DISCUSSION

Comment - 1

(Comment on the paper **Early Proterozoic Aravalli metasediments and their relation with the Ahar River Granite around Udaipur, Rajasthan** by D.B. Guha and R.S. Garkhal, published in the Journal of the Geological Society of India, vol. 42, Oct. 1993, pp. 327-335.)

The paper by Guha and Garkhal contains evidences of misconceived field relationship and doubtful identification of lithology. A few examples:

1. The rocks occurring in the triangular area around the village Sunaria are pelites and psammopelites and not metavolcanics as mapped by the authors.

2. The authors wrongly included "grey" quartzite bands of Paraya in the outcrop of Debari conglomerate. The younging direction in the "grey" quartzite is in a direction opposite to that in the conglomerate.

3. The authors placed the carbonate unit (Rama dolomite) above their Debari conglomerate. The younging data in the map suggest the opposite.

4. Similarly, misinterpretation of the younging data led to joining of two quartzite units into one. The outcrop pattern in the northeastern end of the Ahar River Granite (ARG) outcrop is the case in point.

5. The pattern of younging shown in the conglomerate outcrop south and north of Chhotisar (*cf.* Fig.2) is mutually contradictory. This is the result of combining different non-conformable formations into one.

6. The thrust shown to separate the phyllite from the carbonate between Pratappura and Fatehsagar Lake is nonexistent.

7. With a very brief and sketchy description of microfabric of the granitic rocks the authors wanted to hammer home the point that the granite is intrusive in the metasediments. We, on the other hand, noted post-crystalline deformation features in most of the grains constituting the granite. Had the mylonitisation been coeval with the rise of the magma diapir, the mineral constituents would have indicated evidence of synkinematic fabric of the granite. On the contrary we noted evidence of extreme post-crystalline cataclasis and diaphthoretic alteration of minerals, particularly along the northern and western marging of the granite-metasediment/metavolcanic contact.

8. The presence of ARG as a land mass and its control in differentiating the Aravalli metasediments-metavolcanics is spectacularly exhibited in the distribution pattern of the rocks. Dominance of conglomerate and arkose in the immediate environs of the ARG also proves the presence of a provenance close by. In fact, Heron (1953) has given a good account of the large clasts (the pebbles and boulders) in the conglomerate and arkose being drawn from the adjacent granitic body.

9. Guha and Garkhal's suggestion that the emplacement of the ARG marks a break in sedimentation in the Aravalli succession is indeed very intriguing. Was the granite intrusion an anorogenic event? Or else, should we believe a polyorogenic history of the Aravalli Supergroup on which the imprints of the Delhi orogeny were superimposed? Do the fold chronology and metamorphism support such an evolution? Such an unusual tectonothermal history is unknown in the whole region of the Aravalli rocks.

10. The authors suggested Rb-Sr age of the ARG as 2026±54 Ma on the basis of highly subjective interpretation of a three point isochron. The most recent work on single zircon crystal gave a minimum age of 2.56 Ga with no indication of younger Pb- loss event (Goswami *et al.*, 1994). This certainly proves late Archaean age of the ARG.

11. While referring to the Udaisagar granite as intrusive into the Aravalli sediments, the authors seem to be unaware of the fact that granite gneiss occurring north of Jhamarkotra (Udaisagar granite of Heron, 1953) is one of the oldest Archaean component present in the region, yielding 3.3 Ga Sm-Nd isochron age of the same rock (Gopalan *et al.* 1990). Single zircon crystal date for the same samples is 3.28 Ga (Goswami *et al.* 1994).

12. Authors seem to be unware of the publication by Roy and Bejarnia (1990).

Geological Survey of India,
Antarctica Division
N.H./5-P.N.I.T.
Faridabad 121 001.
B.R. BEJARNIYA

Department of Geology
Mohanlal Sukhadia University
Udaipur 313 001
A.B. ROY

References

GOPALAN, K., MACDOUGALL, J.D., ROY, A.B. and MURALI, A.V., (1990). Sm-Nd evidence for 3.3 Ga old rocks in Rajasthan, northwestern India. Precambrian Res., 48, 287-297.

