DISCUSSION

This section is intended to provide a forum for the discussion of papers published in our Journal by those working in similar fields of investigation and research. Such a discussion is expected to be of value not only to the actual workers in the concerned field, but also to a wider circle of readers interested in the progress of geological studies.—Editor.

Paper on 'THE NATURE AND ORIGIN OF THE BLUE DUST IN PRECAMBRIAN SEDIMENTARY IRON ORES' by K. C. Sahu and R. P. Gurav published in the Journal (Vol. 13, No. 1, pp. 30-38, March 1972).

Comments by R. N. Misra (Geological Survey of India, Sandur).

The paper presented by Sahu and Gurav from their interesting studies on Blue Dust from Noamundi and Goa, ia a commendable attempt. Only the increase in the scope of generalisation, in terms of all Precambrian blue dust deposits, may need wider observation to explain and substantiate a few characters of blue dust in other areas significantly different from the ones examined by the authors. The salient differences in the nature of blue dust occurring on Kumaraswamy Range of Sandur Taluk, Bellary District are outlined below. The serial numbers correspond to those of the authors wherein different characters of this ore are emphasised.

1. The powdery ore is found to crop out in a few extensive areas (over 10,000 sq. mls), below a soil cover of even a metre or less.

3. Powdery ore horizon bottoms both on phyllites (shales) as well as the banded ferruginous quartzites.

7. The proportion of magnetic fraction, as picked by a bar magnet, shows this character varying rather inversely to the sizes; the upper size groups with little or no magnetic fraction, the medium size group with a progressive increase and the – 100 mesh sizes showing over 30% of the magnetic part, on average. For knowing the upper limits, a highly magnetic blue dust sample (68% Fe) was passed through an isodynamic separator, after size classification. The results are as follows:

Size		% of magnetic part
+ 12	mesh	81.9
- 12+15	,,	83.6
- 15+23	,,	90.6
- 23+30	,,	89.9
- 30+40	,,	78.9
- 40+50	,,	88.5
- 50+60	,,	89.3
- 60+80	,,	92.0
- 80+100	,,	92.6
- 100+200	,,	80.4
- 200	,,	69.6

8. Average features of size analysis in Kumaraswamy blue dust are as follows:

Size		% wt.
+ 12	mesh	35
- 12+40	,,	10
- 40+60	,,	8
- 60+100	,,	12
- 100+200	,,	10
- 200	,,	25

The variation from sample to sample is reasonably low.

While partial solubility of hematite in acidic medium is unquestionable from the experiments quoted, the need for subterranean water (essentially different from percolating meteoric water) to account for the formation of blue dust from the pre-existing compact ore, may not be an accomplished prerequisite; for surface water percolation to great depth is not only evidenced by the 'laterite dykes', but also by the thin interlaminated clayey matter in hard and soft lumpy ores in addition to the blue dust, at all depths, as seen here by diamond drilling and exploratory mining. The surface water could perhaps develop the necessary pH or redox potential, as it trickles away from the oxygenated land surface, although well waters around this area are seen to be mildly alkaline.

In any case, the loosening of compaction of the lumpy ores above could alone hardly explain the intricate structures so well preserved in the blue dust; since large scale leaching as envisaged, would have likely repercussion on the total volume of rock. The weight on top would naturally make the powdery ores very much slumped and disturbed with likely obliteration of any structural pattern.

Lastly, when iron gets away by leaching, where does it ultimately go? If it rises up, then the upper layers should get upgraded. Experience in this part of the country is only to the contrary; if it seeps down, the ore bottom could be enriched. Diamond drilling shows the ore bottom impoverished in iron instead.

Therefore, a single theory for origin of blue dust may not explain all such powdery stuff. Even a possiblility of some of these in parts through a clastic mode could not be any way completely ruled out, as indirectly evidenced by some current beddings here in the eastern parts of the range, indicating too shallow an eutactic level during deposition to facilitate chemical sedimentation. This too is with the assumption that the bedded iron ores here mostly are primary sediments, only subjected to minor phases of subsequent leaching and enrichment, both in the ore as well as the adjoining country rock.

