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 'METAMORPHIC BELTS IN SINGHBHUM AND CHHOTA NAGPUR, E. INDIA' by S. Ray and P. K. Gangopadhyay, published in the Journal (Vol. 12, No. 3, September, 1971).

Comments by D. S. Bhattacharyya (Indian Institute of Technology, Kharagpur).

1. Though the paper attempts fairly well to bring out an integrated picture of regional distribution of index minerals both in space and time, the actual relations are rather over simplified. I would like to make certain observations in this connection on the basis of my work in the Sonapet Valley (Bhattacharyya, 1966, unpublished D.Sc. thesis).

2. There is an attempt, in the paper, to correlate the broad metamorphic zonal patterns in relation to structures from Ghatshila in the east to the Sonapet Valley in the west. Accordingly, 'abrupt ending of the highest grade metamorphic rocks' near the Sonapet Valley has been assigned the same significance as that near Ghatshila. Such designation is, indeed incorrect because the structures at these two extremities are quite different. Whereas at Ghatshila, structures correspond to a single main phase of deformation, those at the Sonapet Valley represent two major phases of deformation. The broad fold closures in the Sonapet valley are, in fact, refold closures and do not definitely have the same significance as the fold closures at Ghatshila. Besides, there is no simple anticlinorium in the Sonapet valley.

3. It has been concluded in the paper that there is a single phase of prograde metamorphism. In the Sonapet valley and adjoining regions I have found (Bhattacharyya, D.Sc. thesis) that there are three distinct periods of prograde metamorphism; thrusting is presumed, in the paper, to have been accompanied by retrogressive metamorphism, whereas at Lapsa, it has been seen by me that thrusting is also accompanied by prograde metamorphism.

4. Thus, it seems that correlation of the zonal patterns as also sequence of metamorphic recrystallisation has been oversimplified. Incidentally, it has been remarked in the paper that Bhattacharyya (1966) vaguely reported occurrence of sillimanite at some axial culminations, which is unfortunately not true.

5. It has been concluded in the paper that andalusite does not belong to the zonal patterns of regional metamorphism and is probably formed by superposed heating effect of the vulcanicity (cf. the Dalma volcanics). My observation in this connection is that andalusite is developed in the phyllites which are not exactly in contact with the Dalma volcanics but are separated from the latter by approximately half-

a-mile width of country rocks (phyllites) which are devoid of andalusite. Moreover, I found andalusite extensively developed in a zone beside a staurolite zone and exactly matching the zonal patterns. Further, andalusite is also found far from the Dalma volcanics. Finally, andalusite is seen to enclose garnet and staurolite. The actual picture is more complicated and cannot be dealt with in detail (the details of metamorphism are being published elsewhere). Thus, significance of andalusite has probably been misinterpreted.

6. Depth of burial has been invoked in the paper, as the controlling factor determining the zonal patterns. Is depth of burial sufficient to explain the observed features? If deep burial alone is responsible for recrystallisation of the index minerals, why should these be characteristically synkinematic to post-kinematic? Unfortunately, this aspect has not been discussed in the paper.

REFERENCE

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Author's reply

Para 2. Unless all the published papers pertaining to the whole belt be taken into account and controverted, the remarks made loose significance.

Para 3. Unpublished data, naturally, could not be discussed.

Para 5. Attempt has been made in the paper to bring out probable scientific truth out of published data only through a critical review; unpublished views remained out of our discussion.

Para 6. No unseen conjecture has been evoked. It has been demonstrated by a critical evaluation of published data (which agree with the author's own observations too) that the isogradic planes are broadly parallel to the stratigraphic levels and that the younger grades occur in the direction of the stratigraphic younging: these conclusions have long been arrived at by actual workers in the different parts of this belt.

The main object of bringing out the paper was to take stock of our knowledge about the whole region and to elicit the probable generalisations that they pointed to.

Paper on 'PETROLOGICAL STUDIES IN PARTS OF THE CLOSEPET GRANITE PLUTON, MYSORE STATE' by V. Divakararao, U. Aswathanarayana and M. N. Qureshy, published in the Journal (Vol. 13, No. 1, March 1972).

Comments by A. Achutha Rao, (Central Groundwater Board, Hyderabad).

The concluding remarks on Hosadurga granites are quite interesting. In this connection, I wish to offer some comments on certain studies carried out by me on Nandi granites in Kolar District and a few other granites near Magadi, Banavar, Arsikeri, Honali and Kaivara. The question is whether the metasomatic activity is of less intensity, or a phase of metasomatic transformation is altogether absent in cases

of grey granites. I hold the view that there are varieties of grey and pink granitic rocks constituting different phases of metasomatic activity in time between Peninsular gneisses and a typically pink Closepet granite. Further these phases of metasomatic transformation depend on the geothermal gradient of the reconstituted material and emplacement within the regional belt of tectonic activity. Therefore, in the light of available data and the studies carried out by other workers in this field, a reconsideration for regrouping of the several isolated granitic bodies in the State into one Closepet granitic series which could probably fit into the example of the so-called Granite Series of Read and his co-workers, is a worthwhile study to initiate in future.

Author's reply

The authors agree with the view.

Comments by C. Bhattacharyya (Department of Geology, Presidency College, Calcutta).

I wish to draw attention to some petro-mineralogical aspects dealt with in the interesting paper by Rao *et al* (1972) on Closepet granite.