GOSWAMI, J.N., WIEDENBECK, M. and ROY, A.B. (1994). Single zircon ages from the Precambrian basement of southern Aravalli Mountains (Rajasthan, India). Proc. I.C.O.G. (Abst.).

HERON, A.M. (1953). The geology of central Rajputana. Mem. Geol. Surv. India. 79, pp. 1-339.

ROY, A.B. and BEJARNIYA, B.R. (1990). A tectonic model for the early Proterozoic Aravalli (Supergroup) rocks from north of Udaipur, Rajasthan. *In:* S.P.H. Sychanthavong (ed.) - Crustal evolution and orogeny. Oxford & IBH Publishing Co. Pvt. Ltd., pp. 249-273.

Reply

The keen interest shown by the critics towards our paper is laudable.

1. The rocks around Sunaria are metavolcanics indeed as is evident from its mineral assemblages, viz., Chl-Qz-pl-Ilm, Chl-Bi-Qz-pl-Ilm, Chl-Bi-Act-Qz-pl, Tr-Bi-Qz-pl, etc., and field characters such as the presence of vesicles and pipe amygdules. The chemistry of these rocks also point towards its MORB and OIT nature when plotted in Mullen's (TiO_2 - MnO x 10 - P_2O_5 x 10) diagram.

2. The apparently opposite younging direction near Paraya is due to rotation of beds by supergroup folding in the Debari conglomerate-grit-quartzite unit. It is evident from the Fig.2 of our paper. On unfolding, the regional younging direction becomes northerly. The inclusion of any unit within a group cannot be done on the basis of its colour only, but on its temporal, lithological, and spatial continuity. The quartzite around Paraya are grouped within the Debari conglomerate on such criteria itself and not on the basis of colour only.

3. The carbonates of Rama are younger to the Debari conglomerate because the younging direction of the latter is towards north as explained herein and above and also in the text of our paper (p.332).

4. The lateral continuity of the Debari conglomerate-grit-orthoquartzite can be traced up to NE of Pratappura. Hence, there are no two quartzite units present NE of the ARG outcrop. The critics misinterpreted our map.

5. The younging direction in Debari conglomerate towards the north is aptly evident from Fig.2. The apparent opposite direction is due to supergroup folding as is mentioned herein and above.

6. The tectonised angularity between the Debari phyllite and the Delwara dolomite is manifested near Nimachmata temple hill, north of Bargaon on way to Thur, etc.

7. Bejarniya and Roy are not sure whether they have seen mylonite or cataclasites around the ARG. Their statement is self contradictory. Our observations indicate a mylonitic fabric developed around the ARG pluton where S-C fabric is developed in the ductile mylonites. This mylonitisation of the peripheral part of the ARG is related to the rise of the viscous magma in a semiconsolidated state (*see* p.333).

8. All the available field evidences have been summed up to establish the ARG as an intrusive body. The intrusive nature of a pluton is best seen in the field which can then be substantiated through laboratory investigations and not vice-versa. The presence of large pebbles and boulders of granite within the Debari conglomerate, e.g., in Khetpal ka gura, are attributed to the basement gneisses occurring to the north as inliers within the Delwara volcanics, and not the ARG.

9. We have shown the ARG to intrude the Delwara and Debari Groups and no spatial relation of the ARG is seen with the Jharol Group to constrain mutual relations. This does not imply a polyorogenic fold belt evolution. Break in fold structures is, however, deciphered between the Delwara and Debari Groups; a similar break between the Debari and Jharol Groups cannot be ruled out. This has to be investigated in detail.

10. The Rb-Sr age of the ARG as 2026±54 Ma is based on five point isochron and not three as misunderstood by the critics. They have also not mentioned whether the zircon analysed for dating is afresh or reworked. The ARG is seen to contain reworked zircon also as it is a product of crustal melting (Rahman & Zainuddin, 1990). This reworked zircon will give an apparent older age.