Author's reply

I am grateful to R. N. Misra for his valuable information on the blue dust of Kumarswamy Range of Sandur in Bellary District, Mysore. I also fully agree that wider observations are needed for a conclusive generalisation of any geological feature like the mechanism of formation of blue dust. The conclusion drawn by us is perhaps more applicable to areas studied by us; but local variations are likely to be encountered in other regions depending on the mineralogy of the primary ore as well as the conditions and extent of leaching, which in turn partially control the the size variations.

The occurrence of the powdery ore either at the surface or at shallow depth, covered by a thin layer of laterite as observed by Misra at Kumarswamy Range may either be due to removal by erosion and lateritization of the overlying massive ore or due to extension of the leaching mechanism to the topmost massive hard ore zone. The occurrence of banded ferruginous quartzites below the powdery ore can be as a result of selective silicification/chertification and ferrugination of the underlying phyllites. Alternatively, localisation of selective leaching of the original hard ore or BHQ under favourable conditions like large specific mineral surface, original porosity, availability of solution channels, presence of local impurities and predominance of crystal defects due to sudden fluctuation of depositional environments etc. may give rise to pockets of powdery ore in the body of the BHQ.

The magnetic characters of the blue dust stated by Misra are evident, because the coarser fraction is likely to contain grains of primary magnetite having a thick surface layer of oxidised (martitised) iron ore, in this case hematite or goethite, while the finer fraction may represent the fragments from the core and contains more magnetite grains, thus giving the observed results of inverse relationship between magnetic character and particle size.

The table showing 'size and % magnetic part' for a 'highly magnetic blue dust sample (68/Fe)' fed into an isodynamic separator gives an average of 85% magnetic particles in the whole of the sample and is most usual because unlike in a bar magnet, hematite displays strong magnetic susceptibility in the isodynamic separator even at very low current strength. Incidentally Misra has not given any data on current strength and inclination of the chute of the separator.

The table giving the particle size distribution of Kumarswamy blue dust shows that in contrast to the blue dust of Goa and Noamundi, coarser fractions predominate in the powdery ore of Kumarswamy Range, which again could be due to the original size of the primary mineral grains and the degree of leaching (liberation) or loosening of the mass.

But the actual problem in Misra's query is not the observed phenomena as stated above, but the mechanism of formation of the powdery ore. If surface percolating or descending water has to be brought into action, how to explain the following sequence, found so extensively in many vertical sections in Goa region?

1. Laterite or lateritic ore
2. Massive hard ore with top partially lateritic
3. Friable or laminated ore
4. Powdery ore
5. Phyllites

Laterite dykes, clay fillings and intraformational clay and laterites are quite common in the above sequence but they are distinctly different from the adjacent wall rock/ ore; nor does the intensity of powder formation increase near or starts from such bodies. Descending ferruginous solution has developed large scale precipitation of hard and massive goethite with peculiar concentrically banded, botryoidal or stalactitic structures in vugs, caves and empty spaces found in the lateritic and massive ore zone. Incidentally one has to confirm whether the formation of the powdery ore is as recent a feature as those of laterites and clay fillings, or are they associated with later ferruginous sediments, say in Iron stone clay of Carboniferous time in any part of the world?

'Where does the iron ultimately go? An acidulated ascending solution preferably at elevated temperature (as envisaged by us) can easily dissolve away the mineral grain surface at depth, but becomes slowly saturated as it ascends upwards only to precipitate back the solute in the higher horizon in the form of goethite or hematite. The massive hard ore zone of Goa lying just above the friable ore horizon, presents under the microscope, excellent ore textures depicting the precipitation of hematite and goethite from a fluid medium, around primary magnetite or partially martitised magnetite grains. This texture is uniform and is entirely different from the vug filling of goethite stated above.

Lastly, any theory of clastic deposition of the material will not only bring several sedimentological problems but also has to overrule all the accumulated data on chemical precipitation, that too for an ore of magnetite facies which again is formed at a greater depth of lower oxygenation as compared to the hematite facies. One has to confirm if the observed current beddings in the blue dust could be the primary feature of the current swept palaeo-ocean slope or are partially obliterated (collapsed) tight folds.