1. It is difficult to understand what conclusions the authors are going to draw from the correlation coefficients of modal variables, interpretation of which is as yet problematic. As shown by Chayes (1960) and others, the null values of the correlations between pairs of variables belonging to closed tables are powerfully influenced by the variances of the variables, and even a high value of sample correlation coefficient in such cases may be shown to be statistically non-significant. Interpretation of the correlation coefficients in such cases is, therefore, difficult. The authors could, however, make an attempt to test the significance of the correlation coefficients by the approximate method proposed by Chayes and Kruskal (1966) and Chayes (1967, not 1957 as misprinted in the paper of Rao *et al*). The authors have argued that the negative correlations between K-feldspar and plagioclase and between K-feldspar and biotite + hornblende in the Closepet granite could be due to metasomatic replacement of these minerals by K-feldspar. I have observed negative correlations between the above pairs in case of magmatic units of the Singhbhum granite. In fact, there is 87% a priori that a given correlation from closed table will be negative (Chayes, 1960), regardless of whether the rock in question is of magmatic or metasomatic origin.

2. The linear trends of modal variables shown in Figure 2 (Rao *et al*, 1972) require some comments. It is not clear why all the data of Table II have not been plotted in Figure 2 and whether the linear trends have been drawn by eye or by least-square method. The reason for using arithmetic graph paper for Figs. 2A-2C and logarithm graph paper for Figs. 2D-2E is not also clear. It appears from Figs. 2A-2C that the linear trends have been drawn considering the plots from Closepet granite only; but from Figs. 2D-2E it appears that Hosdurga and Peninsular gneiss plots have also been considered for showing the linear trends. Otherwise, the

trends as shown in Figs. 2D-2E, would be opposite to what have been shown by the authors. Also in some of the figures, the scatter of the plots is too large to be represented by a significant linear trend.

3. For supporting the metasomatic or palingenetic origin of Closepet granite the authors have cited some evidences which may equally be considered as a support for magmatic origin too. For example, it is surprising how the presence of perthite and myrmekite (p. 9) may be a supporting evidence for the replacement origin of Closepet granite. Perthite and myrmekite, it is well-known, are frequently present in granites of magmatic origin (cf. Tuttle and Bowen, 1958). Moreover, the authors give an impression that the difference in the feldspar ratio of Closepet granite from that of Redskin granite, believed to be of magmatic origin, tends to support replacement origin of the former (p. 9). The feldspar ratio in a granite of magmatic origin may depend upon the original composition of the melt and can hardly be considered as supporting evidence for replacement origin.

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Author's reply

We appreciate the perceptive comments made by Dr. Bhattacharyya.

We attempted several approaches—geologic setting, petrology-mineralogy, gravity studies (the paper under discussion), and major and trace element geochemistry (Divakararao *et al.*, 1969, 1972)—to throw light on the problem of the genesis of the Closepet granite. It is realised that, separately, none of the criteria cited above can unequivocally and uniquely establish the magmatic or metasomatic nature of a granite. We, however, beleive that if several such criteria are conjointly in favour of a certain mode of origin, there is a greater probability of that mode of origin being nearer to the real situation. Incidentally, in the present investigation, the trace element geochemistry proved to be the most fruitful approach (Divakararao *et al.*, 1972), though, by itself, it also was not decisive.

1. Notwithstanding the valid limitations of the correlation coefficients of the modal variables to which Bhattacharyya draws attention, the modal analysis data and the relative correlation coefficients have been useful in understanding the genesis of granites (Whitfield *et al.*, 1959). Whereas the observed negative correlation between K-feldspar vs. biotite + hornblende may be valid for magmatic granites also, the observed negative correlation between quartz and K-feldspar appears to be more characteristic of metasomatic granites than of magmatic granites.

2. A few samples listed in the Tables have not been plotted on the scatter diagrams, but we would like to make it clear that neither the nature of the trend line nor the interpretation are affected by the omission, in the present case. The trend

lines in the scatter diagrams have been drawn by least squares fit. The Peninsular Gneisses have been purposely omitted from most plots, as they are basic and are sharply different from the granites to which the present study is principally directed. Semi-log sheets have been used for a few plots because of the large spread of values of one of the parameters plotted.

3. There are three principal modes of formation of perthite: (i) simultaneous growth of K and Na feldspar (ii) unmixing of the original K-Na feldspar and (iii) partial replacement of erstwhile homogeneous feldspar by hydrothermal solutions (Mehnert, 1968, p. 101). The perthite in the Closepet granite belongs to the third type and hence a metasomatic origin was proposed for the granite. As regards myrmekite, post-microcline myrmekite is characteristic of gneissic granites and its formation requires the introduction of excess silica and K (Edelmon 1949; Seitsaari, 1951). Marmo (1971, p. 161) summarised the present status of knowledge in regard to myrmekites and concluded, 'The occurrence of myrmekite is especially characteristic of granitised rocks, but even there, myrmekite is not always similar nor does a similar interpretation seems to work for all varieties. Mostly, however, the replacement in connection with K-metasomatism is evident'. Significantly, the Closepet granite shows unmistakable evidence of having been considerably enriched in K, Si, Rb, Pb and Th (Divakararao, *et al.*, 1969, 1972) and this could account for the presence of myrmekite in the Closepet granite.

The magnitude of feldspar ratio may largely be traceable to the original composition of the magma. In the present instance, however, the gradual change of the feldspar ratio from the Peninsular gneiss to the Closepet granite across the contacts and the considerable variation in the feldspar ratio within the Closepet granite can be more readily explained in terms of post-emplacement metasomatic changes.

If we could not get an unambiguous answer in regard to the mode of genesis of the Closepet granite, it was not for want of trying. It just happens that the problem is too complex.

References

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