DISCUSSION

SHEATH FOLD IN CHARNOCKITE AROUND NEKKANAMALAI, VELLORE DISTRICT, TAMIL NADU by T.M. Ganesan, K. Gopalakrishnan, R. Renganathan and S.S. Sivasankaran. Jour. Geol. Soc. India, v.54(1), pp.69-72, 1999.

Mohanty and K.C. Sahoo, Geological Survey of India, Unit 8, Nayapalli, Bhubaneswar - 751 012 comment:

1. The effort of the authors to bring out a large scale sheath fold (13 x 8 km) in a gneiss-charnockite terrain is commendable. However, our experience in mapping of similar terrains both in Orissa and Rajasthan suggest that, although the gneissic terrains bounded by major shear zones are ideal locales for sheath fold development, establishment of sheath folds of the reported type and scale has been restrained by (a) lack/absence of marker horizons (quartzite and carbonates etc.) to prove unequivocally the continuity of the axial trace of a major fold and to arrive at the overall fold geometry. (b) Identification of structural elements of a particular generation in such a large scale in a gneissic terrain is fraught with an element of risk, because of superposition of subsequent deformation and tightness of the early folds.
2. A close look of the geological map of Nekkanamalai area (Fig.1) shows that (a) there are two major structural trends, i.e., NE-SW trending foliation and shear zones, cut across by NW-SE trending fault zones. The authors have highlighted the structural elements (foliation only) of a particular generation, thereby ignoring the linear and planar fabrics of later deformation. (b) The attitude of the foliations in the eastern part of the map reveals the presence of a tight to isoclinal synformal fold near Vellekkal, the repetition of which within the sheath fold area can hardly be ruled out. (c) Verticality of the limb, being a pre-requisite for limb inversion in sheath fold is not well documented in the map.
3. In view of these points, the authors should have done more justice by elaborating the modalities by which they could trace the axial trace of a single fold in absence of any marker bed in a complex granulitic terrain.

T.M. Ganesan, Geological Survey of India, Op. TNP&K, C-2-A Wing, Rajaji Bhavan, Besant Nagar, Chennai - 600 090 replies:

1. It would have been ideal if we could have had a few marker beds (of pyroxene granulite, BMQ etc.) to establish the continuity of the axial trace. But their absence cannot be helped. However, the same structural element, namely, the regional foliation developed as an axial foliation of F1, has been more or less continuously traced in the major part of the area showing continuous and gradual change in its trend and dip, which clearly suggests that the hinge of the major synformal fold with moderate plunges towards SW, along the strike of its axial trace towards south, becomes an antiformal fold plunging towards south. The synform traced in the north and the antiformal fold traced in the south have their both limbs in common and the axial plane of the synform in the north when traced continuously towards south, becomes the axial surface of the antiformal fold. The trends of foliation in the area do not suggest any swing or attenuation or truncation by faults, where the major sheath fold has been mapped. A few foliation trending parallel to N-NNE in the vicinity of the axial

trace of the fold in the southern part of the area may indicate some shear/slip parallel to the axial trace in this part. However, the map pattern of the S1 plane clearly suggests a sheath fold and does not indicate any distortion or discontinuity due to superposition of later structures obliterating or modifying the major sheath fold structure indicated by the map pattern.

2. (a) Though a larger area was mapped, only the geological map pertaining to Nekkanamalai sheath fold has been described. The paper mainly attempts to describe the geometry of Nekkanamalai sheath fold and therefore had highlighted only the structural elements (foliation) of a particular generation whose map pattern clearly brings out the sheath fold structure. The other shears parallel to NE-SW and WNW-ESE trending/faults are mentioned in passing. The NW-SE trending fractures may be younger faults unrelated to the generation of the sheath folds. However, the complex stresses associated with NE-SW shears and the shear zone bounding the belt may be responsible for the origin of the Nekkanamalai sheath fold.

