically along the contact of Raman Mala and Donimalai Formations. On the contrary, at many places along the contact the metabasic rocks appear to have suffered only mild deformation. X/Y and Y/Z values of accretionary lapellae earlier reported by us from this

zone range from 1.6 to 1.7 (Mukhopadhyay and Matin, 1993). It should be noted that isolated shear zones are present at several other localities throughout the belt within the mafic as well as metasedimentary rocks and are not confined along the so called Sandur valley discontinuity. Our detailed mapping (Fig.1a) shows that no chert bands of the Raman Mala Formation are truncated against the Sandur valley discontinuity (Matin, 1989). We suggest that the mylonite zone ESE of the T B dam (Chadwick *et al.* 1996) join with the high strain belt west of Lingadahalli through the intensely deformed conglomerate horizon SE of Joga and SE of Vadarahalli to define a dislocation plane separating western supracrustal belt (Sandur schist belt) from the eastern supracrustal belt (Joga-Sultanpur and Copper Mountain belts).

5. The conglomerate bands SE of Joga and south of Vadarahalli appear to belong to the same stratigraphic horizon (Bruce Foote, 1895). The authors have included these within the Donimalai Formation. It is difficult to conceive that well rounded quartz-pebble dominated conglomerate beds formed the upper part of a BFQ dominated formation in a continuous sequence. We suggest that it may be included as the lowermost unit of Taluru Formation of the Joga-Sultanpur belt; their contact with the Donimalai Formation being either an unconformity or a tectonic one.

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MUKHOPADHYAY, D. and MATIN, A. (1993). The structural anatomy of the Sandur schist belt - a greenstone belt in the Dharwar craton of south India. Jour. Struct. Geol., v.15, pp.309-322.

Reply

We are most grateful to D. Mukhopadhyay and A. Matin for their comments. Our reply to the points raised is as follows:

1. We did not seek to misrepresent their observations of the vergence of small-scale folds in the banded iron formations in the Raman Mala and Donimalai Formations. Our remarks were based on the descriptions provided by Mukhopadhyay and Matin (1993) in support of their view that two episodes of deformation gave rise to two distinct sets of folds in the western part of the schist belt. They reported that their earlier episode, D_1, produced nearly isoclinal folds on both major and minor scales within the banded iron formations. They noted that axial planes of D_1 folds on all scales are parallel to the regional attitude of bedding. Mukhopadhyay and Matin (1993, p.310) stated that D_1 minor folds are usually isoclinal, long-limbed and with high amplitude. They attributed the schistosity in the

Yeshwantnagar, Deogiri, Raman Mala and Donimalai Formations to their D_1 phase, and they pointed out that primary planar fabrics (depositional or diagenetic) in some fine-grained argillites are crenulated by D_1. Mukhopadhyay and Matin (1993, p.313) stated that their second episode, D_2, produced asymmetric folds with consistent sinistral vergence in the banded iron formations. They attributed the regional, sinistral fold pair in the Raman Mala Formation near Deogiri to their D_2.

In contrast, our observations led us to interpret the structure of the Sandur schist belt in terms of thrusts and folds which formed in one principal episode of deformation, albeit a long-term continuum. This episode gave rise not only to the small-scale folds in the banded iron formations, but also the regional folds (including the fold pair in the Raman Mala Formation near Deogiri, and the Sugalammadevi Konda synclinal sheath fold) and the schistosity and linear fabric (preferred linear orientation of minerals; elongation of clasts and pillows) in the sedimentary and metavolvanic rocks throughout the schist belt. We recognised sporadic, younger crenulation cleavages and chevron folds with varied orientations which were superimposed on these structures and fabrics: some of these younger folds are tectonic, whereas others, for example in the mines at Donimalai, are superficial slope-creep phenomena.

Whereas Mukhopadhyay and Matin (1993) reported that the vergence of their small-scale D_2 folds is entirely sinistral, we found that their D_2 S folds in the banded iron formations are commonly associated with Z folds which they distinguished as D_1. The S and Z folds are commonly combined as conjugate folds, i.e. the S and Z folds were contemporaneous structures. Some of the conjugate folds pass into tight, isoclinal and chevron folds (Fig.1). This relationship shows that isoclinal and chevron folding was contemporaneous with the asymmetric S and Z folds, and they are indistinguishable in terms of having formed in distinct episodes of deformation, i.e. D_1 and D_2 of Mukhopadhyay and Matin (1993).

