DISCUSSION

Comment 1

(A comment on the paper "**Tectonic setting, petrochemistry and tungsten metallogeny of Sewariya Granite in the South Delhi Fold Belt, Rajasthan**" by J. Bhattacharjee, Fareeduddin and S. S. Jain, published in the Journal of Geological Society of India, Vol. 42, No. 1, 1993, pp. 3-16.)

I congratulate the authors for bringing forward the information particularly about the tectonic setting of the area. However, I would like to make a few comments and seek clarification from the authors :

1. The Table II of the paper suggests a very high content of W for the Sewariya granite, i.e., 50 – 100 ppm which is about 5 to 10 times higher than the W content of any other tungsten bearing granite, i.e., 5 – 12 ppm (Levashev 1978 ; Liu *et al.* 1982). The experimental work of Stempork (1990) also suggests that the granites even in a close spatial association with W deposits are undersaturated with respect to W. It may thus be an interesting point to be discussed as to the high content of W and the method by which it is analysed.

2. The authors have not clearly mentioned the chemistry of the two phases of Sewariya granite, as suggested by them, i.e., an *early* porphyritic, foliated granitic phase and a *late* equigranular, nonfoliated phase separately. It seems that the relationship is established between the two phases only on the basis of field relations. It may be possible that the late phase is an intrusive phase in the porphyritic granite as in the case of Balda which is a nearby area, where the tungsten mineralization is genetically associated with this equigranular, nonfoliated leucogranite phase named as Balda Granite (Srivastava and Naik, 1991). It will be interesting to know as to which phase of the Sewariya granite is the tungsten metallogeny related.

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Reply

We thank Dr. P. K. Srivastava for his interest in our paper. Replies to his specific comments follow.

1. The W content of the samples were analysed by AAS method. The two samples listed in Table II with 100 ppm W are of greisenised granite. The apparently unaltered Sewaria granite contains 40-50 ppm W (please *see* Table V of our paper). In contrast to the observation that all W bearing granites have W values of 5 – 12 ppm, we may point out that the average W content of Degana granite varies from 121 ppm in the porphyry and volcanic phase, 334 ppm in the coarse grained granite phase and 1275 ppm in the pneumatolytic phase. The abnormally high W values of Degana granite is because of the presence of Wolfrom associated with thin pneumatolytic veins traversing these rocks in all scales from sub-microscopic to fraction of a millimeter to few millimeters (Chattopadhyay *et al.* in press). Secondly, undersaturation of W in granite would arise only if the processes of magma emplacement, pneumatolysis and post emplacement – fluid induced elemental readjustments occurred in a chemically closed system. Such a situation is hard to reconcile for the Precambrian granitoids that are extensively metamorphosed. Recent experimental study of a system $Na_2WO_4 - 2H_2O - SiO_2 - H_3BO_3$ by our colleague (Dr. Balaram Chattopadhyay, *pers. comm.*) has suggested that 40 – 60% WO_3 may be carried even under metamorphic conditions. Therefore, we suggest that higher concentration of W in Sewariya granite samples may be either due to one or both of these two factors.

2. On the basis of field relations and petrographic characteristics we have identified two granite phases in Sewariya pluton. The early phase, which forms bulk of the massif is a grey, very coarse grained, porphyroblastic rock. This is traversed by minor veins and ribs of non-foliated medium to fine-grained granite. Unlike the Balda pluton, Sewariya's early phase is extensively greisenisied with several W-Li prospects. We have carried out our detailed study on this phase only. Further study on the geochemistry of late granite phase and its relation with respect to W-Li mineralisation is in progress.

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Comment 2

(Comment on the paper '**Stratigraphic Position of the Tirodi Biotite Gneiss in the Precambrian Terrane of Central India: Evidence from the Mansar Area, Nagpur District, Maharashtra**' by S. Mohanty, published in the Journal of the Geological Society of India. Vol. 42, No. 1, 1993, pp. 55-60.)

We appreciate the efforts by the author to evaluate the stratigraphic position of the Tirodi Biotite Gneiss. However, a more clear understanding of the theme is advisable. Our comments are as follows:

1) Due to the absence of a detailed geological and location map, the efforts by the author to describe various outcrops around Mansar serves no purpose.