11. The sample locations shown in the paper by Gopalan *et al.* (1990) fall well within the basement gneisses. The Udaisagar pluton contains an older, tonalitic gneissic component and a younger, massive granite-granodiorite component; the latter being intrusive. The host gneissic component has yielded Archaean age.

12. This paper is not relevant to the topic of our paper.

Geological Survey of India D.B. Guha
Jhalana Dungri, Jaipur - 302 004. R.S. Garkhal

References

Gopalan, K., Macdougall, J.D., Roy, A.B. and Murali, A.V. (1990). Sm-Nd evidence for 3.3 Ga old rocks in Rajasthan, northwestern India. Precamb. Res., v.48, pp. 287-297.

Rahman, A. and Zainuddin, S.M. (1990). Geochemistry and genesis of the Ahar river granite, northwest of Udaipur city, Rajasthan. Jour. Geol. Soc. Ind., v.35, pp. 620-630.

Comment - 2

(Comment on the paper "**A New Occurrence of Kimberlite near Kotakonda, Mahboobnagar District, Andhra Pradesh**." T. Kameswara Rao and K.J. Sarma (1994). v.43, pp. 75-85.)

The authors, at the first place are to be congratulated for recording a new kimberlitic dyke from the area. However, there are certain points which deserve to be clarified:

1. The major drawback of this work pertains to the Rare Earth Elements (REE). No reference had been made of the chondrite normalizing values adopted for the REE distribution pattern presented for the Kotakonda kimberlitic body. A contradicting feature is the presence of a negative Eu anomaly in the Kotakonda body because no Indian kimberlite or even lamproite has so far shown Eu depletion (Paul *et al.* 1975; Middlemost *et al.* 1988; Paul, 1991; Chalapathi Rao, 1993) and in fact the REE analyses made for five of the samples of the very Kotakonda kimberlitic rock by the present author at the Geochemical Laboratories of N.G.R.I., Hyderabad on ICP-MS using the international

standards SSY-2, SMRG-1 and NEGJB-2 does not show the presence of any Eu depletion wherein the adopted chondrite normalizing values are from Haskin *et al.* (1968). The presence of Eu anomaly is not entirely unknown from kimberlites (Kaminskii *et al.* 1978) but as pointed out by Mitchell (1986) its presence in kimberlite is more due to an analytical error rather than an inherent one. Further, the absence of Eu anomaly from the same kimberlitic body as shown in the present work suggests that the apparent reasons given by the authors for its presence in their work appear to be invalid.

2. Detailed petrographic study of the Kotakonda kimberlitic rock by the present author (Chalapathi Rao, 1993) revealed that it has the highest modal phlogopite than the Maddur kimberlitic bodies of Mahboobnagar district or even those from the Anantapur district including the latest pipe find near Chigicherla (G.S.I. News, 1992). In fact spectacular laths of fresh and primary phlogopite abound as phenocrysts throughout the Kotakonda body and constitute a typical feature of it, a point surprisingly omitted by the authors according to whom the phlogopite is mostly restricted to "intergranular spaces."

3. The authors state that the Kotakonda kimberlitic rock has its REE abundances similar to those of pipe 2 of Vajrakarur, Anantapur district. It is interesting to note here that pipe 2 of Vajrakarur was considered to be of lamproitic affinity rather than a kimberlite (Ajit Kumar Reddy, 1987). It is thus not clear whether authors want to consider the Kotakonda rock too as a lamproite, which they eventually did not, by drawing a parallelism with the Vajrakarur pipe 2.

Department of Earth Sciences,
Bullard Laboratories,
University of Cambridge, Cambridge
CB3 EOZ., U.K.

N.V. CHALAPATHI RAO

References

AJIT KUMAR REDDY (1987). Kimberlite and lamproite rocks of Vajrakarur area, Andhra Pradesh. Jour. Geol. Soc. Ind., v.30, pp. 1-12.