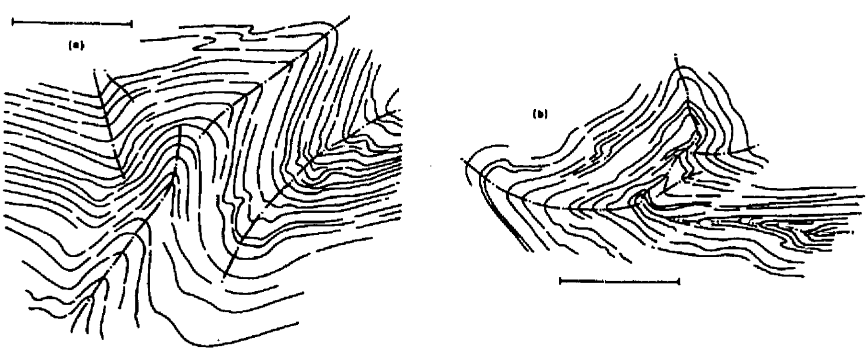

Fig.1a. S and Z folds combined as a conjugate fold which passes into a tight fold in its core; (b) part of a conjugate fold passing into an isoclinal fold; note the curvature of the fold axial traces which is an effect of a folding continuum, not distinct episodes of deformation. Both drawings are tracings from photographs of outcrops in banded iron formation of the Donimalai Formation c.2 km NE of Donimalai peak (Fig.2). Scale bars are 10 cm long.

Separation of small-scale folds (including those with curved axial surfaces, e.g. Fig.1b) in banded iron formations into distinct phases of deformation is fraught with difficulty because of the common disharmonic behaviour of the deforming multilayers. We contend that the rare small-scale sheath folds illustrated by Mukhopadhyay and Matin (1993; Fig.8a, b) rotated during a continuum of disharmonic folding and were refolded by later folds of the same period.

2. Matin and Mukhopadhyay (1987, p.215) stated that although they observed interdigitations of cherts and metavolcanic rocks in the northwestern part of the Donimalai Formation, they were unable to see the systematic change in bedding orientation that was necessary to confirm the presence of large isoclinal closures. We have been unable to refer to other data which may be available in the PhD thesis of Matin (1989). However, Mukhopadhyay and Matin (1993; Fig.5) show one isoclinal closure in the area of interdigitation in the northwest of the Donimalai Formation, and they refer to other folds in their comment (2) which we suggest may also be attributable to their D_2. They reported an unambiguous, large-scale isoclinal closure marked by the banded iron formations in the Raman Mala Formation northwest of Donimalai Township with which we are fully in accord. This anticlinal closure, which is part of the Deogiri sinistral fold pair (their D_2), has a steep to vertical plunge (Fig.2).

Their maps (Fig.1 with their comments) also show isoclinal closures in the banded iron formations of the Donimalai Formation northwest of Donimalai peak. Our map is distinctly different (Fig.2). Their map (Fig.1b with their comment) appears to be a generalised representation of trends in the Donimalai Formation. We found none of the

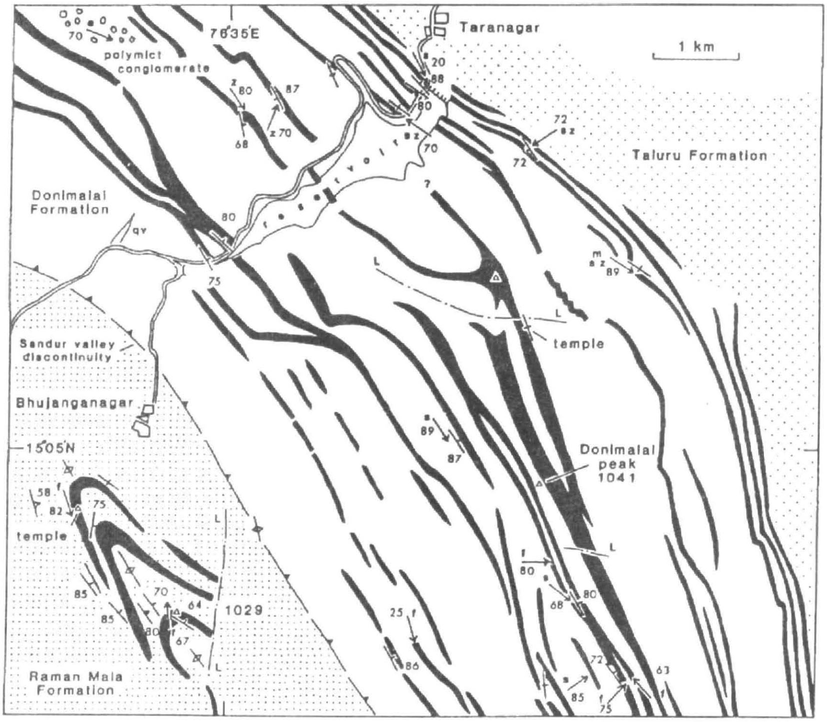

Fig.2. Map for comparison with Fig.1b with the comments of Mukhopadhyay and Matin. Black: principal banded iron formations and cherts in the Raman Mala and Donimalai Formations; blank: mafic volcanic and subvolcanic rocks and phyllites; circles: polymict conglomerate; qv: quartz reef; arrows: s, z, m, f, plunge of asymmetric S, Z, symmetric M, and undifferentiated folds in banded iron formations; e, elongation of deformed clasts; bar+ tick: bedding with dip; bar + triangle: schistosity with dip; the anticlinal fold axial trace in the Raman Mala Formation is shown with two open triangles.

