DISCUSSION

Satyajit Biswas, Kolkata, replies:

1. Groundwater occurs in unconfined aquifer under water table condition in Nadia district and is mentioned and discussed in the section Geological History and Hydrogeology (p.23, para 3). Moreover, the entire analysis is based on water table data which signifies the nature of the aquifer.

2. It is true that the use of the term underground is superfluous.

3. It is implied from the aquifer condition, post monsoon water table trend and rainfall trend discussed in the paper that the unconfined aquifer of Nadia district is directly charged and saturated with rain water in monsoon period, verification of which was also revealed by the monsoon and post monsoon depth to water level data. As a consequence, the perennial river and regional groundwater are in equilibrium in monsoon period. However, in lean period, water table goes below with respect to the river water level in accordance with increasing conjunctive use of groundwater specially in agricultural sector. Under these conditions, groundwater is locally recharged by perennial sources during pre-monsoon period.

4. It is already discussed in the section Geological History and Hydrogeology (p.23, para 3) that unlike the classical deltaic alluvial plain, a thick continuous granular zone represented by sand has persisted right from the top surface down to a depth of 100-150 m in most of the Nadia district. Groundwater occurs in this area in a thick zone of saturation within the alluvium represented by sand. Thus, the geological factor controlling the occurrence of groundwater in this district exists under water table condition i.e. in an unconfined state. This is due to the occurrence of permeable layer from the surface and or the non-existence of any significant confining strata over the water saturated granular layer. Under such condition, the aquifer is directly recharged from rain water and the area behaves like recharge zone. It is mentioned in the section Geological History and Hydrogeology (p.23, para 3) and is not left for imagination of the reader. Extent of water table fluctuation can be observed from Fig.7.

5. The objective of the paper was not to establish the hydrogeology of Nadia district but to study the fluctuation and trend of water level within a known hydrogeological condition discussed in the paper, which is ignored by the commentator. All the inferences and phrases are well documented and depicted in the results obtained by the analysis of water table data.

6. Under the hydrogeological condition of Nadia district discussed above, the possibility of vertical variability of transmissivity, leaking condition within the aquifer or poor recuperation of aquifer is less significant or does not arise.

(Comment received on 9 January 2003 and the Reply on 30 March 2003)


S. Mohanty, Department of Applied Geology, Indian School of Mines, Dhanbad - 826 004, Email: mohantysp@yahoo.com, comments:

The interpretation of geology of the discussed area by Chattopadhyay et al. (2003) supports my view that the dolomite and quartzite units to the south of Mansar Mine area are not younger Bichua and Chorbaoli Formations but represent older units, and the synformal fold closures of Ramtek and Kandri area represent polyharmonic (W-shaped) second generation folds, but differs in three aspects: (a) status of the granite gneiss, (b) nature of the conglomerate and (c) the map pattern near Ramtek. However, the
Differences discussed by these authors have arisen out of their overlooking the basic principles of structural geometry and interpretation of structural-stratigraphic relations. The authors may clarify the following points.

1. The authors consider the granite gneiss of the discussed area as an intrusion in the Sausar Group. The main reasons for such an inference is given to be (a) presence of Sausar deformation fabric in the granite, (b) occurrence of thin granite veins along S2, schistosity, (c) discordant relation between granite and mica schist in Waitola and Kandri mine area, (d) presence of enclaves of dolomite near Waitola, and (e) lithological dissimilarity between K-feldspar rich granite of Mansar area and Tirodi gneiss. The first two features can be explained by remobilisation of basement complex. Third and fourth features are not clear from the map given by the authors, and can also be explained by remobilisation of basement. Geological mapping by me in different parts of Sausar belt indicates that the Tirodi Gneiss comprises of an older TTG suite, migmatite, biotite gneiss, and metasedimentary and metabasic igneous rocks, and a younger intrusive phase of high-K granite. The contacts of such high-K granites with the Sausar Group are marked by conglomerate horizons. Therefore, the dissimilarity mentioned by Chattopadhyay et al. (2003) between the granite gneiss of Mansar area and Tirodi Gneiss is due to their lack of experience in mapping the Sausar Group. It may be noted that Chakravarty (1973) has shown the granite gneiss exposed to the west of Kandri Mine and at the market place of Mansar as Tirodi gneiss (Fig. 1b of Chattopadhyay et al. 2003).