Paper on 'DHARWAR STRATIGRAPHY' by R. Srinivasan and B. L. Srinivas, published in the Journal (Vol. 13, No. 1, pp. 75-85, March 1972).

Comments by B. K. Dhruva Rao, M. Ramakrishnan and M. N. Viswanatha (Jayanagar, Bangalore).

While we appreciate the efforts of the authors to rationalise the complex stratigraphy of the Dharwar rocks of Mysore, we wish to point out that the field evidences go against most of the conclusions drawn, vide Table I of the article. The comments are detailed below:

1. *Age relationship between Dharwars and the Peninsular gneiss:* The authors have advanced five evidences to show that the Peninsular gneisses are essentially syntectonic migmatites with respect to the folding and metamorphism of the Dharwars. The first evidence (a) is the comformable relationship of schists with gneisses. There are several places where the gneisses show discordant relationship with respet to the Dharwar schists, one example being the Someshwar-Agumbe area where the gneisses show an E–W trend while the Dharwar schists trend NNW. In these places the gneisses are not always anatectic, and clear unconformities can be demonstrated. In some cases the parallelism of schists and gneisses can be explained as an evidence of migmatization of pre-Dharwar schists, which occur as bands in gneisses. An excellent example of these older schists is the garnetiferous mica schist enclosed in gneisses which unconformably underlie a quartzite carrying detrital garnet at Sigegudda near Hassan. The next three evidences (b, c & d) can also be used to demonstrate the existence of schists of pre-Peninsular gneiss age. Regarding the evidence (e) of the similar grades of metamorphism between the gneisses and the adjacent schists, it may be pointed out that the rocks in a polymetamorphic terrain carry the impress of the last metamorphic episode; and therefore the evidence of similar grades of metamorphism is not an infallible evidence for fixing age relationship.

Field evidences in the form of sedimentary structures are available in the basal sections of the Bababudans and western margin of the Chitaldrug schist belt indicating that the Peninsular gneisses with the associated grey granites are older than the Dharwar rocks as suggested by Nautiyal (1966) and Radhakrishna (1968). For example, the unconformity at the base of Dharwars can be seen in oligomict conglomerates at Devagonahalli area. This conglomerate is seen above the grey granites with a well defined angular unconformity and is overlain by a thick bed of current-bedded quartzite (Kalasapura, Sagnipura, etc.). The current bedding shows that the rocks are right side up and the bottoms are towards the grey granite. This band has been traced along the strike up to the pyrite-gold-conglomerates exposed in the tank bund at Chikmagalur on the Kadur Road. Similar evidences are seen in the Kartikere basin south of Chikmagalur.

In the western margin of the Chitaldrug-Chikkanayakanahalli schist belt, near Karadi, excellent evidences of the unconformity and normal positions of the Dharwars overlying granites is evidenced by current-bedded quartzites and the disposition of the pillows. Similar evidences can be demonstrated in practically all the schist belts, such as the bottom of Western Ghats on Someshwar-Agumbe sections, current bedded quartzite of Saulanga area in Shimoga schist belt, etc.

2. *Classification of the Dharwars:* The authors have revised the earlier classifications and have postulated four cycles of sedimentation and seven magmatic cycles. The stratigraphy as established by field evidence by us does not at all tally with the picture presented. We have offered specific comments in respect of the Bababudan and the Chitaldrug belts.

Bababudan belt: The base of the Bababudan belt, in the Chikmagalur area, starts with a conglomerate-quartzite horizon and the Lingadahalli-Santaveri traps overlie them as already explained. There are no orthoquartzites and limestones at Nandi-Hosalli area, as shown in the II cycle of sedimentation. The rook types here belong to graywacke-lava sequence comprising polymict conglomerates (with graded bedding), pyritic-chlorite quartzites and carbonate-chlorite schists, and these rocks also underlie the Lingadahalli-Santaveri traps. Therefore these rocks do not belong to the II cycle of sedimentation. The Chikmagalur granite which is shown in the top should be below the Bababudan sequence.