2) No effort has been made to correlate the lithounits exposed at various localities with one another as also with the Formations of the Sausar Group and to compare their field and petrographic characters.

3) The structural set-up in the area should have been given in much more detail. All the above points must be taken into consideration when setting up a stratigraphic order of superposition, especially in the Sausar terrane where the structural set-up is often very complex.

4) No reason has been given for calling the gneiss exposed around Mansar to be the Tirodi Biotite Gneiss.

5) An important objection is for the incorrect usage of the stratigrapic name Tirodi Gneiss : it should be Tirodi Biotite Gneiss.

6) The stratigraphic position of the Tirodi Biotite Gneiss has always posed problems. For want of any conclusive evidence Narayanaswami *et al.* (1963) placed the Tirodi Biotite Gneiss '. . . tentatively below the Sausar rocks with a disconformity. . .' Nowhere have they called the Tirodi Biotite Gneiss to be the basement for the Sausar Group: a statement which the author has wrongly attributed to them. Even Chakravarty (1973) said the same thing for the Kandri-Mansar area.

7) Usage of terms like 'lower Precambrian' should be discouraged, now that the IUGS has ratified the subdivision of the Precambrian into two subdivisions, the Archaean and the Proterozoic (Plumb, 1991). Many workers consider the deposition of the Sausar Group to have taken place during the early part of the Proterozoic (Radhakrishna and Ramakrishnan, 1988; Yedekar *et al.* 1990 and Others). It is wrong on the part of the author to brand the Sausar terrane as a Lower Precambrian terrane.

8) It is not understood what the author means by the term 'metamorphosed palaeosol' for the sillimanite-bearing schists. His term 'nodular' for these rocks is also genetically unscientific.

9) The field photographs of the conglomerate are not truly representative and give the impression of it being more a result of cataclasis than truly sedimentogenic.

Taking into consideration all the points raised by us, we feel that it is wrong on the part of the author to make summary statements of the stratigraphic position of the Tirodi Biotite Gneiss. This is a far more complex problem—take the example of the Dharwar Craton—and demands a very detailed study over the whole Sausar terrane. Superficial studies and that too in a very small area should not be used to draw far-reaching conclusions.

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Reply

I am thankful to Dikshit and Phadke for their interest and comments on my paper. The following clarifications given pointwise against comments may be useful to readers.

1. In order to keep the number of figures proportionate with the size of the paper, only those figures which are essential have been given. A detailed geological map, showing different rock types and location of the Mansar village is given in Figure 3.
2. It is not scientific to extrapolate the observations made on a small area to the entire Sausar belt which shows wide variations in character before understanding structural-stratigraphic patterns of different areas.
3. Structural evolution of the area has been summarised in page 56. Detailed structural pattern of the Mansar area is proposed to be published at a later date. Structural pattern has been properly considered before suggesting the stratigraphic order of the area.
4. The reason for considering the gneissic rocks near Mansar as the basement of the Sausar Group is given in page 57 (column 2, line 33-40). Since Tirodi gneiss is considered to be the basement of the Sausar Group, the gneissic unit near Mansar is correlated with Tirodi gneiss. The geological map of Chakravarty (1973), partly reproduced in Figure 3, also shows the gneissic unit near Mansar as Tirodi gneiss.
5. Both the terms, Tirodi biotite gneiss and Tirodi gneiss, are in common use. The latter term is more frequently used than the former (*see* Straczek *et al.* 1956, p. 69 ; Narayanaswami *et al.* 1963, p. 13 ; Rao, 1970, p. 3 and 6 ; Narayanaswami and Venkatesh, 1971, p. 18 ; Subramanyam, 1972, p. 6 ; Vemban and Nagarajaiah, 1974, p. 7). Because of diverse lithological characters of this unit, I have used the term Tirodi gneiss in preference to Tirodi biotite gneiss.
6. There are three different views about the stratigraphic position of the Tirodi gneiss which are properly quoted (*see* page 55, column 1, lines 22 and 24, and column 2, line 13). Narayanaswami *et al.* (1963) have mentioned that 'The stratigraphic position of the Tirodi biotite-gneiss is very doubtful, and has led to much controversy, as to (1). . ., or (2) they are older basement gneisses which have suffered intense deformation and metamorphism with the Sausar rocks and now appear to have a conformable position (disconformity), or (3). . . The Tirodi gneiss which has been included as the basal member of the Sausar series in the joint paper submitted to the International Geological Congress has now been removed from this position and placed tentatively below the Sausar rocks with a disconformity' (pp. 13-14). Therefore, Dikshit and Phadke should be able to find out where the Tirodi gneiss is stated to be the basement for the Sausar Group; I have not wrongly attributed it to Narayanaswami *et al.* (1963) as alleged. The views of Chakravarty (1973) have been reported in page 57 of my paper.
7. The subdivision of the Precambrian into Archaean and Proterozoic is not new. The reference to Plumb (1991) *vis-a-vis* the Precambrian terrane of central