As discussed by Mohanty (1988), when we examine the maps by Chakravarty (1973) and Rao (1970) side by side it becomes apparent that Tirodi Gneiss and orthogneiss (post-Sausar intrusion) classification is a lithological bias of different workers of the Sausar Group. It is clear from the their description by Mohanty (1988; Figs. 2 and 4). This quartzite unit of Ramtek area has four lithological variants – feldspathic quartzite, massive quartzite, micaceous quartzite and garnetiferous mica schist (Table 1 and Fig. 2 of Mohanty, 1988). The key horizon forms early closures near Nagarjuna temple and southeast of the tourist resort. All along the ridge from east of tourist resort up to the last termination point of the quartzite, orthogonal relations between S2 and S1 are present. It is clear from the their description by Chattopadhyay et al. (2003) that an intersection lineation is folded by a set of folds with near EW axial trace in this region. However, with the belief that no regional F1 fold closure is present in the Sausar belt, they considered the intersection lineation to be of second generation and the folds affecting them to be F2. Except this no other evidence for F2 is provided. If one consults the map given as Fig. 2 (Mohanty 1988), it can be seen that near the Nagarjuna temple and on
the hill to the east of Ramtek-Ambala road second order \( F_2 \) folds have developed. Therefore, the folds thought to be \( F_3 \) by Chattopadhyay et al. (2003) are all \( F_2 \) folds and the deformed lineations are not \( F_2 \) but belong to \( F_1 \) intersection lineations. As mentioned earlier, from the repetition of the key horizon down the plunge of the axial trace, opposite younging directions, repetition of all other lithological variants of quartzite, orthogonal relation between \( S_0 \) and \( S_1 \), the “mirror-image” type of map pattern of Ramtek area was established by Mohanty (1988). Therefore, I would like the authors to explain the changed younging directions present in the quartzite units and the earlier official view of GSI.

A. Chattopadhyay, A.S. Khan, A.K. Bandyopadhayay, Geological Survey of India, Nagpur - 440 006 reply:

First of all, we would like to thank Dr. Mohanty for taking keen interest in our paper and pointing out some differences of opinion. Following are the point-by-point replies to the comments by Dr. Mohanty.

1. The discordance of the biotite-granite (granite-gneiss) and Sausar Group (SSG) is quite apparent from the fact that the granite intrudes the schistose rocks of SSG near Waitola as tongues and often completely separates the outcrops of schists from those of dolomitic marbles (both of which belong to Mansar Formation). We are quite aware of the fact that TBB is a basket term comprising biotite-plagioclase gneiss, tonalite gneiss, migmatites and occasional granite gneiss with lenses of high-grade, older (pre-Sausar) supracrustals and enclaves of metabasic rocks (Pal and Bhowmik, 1998; Chattopadhyay et al. 2001). But we argued that this particular granitoid does not belong to the basement (pre-Sausar) status, as it has intruded the Sausar rocks and is certainly younger to SSG.

Dr. Mohanty intends to explain the intrusive relation by ‘remobilisation’ of the basement. What he possibly means is that part of TBB (basement) underwent partial melting during Sausar deformation and metamorphism and thereby could have intruded SSG. Now, in Mansar-Kandri area, the metamorphism of Sausar Group is generally low – it has hardly crossed upper greenschist facies (see Narayanswami et al. 1963; Pal and Bhowmik, 1998). *Even diagenetic imprints have been identified in Sausar rocks from the adjacent Mahuli-Ghogra (Bhowmik et al. 1997).* Recent study on the metamorphic evolution of Sausar Group (Pal and Bhowmik, 1998) has categorically rejected the possibility of partial melting/migmatisation during Sausar tectonothermal events, even in the north-western part of SSSB, where metamorphism of SSG reached upper amphibolite facies. It is, therefore, incomprehensible how basement rocks can be partially melted in an area where Sausar metamorphism is at such low grade.