Though the typical geosyncline as given by Pettijohn consists of orthoquartzite-carbonate facies followed successively by euxinic facies, flysch and molasse, the generalised picture may not fit all geosynclines (Abouin, 1965). It is necessary to analyse each geosyncline in detail before pigeonholing the formations into an idealised geosynclinal cycle.

Chitaldrug belt: In the III cycle of sedimentation, Talya-Aimangala-Marikanive-Kurubaradikere conglomerates are treated as coeval. The Talya conglomerate occurs at the western edge of the Chitaldrug schist belt and overlies the Peninsular gneisses. It carries waterworn quartzite pebbles set in a chloritic matrix. The other three conglomerates are polymictic and contain pebbles of granite, pyritic chert, meta-lava, ferruginous quartzites, etc., set in a chloritic matrix. These latter conglomerates are clearly younger than the lava, chert and ferruginous quartzites which overlie the Talya conglomerate. Conglomerates similar to those at Talya (containing granitic pebbles in addition) are seen at a number of places on the Channagiri-Bhadravati road where the sequence can be readily established. Thus the authors have mixed up conglomerates of two totally different ages. Similarly the basaltic flows (pillow bearing), keratophyres, rhyolites, etc., are shown above the Aimangala conglomerates, which contains pebbles of many of these rocks. The IV cycle of sedimentation with Red beds of G.R. Series also requires rethinking as these rocks on drilling have proved to be grey and black phyllites (pyritic) formed not under oxidising conditions, but under reducing conditions. On weathering, the pyritic limonite has stained the rocks giving a misleading impression of red beds.

The field data must be carefully evaluated irrespective of whether the results pointed out by field evidence fit into any idealised pattern established elsewhere. Each geosyncline will have its own peculiar characteristics. The stratigraphy of the individual belts has to be worked out in greater detail before the overall stratigraphy of the Dharwars can be reconstructed. Therefore such a sweeping revision of stratigraphy as attempted by the authors appears premature unless backed by massive field data.

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Authors' reply

We appreciate very much the critical comments by Dhruva Rao *et. al.*, on our paper focussing attention on some of the most intriguing problems of the Dharwars of Mysore State.

Concerning the age relation between Dharwars and Peninsular gneiss, the occurrence of EW trends in gneisses of South Kanara region recognised by Dhruva Rao *et. al.*, is an important relict feature of the Dharwar basement. However, preservation of such relict features is not in contradiction to our view that the basement got remobilised during the Dharwar tectonism. The axial planes of the minor folds formed by schist interlayers and the foliations parallel to them in the gneisses SW of Hosangadi have a NNW–SSE trend parallel to the Dharwarian fold axial planes of the Agumbe schist belt. The gneisses in this region are migmatitic, and do bear evidences of plastic deformation characteristic of syntectonic migmatites. The Kanara granites might represent the anatectic phase.

It has been stated that Kalasapura gneisses and Chikmagalur granites are the base on which Bababudan series accumulated. The eight mile long bay of Chikmagalur granite recognised by Sampat Iyengar (1908) near Devagonahalli and the occurrence of steatite inclusions in the Kalasapura gneisses indicate that the gneisses and granites of this region are also younger to Dharwars. To use current bedding of an overlying sedimentary formation across reactivated basement contacts and considering the reactivated rocks of the basement as older than Dharwar schists, we feel, is not correct.

In the Karadi area, east of Halkur tearing apart of schists by gneisses producing a lobate pattern, again suggests an younger age for the gneisses.

Garnetiferous mica schists of the Shigegudda region are stated to be pre-Dharwarian. Garnetiferous mica schists and garnetiferous quartzites are common products of metamorphism of the pregeosynclinal platformal sediments in Dharwars. Since we consider that platformal sediments noticed along the margins at the schist belts are actually remnants of much extended regions of platforms that existed between the schist belt, we are unable to reconcile that they are pre-Dharwarian. The garnets in the quartzites, if they are really detrital, could as well have been derived from the charnockitic provenance which we have suggested to be older. It remains for Dhruva Rao *et. al.*, to give us more evidences in favour of detrital nature of garnets and that they were derived from Shigegudda garnet-mica schists.