India is inappropriate. Whereas the classification suggested by Plumb (1991) is chronometric in nature, the significance of a few radiometric dates available for central India are yet to be properly understood in relation to structural and stratigraphic evolution of the region.

The Precambrian terrane of central India consists of a large number of gneissic domains which have been dated to be Archaean in age. The time of deposition of the sediments now forming the schist belts associated with these domains, has so far not been dated. Considering these factors I had mentioned the central Indian terrane, as a whole, to be lower Precambrian. I have not branded the Sausar Group as lower precambrian.

8. The motivation for this comment is not clear. Quartz-sillimanite aggregates have been commonly referred as 'tabloids' and 'nodular rocks' in literature (*see* Losert, 1968; Ramakrishnan, 1974). The origin of these aggregates is a matter of controversy. The association of these aggregates with a basement-cover interface led me to suggest their development from metamorphism of a paleosol horizon. More information about 'Precambrian Paleosols' can be obtained from the proceedings of a symposium of IGCP project 157 (*see* Retallack, 1986).

9. I regret about the quality of printing of the field photographs after reproduction. The appearance of Figure 2b is due to uneven outcrop surface and partly due to differential weathering of the components.

From the study of an equally smaller area Phadke (1990) has considered Tirodi gneiss to be migmatites developed from the rocks of the Sausar Group. Not even a single map has been published by him to evaluate relationship between different rock types of the area. Simply on the basis of lithological similarity a gneissic unit is considered to be Tirodi gneiss. It is time Phadke should appreciate the fact that two rocks may be petrologically similar but belong to different ages. For example, the rocks previously considered to be of Chorbaoli Formation have been reclassified as Sitasaongi Formation by Narayanaswamy *et al.* (1963) in the Sausar belt.

I agree with Dikshit and Phadke that the structural-stratigraphic relations in the Sausar belt are very complex, but differ from them on the point that no conclusions should be drawn from local studies. On the contrary, structural-stratigraphic problems in different localities should be solved first to draw valid conclusions. It is suggested that instead of being critical about the results which are against those propounded by one of them, Dikshit and Phadke should publish their work with good maps in journals having wide circulation so that it can stand scrutiny.

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Comment 3

(Comment on the paper "**Geochemistry and Petrogenesis of the Champawat Granitoids occurring around Dhunaghat, District Pithoragarh, Uttar Pradesh, India**" by Singh *et al.* 1993, published in the Journal of the Geological Society of India, Vol. 42(3), pp. 289-302.)

Singh *et al.* (1993) have presented a set of scarce petrographic and geochemical data on Pre-Himalayan Champawat granitoids (550 Ma) which support the "restite" model of granite petrogenesis in an anorogeneic environment characterized by enrichment of rare earth alkaline elements. The enclaves hosted in

Champawat granitoids and their chemical variations have formed the strong bases of "restite" unmixing model which is a critical issue discussed herewith.

Two types of enclaves, viz., mafic-rich (magmatic) enclaves (MME) and metasedimentary (surmicaceous) enclaves are found to be present in biotite-rich granitoids which, in fact, are a common occurrence in I-type calc-alkaline granitoids described elsewhere (e.g., Broska and Kumar, 1991). Before making any petrogenetic remark, enclaves hosted in granitoids should be classified properly, which has a direct genetic implication on magma-mixing (e.g., Reid *et al.* 1983), cumulate hypothesis (e.g., Dodge and Kistler, 1990) and the restite hypothesis (e.g., Tindle and Pearce, 1983) of granitoid genesis. The elliptical, lensoid and subrounded shapes and microstructures (not explained by Singh *et al.*) of magmatic enclaves in Champawat granitoids themselves suggest stretching and mingling of (enclave) magma (alkaline?) within their host granitoids probably near the proximity of their interaction (e.g., Vernon *et al.* 1988).