closures shown in their Fig.1b. Instead, we found that the banded iron formations split or bifurcate, commonly opening towards the northwest. These bifurcations are not related to isoclinal folding. On the grounds of outcrop data of small mafic sills hosted by banded iron formations in the Sandur schist belt, we attribute the bifurcations principally to intrusion of large mafic sills, but they may also be an effect of differential subsidence during volcanism and deposition of the banded iron formations.

There are three reasons why we remain doubtful about the occurrence of regional isoclines older than our principal phase of deformation in the banded iron formations of the Raman Mala and Donimalai Formations. First, we were unable to find large closures of the type described by Mukhopadhyay and Matin (1993) which are unambiguously older than our principal phase of deformation; second, the numerous way-up criteria in the Donimalai Formation do not support the existence of regional isoclines older than our principal phase; third, the splitting of the banded iron formations in the Donimalai Formation is not related to isoclinal folding, but to either intrusion of wedges of metadolerites or variable subsidence during volcanism and deposition.

3. Mukhopadhyay and Matin take issue with our interpretation of the regional strucutre in the Yeshwantnagar, Deogiri and Raman Mala Formations as part of a dismembered synclinal sheath fold. Our interpretation is based on first, the change in plunge from relatively shallow northwesterly in the southeast to steep or vertical in the northwest of the Tonasigeri-Deogiri-Nandihalli-Sandur tract where the Yeshwantnagar, Deogiri and Raman Mala Formations make up the regional sinistral fold pair; second, the southeasterly plunge of folds and fabrics in the Deogiri and Raman Mala Formations northwest of, and flanking, the Tungabhadra reservoir; third, similarity with the form of the Sugalammadevi Konda synclinal sheath fold in the east of the Sandur schist belt.

4. Mukhopadhyay and Matin also question the Sandur valley discontinuity. There are difficulties in defining its position precisely because of the generally poor exposure in the Sandur valley. However, our interpretation is consistent with the shear sense indicators in the mylonitised granites in the southeastern part of the discontinuity, the intensity of deformation in its limited outcrop, and the truncation of the Donimalai and Raman Mala Formations in the northwest and southeast of their principal outcrop. We are not persuaded to retract our claim that the regional structure and the c.35 km thickness of the stratigraphy of the Sandur schist belt are effects of steepened thrusts and two variably modified, synclinal sheath folds.

Our observations of the wide range of finite strains in the Sandur schist belt are fully in accord with the variations in strain and the sporadic occurrence of small-scale shear zones noted by Mukhopadhyay and Matin. We agree with their suggestion that the high-strain zone in the Taluru Formation near Lingadahalli may join with the mylonites east of the Tungabhadra dam, but we found no outcrop evidence to prove the link.

5. The principal beds of polymict conglomerates southwest of Joga are separated along strike from the polymict conglomerates southwest of Vadarahalli by a zone of phyllites. We found no equivalent of the quartz-pebble conglomerate south of Vadarahalli among the polymict conglomerates southwest of Joga. Greywackes and polymict conglomerates (which include clasts of vein quartz and chert) are interbedded with the banded ferruginous and non-ferrugionus cherts, iron formaitons and metabasites of the Donimalai Formation. Consequently, we see no reason to accept the suggestion of Mukhopadhyay and Matin that the quartz-pebble conglomerate (with its clasts of vein quartz or coarsely recrystallised chert) southwest of Vadarahalli should be excluded from our

Donimalai Formation and placed in the predominantly volcanic sequence of the Taluru Formation.

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Comment (2)

[Comment on the paper "**Quaternary Facies and Palaeoenvironment in North and East of Sambhar lake, Rajasthan**" by R.M. Sundaram and Suresh Pareek, published in the Journal of the Geological Society of India, v.46, October, 1995, pp.385-397].

While congratulating the authors for their contribution on Quaternary facies distribution in the north-eastern part of Sambhar Salt lake, Rajasthan, I would like to make the following comments:

1. The locations of the pitting and trenching of the section 1, 5, 6 and 8 are not clear (Fig.3).

2. Kuni and Khatwari Khurd village (Fig.1) area have been shown as a part of the Sambhar Salt lake. Palaeo-channels were inferred at these sites by Raghav (1986, 1988, 1991, 1992) which have not been cited in their paper.