CHALAPATHI RAO, N.V. (1993). A comprehensive and comparative study of the kimberlites of Anantapur and Mahbubnagar, the Lamproites of Chelima and the Lamprophyres of Elchuru with special reference to their petrology and geochemistry. Unpublished Ph.D. thesis, Osmania University, Hyderabad.

GEOLOGICAL MAP OF INDIA (1962). Published under the direction of Dr. B.C. Roy, Director General G.S.I. (Scale 1:5,000,000).

GEOLOGICAL SURVEY OF INDIA NEWS, Southern Region (1992). V.10, 11p.

HASKIN, L.A., HASKIN, M.A., FREY, F.A. and WILDERMAN, T.R. (1968). Relative and absolute abundance of the rare-earths. Origin and distribution of the elements (Ed. Ahrens, L.H.) Pergamon, New York, pp. 889-912.

KAMINSKII, F.V., SAZONOVA, O.F. and FRANTSESSON, Y.V. (1988). Rare earth levels in kimberlites and ultrabasic xenoliths. Geochem. Int., v.15, pp. 68-74.

MIDDLEMOST, E.A.K., PAUL, D.K. and FLETCHER, I.R. (1988). Geochemistry of Minette-lamproite association from the Indian Gondwanas, Lithos, v. 22, pp. 31-42.

MITCHELL, R.H. (1986). Kimberlites: Mineralogy, Geochemistry and Petrology, Plenum press, New York, pp. 442.

PAUL, D.K. (1991). Indian kimberlites and Lamprophyres: Mineralogical and Chemical aspects, Jour. Geol. Soc. Ind., v.37, pp. 221-238.

PAUL, D.K., POTTS, P.J., GIBBSON, I.L. and HARRIS, P.G. (1975). Rare Earth abundances of Indian kimberlites, Ear. Plan. Sci. Lett., v.25, pp. 151-158.

Reply

To the above comments the following is my response:

1. For the purpose of REE plots of Kotakonda kimberlite, the chondrite normalizing values are adopted from Haskin *et al.* (1986). The REE values are determined by 'Hyphenated ICP-AES Method' at the CCL, GSI, Calcutta (page: 80-81). As pointed out by

Dr. Chalapathi Rao, the 'Eu' depletion could be due to inherent chemical behaviour of the kimberlite rock under discussion or due to analytical error, which needs further confirmation.

2. Laths of phlogopite in the Kotakonda kimberlite enclose macro- and microphenocrysts of clinopyroxene, orthopyroxene and olivine (Photographs: 3, 4 and 5 on page 77). Phlogopite also fills in the tiny intergranular spaces and replaces olivines and pyroxenes along fractures and cleavages. The observations indicate clearly that the phlogopite has formed subsequent to the formation of macro- and microphenocrysts of olivines and pyroxenes. There is no doubt that the phlogopite is abundant in the rock (page 83). In fact, the modal percentages of phlogopite in the kimberlite pipes 2 and 5 of Vajrakarur area are distinctly higher than that of Kotakonda kimberlite, which, however, is richer in its phlogopite content than the closeby Maddur pipe rock.

3. The REE pattern is not the sole distinguishing factor between kimberlite and lamproite. The authors only wished to present a comparative picture of the Kotakonda kimberlite with reference to what-so-ever corresponds closely with the multifarious aspects of its chemical behaviour.

Geological Survey of India
Bandlaguda Complex
HYDERABAD - 500 068.

T. KAMESWARA RAO

Comment - 3

(Comments on the Research Note **"On the Origin of Bole Beds in Deccan Traps"** by P.M. Inamdar and Darshan Kumar. Jour. Geol. Soc. India, vol. 44, No. 3, Sept. 1994, pp. 331-334.)

1. The author's conclusions about the origin of the red bole bed described by them are quite valid, but it appears from their description that what they have described is different from the red boles of the western parts of the Deccan Trap outcrop. For example, in the parent material of the western red boles no grains are discernible; flow contacts of basalts in the west are not always marked by red boles; there are innumerable flow contacts without them; western red boles are not associated with inter-Trappean sediments as there are no inter-Trappean sediments over a major portion of the Deccan Trap outcrop.