   (b) There is a tight isoclinal synformal fold near Vellakkal but its repetition or corresponding antiform in the sheath fold area can neither be assumed nor established, since there is a major NE-SW fault and shear which separates these two areas. Even if the folds in the sheath fold area originally represent the complimentary fold of the Vellakkal fold, the geometry of fold in Nekkanamalai is not similar to the Vellakkal area, which is a tight to isoclinal fold, whereas the Nekkanamalai fold is a sheath fold whose geometry is very different and distinct as described in the paper. The present geometry of the Nekkanamalai fold only indicates that the original tight to isoclinal fold has been refolded to form the sheath fold due to asymmetrical stress conditions, conforming to any one of the geometric models proposed in the paper.

   (c) As already stated, in the absence of marker horizons, verticality of the limb does not get well documented in the map. However, the map pattern exhibited by the foliation, observed and documented at close intervals, clearly brings out that the synformal hinge of the fold in the northern part of the area when traced southward along its axial trace passes to form an antiformal hinge plunging south.

3. This point has been covered in the foregoing discussion. In the absence of marker bed only the intensive mapping of a structural elements of a particular generation (foliations) at closely spaced intervals in a continuous area could help one decipher the sheath fold by recognising the transition of the hinge of the synformal fold, when traced along its axial trace to become the axial surface of an antiformal fold plunging in the same direction. Its recognition in the area has been facilitated due to preservation without dismemberment or distortion by later deformation.

EVIDENCE OF EPITHERMAL ACTIVITY AND GOLD MINERALISATION IN NEWANIA CARBONATITE, UDAIPUR DISTRICT, RAJASTHAN by

P.R. Golani and M.K. Pandit, Jour. Geol. Soc. India, v.54, 1999, pp.251-257.

Rajesh K. Vishwakarma, Investigation Division, NMDC Ltd., Masab Tank, Hyderabad - 500 028 comments:

This paper appears significant primarily by virtue of the suggested association of gold mineralisation with carbonatite. Though this is not consistent with the quote that "*till date there is no gold deposit associated with carbonatites*" (Pirajno, 1992), the authors' recent study suffers from their assumption of the gold-free nature of chalcopyrite, mainly arising out of a major misinterpretation, in which it is said that the chalcopyrite grains in ankeritic carbonate rock given by Viladkar (1998) are completely gold-free. Surprisingly, in Viladkar's (1998) contribution, only 'select' analyses of three elements, viz. Cu, Fe and S have been given. Absolutely no attempt has been made to analyse Au. Hence, it can be inferred with confidence, that nothing can be suggested, directly or indirectly, on the nature of the chalcopyrite, particularly in terms of Au. Furthermore, while assuming a direct association of gold with hematite and ankerite (p.256), no corroborative evidence from the gold analyses of these individual minerals are provided. It is essential because the reported whole rock analyses of ankeritic and hematite-rich carbonates (containing chalcopyrite, pyrite and pyrrhotite) may also open up other possibilities of gold occurrence, as has been brought out below:

If it is believable that there are some pure chalcopyrite phases in the ankeritic carbonate rock of Newania (through eight analysis on p.255), it does not necessarily warrant that whole of the extensive zone of disseminated chalcopyrite grains found in that locality is of only pure chalcopyrite phase. At places it may be associated with gold, if not gold-bearing in a strict sense. In addition to this, attention is to be focussed on the presence of iron sulphides, such as pyrite and pyrrhotite, and their possible relation to gold occurrence. Here, it may be recalled that pyrite may also contain extremely fine gold particles (Gasparrini, 1993, p.289). Hence, considering the presence of minor amount (and not trace/accessory amount) of iron sulphides in the analysed samples, the direct relation of gold mineralisation to iron content can be explained alternatively.