3. Observations that the Mendha river is having impaired terraces in the study area are not factual (Fig.3). The area is almost flat with occurrence of active sand dunes north of village Nanan on the left bank of the river (Raghav, 1986, 1988). Evidences of drainage inversion north of Borjan is not clear because authors have shown undulating mounds and longitudinal dunes with some tributaries originating from isolated hill (Fig.1).

4. Raghav (1991; Fig.2) described the occurrence of 100 m to 130 m thick Quaternary alluvium in the north-western part of the Sambhar Salt lake area. This indicate existence of subsiding basin attributed to tectonism which is further supported by the shifting attribute of the Mendha and Rupangarh rivers. These rivers show a lateral shift toward north west leaving behind many channels. In addition to this a number of neotectonic evidences are cited by Raghav, 1991; do the authors differ or support those views?

5. The Delta plain and flood plain boundary on Fig.1 is not clear.

6. Raghav (1992) described Quaternary history of a part of the north-east fringe of the Thar desert, India, including the Sambhar Salt lake. In this area authors have suggested the commencement of the Quaternary sedimentation with a fluvial cycle. During this period present day lakes like the Sambhar Salt lake and Zean Mata lake probably constituted part of a well organised drainage. The onset of aridity reduced the discharge resulting in

unloading of sediments. The sediments thus deposited caused formation of playa and lake along various river channels. Therefore, authors statement that the presence of fluvial sediments forming the lake base contradicts the earlier observation which suggested an aeolian base for these lacustrine sediment, is not correct. Authors have touched the base of the Sambhar Salt lake on the eastern periphery margin at the meeting point of Khandel Nala with the lake in a borehole only. On that basis authors can only say that it supports the observations made by Roy (1978) and Raghav (1992).

7. Authors have also concluded that fluvial action was more dominant in the northern part of the Sambhar Salt lake. It is not clear because the map shows coverage of large area by aeolian sediments toward north except the meeting point of the Mendha river. It may possible that authors have not studied the southern part of the Sambhar salt lake where the area is dominantly covered by fluvial sediments (Raghav, 1986, 1991; Fig.1).

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References

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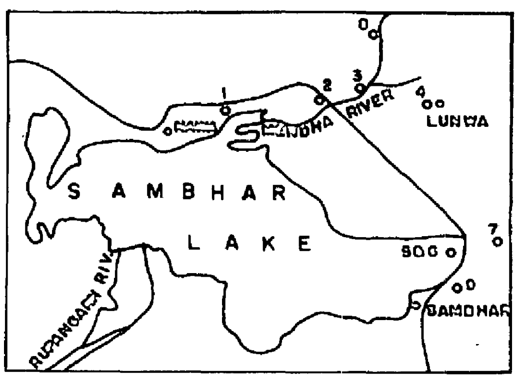
Reply

At the very outset, we offer our sincere apologies for not referring to the work cited by K.S. Raghav. We are thankful for his interest in our paper to which our point-wise reply is as follows:

1. The locations of pitting and trenching are marked by numbers 1 to 9 near to the circles in the schematic section. A new figure showing all the locations is given below:



2. Kuni and Khatwari villages fall along a linear patch of sandsheet as indicated in the legend with other aeolian landforms. This sandsheet patch has a distinct linearity and is certainly eye catching. No ground truth for fluvial sediments could be seen.

3. (i) The terrace in the northern bank of Mendha river is very clear with distinct geomorphic expression and lithological characteristics. It is a low lying flat area, all along the Mendha river, with upward fining fluviatile sediments. Active sand dunes (barchan clusters), north of Nanana, are seen within the dry river bed.

ii) Couple of nalas, dissecting the aeolian country and meeting the Mendha river in upstream direction is certainly quite significant as drainage reversals.

4. The description of varying thickness of Quaternary alluvium, differential subsidence and some of the neotectonic evidences are much generalised without much substantiation and therefore the authors are not convinced.

5. The boundary between the flood plain and the delta plain is marked by the F-F fault, however, both are represented by same symbols.

6 & 7. The contention that Sambhar lake and Zean mata constitute a major well organised drainage in the past is incorrect. There is no sediment record or ground truth. The oldest fluvial deposits are the reworked rock fragments, laterocalcretes and other clastics as colluvial fills by ephemeral rivers. In fact, the authors worked subsequently, in the Southern and Western parts of Sambhar lake and observed occurrence of denuded hills of Precambrian rocks and extensive pediment tracts with latosols. Ephemeral drainages of Rupangarh river dissecting the pediment country, mainly active, during F3 and F4 phases can be seen as similar to dominance of F3 and F4 phases of Mendha river basin in the northern parts, where extensive terracing and deltaic deposition are seen.

The view held by Singh *et al.* (1974), more popularly accepted, that the aeolian sands occurring South of Sambhar lake extend below the lake sediments, especially at the same place, where borehole was studied, was mainly contradicted by the authors.

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