Dr. Mohanty talks of the earlier ‘official’ view of GSI. The ‘official’ view of GSI on the geology of Sausar Belt is best represented in the classic publication (GSI Bulletin Ser.) by Narayanswami et al. (1963), of which Chakravarty was a co-author. *The map accompanying the publication clearly shows that ‘orthogneiss’ (granite-gneiss) occurring along the southern part of Mansar Mines is younger to Sausar Group and is certainly not part of TBB (see Fig.1 of the present paper).* It is not our ‘lack of experience’ that created any ‘misinterpretation’. GSI mappers always held a similar view in this regard.

2. There are reports of basal conglomerate along the contact of TBB and SSG from the eastern part of SSSB (Ukwa-Balaghat section) by GSI (see Chattopadhyay et al. 2001 and references therein). But in the present study area, the contact between the banded biotite granite (TBB of Mohanty 1993) and the adjacent Sausar Group schists is not marked by a conglomerate as described by Mohanty (1993). Neither we, nor other non-GSI workers (Bopche and Siddiqi, 2000) could find the gneiss-pebble conglomerate described by him in Waitola area. What we could find, nearest to his description is the autogenic breccia of deformed quartz veins, thin quartzite interbands and intrusive granitic tongues within the schists. Moreover, Mohanty et al. (2000) described extension of this deformed pebble conglomerate horizon along the southern slope of Mansar ridge, where the same contact between granite gneiss and schists can be traced. However, the deformed pebble-like ‘discoidal’ objects found within sericitic schist in this area are mostly ‘quartz-fibrolite bearing tabloids’ classically described by West (1936) from Sausar Belt. If Dr. Mohanty finds time, he may please visit the northern part of SSSB (Manegaon-Arjuni-Karwahi area), where he can see very large, deformed (occasionally folded) tabloids within TBB as well as in Sausar Group. Origin of the tabloids is not very well understood. Recently, Bhowmik et al. (1999) argued that fibrolite is a product of ‘base leaching’ of feldspars through intermediate muscovite formation, under the influence of a hydrogenous fluid.
under low-T metamorphic (metasomatic) condition. In any case they are not transported, deformed 'pebbles'.

3. The outcrops of quartzites and schists of Chorbaoli Formation overlying the Mn-bearing schists of Mansar Formation to the east of Kandri Mine (Fig.2) are not a 'mirror-image' or 'boomerang' shape interference pattern typical of non-plane, non-cylindrical superposed fold. It does not show any structural closure in the limbs of the main westerly closing F2 fold at Kandri Mine. The eastern end of the exposure is marked by 'questionable' lithocontact, as this area is covered under soil and occasionally under transported mine dumps. This quartzite and garnet-mica schist package occupies the core of the Kandri synform. It may be noted that the axial trace of Kandri synform and Ramtek synform are nearly parallel, but may not be along the same line. Our interpreted map pattern rather suggests that they may be two adjacent synforms with the intervening antiform mostly eroded out and/or covered under soil (the easterly closure outcropping at Nawargaon).

One major difference between our map and Mohanty's (1988) map is that Dr. Mohanty possibly assumed one major quartzite unit (with some variants) and one garnetiferous mica schist unit overlying the quartzite, as the key horizon of Chorbaoli Formation. However, our observation in different parts of Sausar belt (over a total area of nearly 2500 sq. km) led us to believe that there are more than one quartzite and garnet-mica schist unit in Chorbaoli Formation (not folded repetitions) that lie conformably on the Mn-bearing schists and marbles of Mansar Formation. Taking a particular band as a key marker in interpreting the structure will therefore create a problem. We have to rely more on the structural data in the rocks than jointing bands on the basis of lithologic identity (also see Basu, 1965). Structural relations and field disposition of rocks in Ramtek area do not match with Mohanty's map interpretation. We would like to ask Dr. Mohanty that:

(i) If the northern limb of the Ramtek fold shows a large scale F1 closure near Nagarjuna temple, as interpreted by him, then why the same quartzite unit continues beyond this point for nearly 7-8 km (continuously traced up to Salaimeta towards east)? Is this explicable by 'apparent thickness' of Ramtek quartzite at F1 hinge?
(ii) If S0 and S1 are really orthogonal in this area (which is expected at a F1 hinge), then how do you explain the presence of a protomylonite foliation defined by stretched grains of quartz (and characterized by core- and mantle texture of quartz in thin section, see Fig.7) at a very low angle to S0 in this area? To which deformation you then correlate this foliation?