The aspect ratio of apatite, patchy zonation of plagioclase disequilibrium texture in new magmatic environment) and ocellar quartz are particularly very important in this regard (e.g., Vernon, 1990). The quartz-rich granitoids and quartz monzonite enclaves in Champawat granitoids either may represent partial melts of two different protoliths (heterogeneous) or may represent two (hybrid) magmas quenched in plutonic environment against partially crystallized Champawat granitoids. The composition of plagioclase (An-60) of enclaves suggests at least an involvement of relatively basic (enclave) magma than those of host granitoids.

The position of only three enclaves on different Harker diagrams appears to be "autoliths" which could have arisen from differentiation mechanism but could not be explained as restite unmixing (e.g., Chappell *et al.* 1987) and, as a whole, Harker diagrams alone cannot be used for process diagnosis (e.g., Clemens, 1989) which may be overwhelmed by processes like magma-mixing and crystal fractionation. Therefore, the petrogenesis of Champawat granitoids seems to be highly based on several assumptions which do not include parameters discussed elsewhere (e.g , Wall *et al.* 1987). The higher contents of incompitable elements (Nb, Y and REE) of enclaves than those of host Champawat strongly suggest an involvement of alkaline basic magma or HFSE-enriched source which may, further, enhance the same elements in host granitoids probably through diffusion mechanism maintaining small scale of disequilibrium (e.g., Kumar, 1992) although chemical modification of enclave magma cannot be fully ignored by the process of post-emplacement crystal fractionation, diffusion and metasomatism (e.g., Eberz and Nicholls, 1990). Alternatively, melting or assimilation of metasedimentary (lower crustal) enclaves may be the best candidate for producing melts with higher content of incompatible elements characteristic to Champawat granitoids (SrI=0.711) which interacted with mantle-derived MME magma—a major heat source of partial fusion.

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Reply

We thank Dr. Santosh Kumar for his interest and comments on our paper entitled "Geochemistry and petrogenesis of the Champawat granitoids occurring around Dhunaghat, District Pithoragarh, Uttar Pradesh, India". Kumar has discussed some other possibilities regarding the origin of Champawat granitoids. However, our paper is largely based on the geochemical signatures of the Champawat granitoids, which do not support either magma-mixing hypothesis or the Champawat granitoids being an end differentiated product of an alkaline-basic magma. Nevertheless, the quantitative modelling of partial melting process of different protolith compositions (references given in the Comment, e.g., Wall *et al.* 1987), probably represented by magmatic enclaves and/or metasedimentary envalves, could be possible, but it was beyond the scope of our interpretation. However, our chemical data for the calc-alkaline Champawat granitoids show some degree of fractional crystallization, although processes such as restite unmixing and different degrees of partial melting may also have been important for the observed variation trends. We have also mentioned on page 298 that the genetic link between the mafic-magmatic enclaves (MME) and the host Champawat granitoids, i.e., whether or not the mafic enclaves represent restite (cf. Chappel *et al.* 1987, reference given in Comment) cannot be unequivocally determined. We do not assert a definite anorogenic environment for the origin of the Champawat granitoids. However, our granitoid samples are characterized by enrichment of Y, Zr, Th, U, Nb and LREE and just show affinities with 'A' type (anorogenic) granites defined by Collins *et al.* (1982) and Whalen *et al.* (1987). We have also pointed on page 301 that it is not possible to characterize the source rocks unambiguously with the available data. A detailed study (i.e., Trace and REE analyses), on more samples of enclaves and host Champawat granitoids are required for a more definitive conclusion regarding the source of the Champawat granitoids.

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CORRIGENDUM

Kindly read S. B. K. Mohan instead of S. B. K. Soman on page 101 of the Jour. Geol. Soc. India, Vol. 43 (1) 1994. The geographic coordinates of Gogalgatti are: lat. 16°21′N : long. 76°37′E.