For the above reasons we are not convinced of the undoubted older nature of the Peninsular gneisses. It would be pertinent to recall here, that the term 'Peninsular gneiss' was coined by Smeeth (1916) at the request of Hayden of the Geological Survey of India to distinguish the gneisses that showed intrusive relation into Dharwars from the 'Fundamental gneiss' which was known to constitute basement elsewhere. In view of the above it would be desirable to restrict the term 'Peninsular gneiss' to the gneisses that resulted from remobilization. Relicts of basement trends in a remobilised complex is not an evidence against younger age of the Peninsular gneisses in their present migmatitic state. It may be noted that we wish to stress 'present migmatitic state'.

Classification of Dharwars: The basic lavas of the Bababudan schist belt namely Lingadahalli-Santaveri traps are stated to be younger than conglomerate quartzite sequence and even younger to polymictic conglomerates of the geosynclinal stage. However, examination in the Joladahal-Allampur areas shows that the lavas occupy a position inferior to conglomerate-quartzite sequence. Amygdaloidal Lingadahalli trap pebbles present in the SW portion of the polymictic Kaldurga conglomerates bear evidence to their pregeosynclinal age. As pointed out by Dhruva Rao *et. al.*, it is true that the limestones are not in full force in the Nandi-Hoshalli area; but thin intercalations do exist. But in similar stratigraphic position whose physical continuity can be established with the formations in this area, limestones are noticed in the SE portion of the Shimoga belt. Occurrence of huge quartzite boulders along the western margin of the Kaldurga conglomerate and the presence of limestone pebbles, though rarely, in them round about Huvinhalli suggests that quartzite-limestone sequence of Nandi-Hoshalli is pregeosynclinal and predate the greywacke conglomerates of Kaldurga. The Kaldurga conglomerates unfortunately have been omitted in the Table by oversight.

The polymict immature nature of the Talya conglomerates came to be evident as the granitic pebbles were noticed in them also by Radhakrishna (1939). The validity of using mere pebble compositions for fixing the stratigraphic positions of geosynclinal conglomerates (compared among themselves) was questioned by Sreenivas and Srinivasan (1968). Here we would like to make it clear that we are aware that some conglomerates are younger and some are older than the geosynclinal volcanism. It is for this reason we consider the greywacke-greywacke conglomerates as interbedded with lavas and we have drawn attention to this point on p. 81 of our paper.

Dhruva Rao *et al* have drawn attention to the secondary nature of the red beds based on drill core data. The possibility of oxidation as a factor in reddening the beds cannot be ruled out. But the surface studies which were at our disposal, indicated that the shales and sandstones possess undoubted primary laminations, not of the type that could possibly have been formed by alteration of phyllites. In the silty sandstones there are certain delicate concentric features (such specimens yielded fossil achritachs, reported by Sambe Gowda and Srinivasa, 1969) probably relatable to life (?) whose preservation can hardly be expected had the rock undergone metamorphism and then reverted to present day sandstone-like rock through surface oxidation. Moreover G. R. formations are disposed in a narrow shoe string like body and are composed of shales, sandstones and breccias in the order of younging which feature is considered to be characteristic of red bed molasses.

In concluding our discussion we would like to mention that in working out the stratigraphy of a Precambrian formation like Dharwars so as to make the classification meaningful for intercontinental correlations, the philosophy that correlations in the Precambrian sequences relate mainly to the evolutionary stages rather than time units unlike in the Phanerozoic has been kept in mind. We have kept this aim also while working out the classification of Dharwars without losing ourselves in minor discrepancies. We have only made a beginning to reconstruct the Dharwar stratigraphy in terms of geosynclinal evolution and do not feel that we have said a final word about it. Such comments as are put forth by Dhruva Rao *et. al.*, are bound to bring out more clarity, and hence we are very thankful to them.

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