(iii) If the southern limb of Ramtek synform also closes east of the tourist resort (another map scale F1), then how do you account for the antiformal closure near Nawargaon, another 2-3 km east of the Khindsi road? In fact, in this area also, S0 is accompanied by a foliation defined by stretched quartz grains and/or fibrolite needles which is nearly parallel to the bedding.

The lineation folded by F2 folds is certainly not L1 lineation. In Ramtek area, S1 generally occurs as protomylonite foliation in quartzite, as relic crenulation folds within S2 microlithons, and also as inclusion trails in later porphyroblasts (Fig.6). S2 on the other hand, is a quite strongly developed penetrative cleavage axial planar to F2 folds and produces strong intersection lineation, on the S0 surface, parallel to F2 axes. If you look at the photograph of F2 folds (Fig.9) it is immediately apparent that this fold does not have any axis-parallel intersection lineation (or any strong axial planar fabric) which is expected for a F2 fold. Rather it bends a very strong intersection lineation (L2). These folds also describe a general trend for the fold axes (90-100) which is different from the general trend of F2 mesoscopic folds (c.120). It may at most be argued that we could designate these two fold sets as F2a and F2b instead of F2 and F3 because of the local development of F3. But we designated them as a separate fold generation as this folding event is not accompanied by the characteristic metamorphic fabric generation associated with F2 throughout SSFB. Moreover, we have observed folds with this type of overprinting relation in other parts (in Lendejhari-Tumsar-Gobarwahi sector) of SSFB and hence their development is not as localized as we initially thought. In either case, these folds cannot be F2 folds folding L1 lineation, as Dr. Mohanty claims.

Despite Dr. Mohanty's apparent lack of faith in the present authors who have mapped over 2500 sq. km of the Sausar belt on 1:25,000 scale recently, we regard his erudition and capability as a structural geologist with high esteem. We therefore request him to revisit the area, critically examine the outcrops in the light of our new observations and then publish his view, if he still differs with us. After all, differences of opinion and resulting debate has remained the fountainhead of progress in science.
DISCUSSION

References


(Comment received on 27 January 2003 and the Reply on 13 March 2003)

(2)

R.K. Bopche, KITS, Ramtek - 441 106, District Nagpur, Maharashtra comment:

I congratulate the authors for describing actual facts about the stratigraphy and structures of Sausar Group in Ramtek-Mansar-Kandri area, Maharashtra. I have the following comment:

The authors have described the rock type as foliated granite in the south of Mansar area (refer Fig.2, p.78). But in my view the rock type is quartz-mica-schist. This quartz-mica-schist has been identified in dug wells present in the area (around Hivra, Hivri and Bijewada) during hydrogeological investigation. From bore well drilling also the same rock type has been identified in the area.

(Comment received on 31 January 2003 and the Reply on 13 March 2003)

A. Chattopadhyay, A.S. Khan, A.K. Huin and B.K. Bandyopadhyay, GSI, Nagpur - 440 006, reply:

We thank Dr. Bopche for his appreciation of the paper. As far as his observation of quartz-mica schist in south of Mansar area goes, it is quite possible and logical. Actually, the area south of Mansar where we have shown foliated granite is a soil covered terrain, where many outcrops of granite are seen here and there. The country rock which the granite has intruded, must be quartz-mica schist of Mansar Formation, which should be present in the area in large patches. One or two such patches are shown in the northwest of Mansar (Fig.2). However, because of the soil cover and generally easy weathering of mica schists, it was not possible to map all the country rock patches, one of which he may have encountered during his hydrogeological investigation.