Additionally, there does not seem to be a justifiable comparison between the gold mineralisation in Newania carbonatite and the gold-bearing sulphide in Bhukia area (at ~70 km SSE of Newania), in order to invoke the economic potentiality of the former (p.256). Both are of entirely different mode of occurrence exhibiting sharp contrast in geologic setting as well. For example, the formation of Newania carbonatite has distinct relationship with 1587±51 Ma old mantle derived primary melt (Viladkar, 1998) in the South Delhi Belt (Sinha-Roy et al. 1998, p.263), whereas the gold mineralisation in Bhukia (Grover and Verma, 1993) belongs to the much older Mesoproterozoic Debari Group of Aravalli Supergroup (Gupta et al. 1992), quite characteristic of volcanic-free metasediment-hosted deposit in a rift zone (Sinha-Roy et al. 1998, p.89). Tourmalinite occurrences in the Bhukia gold prospect (Golani et al. 1999) aptly support a rift-related stress regime, for which a viable inference is drawn from Vishwakarma (1996).

P. R. Golani and M. K. Pandit, Geological Survey of India, AMSE Wing (Central Zone), Seminary Hills, Nagpur - 440 006 reply:

We are thankful to Rajesh K. Vishwakarma for his interest in our work and for his observations. We have reported gold values from epithermal ankeritic carbonates occurring within Newania Carbonatitic Body (NCB) rather than from the carbonatite *sensu stricto*. It is not at all inconsistent with our quote that "till date there is no gold deposit associated with carbonatites (cf. Pirajno, 1992)". In addition, it needs to be mentioned again that so far only traces of gold have been reported from carbonatite complexes of South Africa and no gold mineralization worth calling a 'gold deposit' is reported from such plutons (*see* Mariano, 1989; Eriksson, 1989).

We are surprised at the supposedly 'major misinterpretation' as commented by Vishwakarma regarding our mention of gold-free nature of chalcopyrite. We have taken cognizance of our data (Table 1a) and referred to Viladkar's (1998) work before mentioning the relationship between gold and chalcopyrite. We have no reason to disbelieve that the selected samples probed by Viladkar (1998) are not representative. The gold-free nature of chalcopyrite is obvious from the average 100.09 wt% of Cu, Fe and S (ranging from 99.68 to 100.50%). A microprobe analyst would not attempt to analyze gold or feed standards of other metals for additional probing once the Cu, Fe and S sum to 100. Neither the microprobe analysis of Viladkar (1998) nor our chemical data (given in Table 1a) suggest any positive relationship between Cu and Au values. However, we believe that our findings would initiate detailed work on different aspects of the NCB including gold-oxide-sulphide mineralogy.

In the section on discussion, we have not tried to draw parallels between gold mineralization in the NCB and gold bearing sulphide in the Bhukia area. Instead, we have provided comparison in mineral association, which may be important for those interested in gold prospecting. Vishwakarma has surely not done adequate groundwork before giving us the example of his understanding about geology of Rajasthan, as:

(i) He has not taken cognizance of 2.27 Ga Pb/Pb age determination by Schleicher et al. (1997) before proposing 'distinct relationship' (age ?) between Newania carbonatite and much younger South Delhi Fold Belt. Further, he has quoted a Pb/Pb age of 1587±51 Ma for ankeritic 'carbonatite' given by Schleicher et al. (1997). The correct figure as given by Schleicher et al. (1997) is 1551±46 Ma, which was wrongly quoted as 1587±51 by Viladkar (1998, p.304).

(ii) Gold mineralization in Bhukia, according to Grover and Verma (1993) belongs to Pre-Aravalli rocks (see also Grover and Verma, 1995).

(iii) According to Gupta et al. (1992), Debari Group forms Lower Proterozoic basal sequence of Aravalli Supergroup containing Delwara volcanics, apart from metasediments (see Table 2, p. 65).

(iv) Sinha-Roy et al. (1998), contrary to the work of Gupta et al. (1992), propose "Debari Group' for an altogether different sequence of rocks (excluding Delwara metavolcanics) and forming the middle part of the Aravalli Supergroup (see Table 3, p. 88).

In the light of this discussion we believe that the parallels drawn by Vishwakarma about the geology of Rajasthan are not valid.

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