2. Our paper referred to by the authors does not give any idea of our findings about the red boles as the major portion of our work on red boles was carried out after that paper was written. As red boles were, at one time, a major geological problem at sites of engineering projects we carried out extensive studies on red boles at project sites. Results of these studies which are described by Gupte (1971, 1980, 1992), led to a proper understanding of the origin and properties of this deceptive material, have dispelled the unwarranted fears entertained about it and have made possible large reductions in project costs. They are briefly summarised below.

3. As seen at the surface red bole is a soft fragile clayey material that softens in contact with water. But our investigations have shown that what is seen at the surface as soft loose red bole occurs below the surface as hard sound red basalt glass, i.e. hydrothermally altered tachylyte, and red boles are therefore only the surface form of red tachylytes. Hence the soft red bole is confined only to the surface and does not occur as a continuous layer below the surface.

4. Exploratory drilling and excavations at project sites have shown that what occurs as a bed is red tachylyte and this is converted into red bole on exposure to atmosphere. In test pits, what is encountered at levels at which red bole occurs at the surface is not soft red

bole but hard red tachylyte. Excavated blocks of red tachylyte crumble into red bole after some days, but if exposure to atmosphere is prevented by immersing a block of red tachylyte in water immediately on extraction, it remains intact indefinitely. Similarly during core drilling, if soft red bole were occurring below the surface it would be washed away and would not give a core. However, a sound core of hard red tachylyte is invariably obtained, which shows that what occurs below the surface is red tachylyte and not soft red bole. This sound core disintegrates into red bole after some days, but if exposure to atmosphere is prevented by covering the core with wax or by immersing it in water immediately on extraction, the core remains intact indefinitely. Red tachylytes occur commonly as small flows or sill like intrusions between flows. They also occur entirely inside a basalt flow as small veinlike intrusions inclined at all angles.

Our investigations have shown that material occurring at the surface is difficult from the material below the surface. Hence in red bole studies material occurring below the surface must also be studied.

"Tridal" R.B. Gupte
Municipal Colony, 1206 B/35, Deccan Gymkhana,
Pune - 411 004

References

Gupte, R.B. (1971). Engineering Aspects of Deccan Trap Basalts, Mah. P.W. Journal, VII, 3-4. pp. 7-21, Mah. Engg. Res. Inst. Nashik.

Gupte, R.B. (1980). P.W.D. Handbook, Chapter 6, Part II, Engineering Geology, p. 212, Government of Maharashtra.

Gupte, R.B. (1992). A Text Book of Engineering Geology, 2nd Edition, 1992, p.104, p.178. Pune Vidyarthi Griha Prakashan, Pune - 411 030

Reply

1. As a matter of principle the red boles of western parts of Deccan flood basalt province cannot be different since it is a single province. Some differences may be possible if a bole is studied in a source area as its composition and physical properties may be affected by continuous or intermittent eruption. A quiet type of eruption need not affect the bole except to disturb its continuity. Example Mt. Sawargaon in Parbhani District. If the bole does not have any grains, it can be just a claystone or a mudstone.

A flow contact not marked by a red bed (or green, brown, grey, etc.) is a unit contact. As such it should not be given the status of a flow. Flow contacts are generally smooth and if there is any irregularity, it is very limited but unit contacts with occasional streaks of clay are very irregular and mapping such contacts would lead to miscorrelation, multiplicity of flows and finally a map which will not withstand the test of time. A systematic mapping geologist can claim 90% accuracy based on red beds in non-rugged terrains. Units in flows have been accepted as evident from the many Compound Pahoehoe flows described by different workers. A flow has two ends. One, the distal which signifies the end of eruption and the other, the proximal which is the source itself. Two sources operating at the same time or alternately should emit flows which while flowing in opposite directions would either coalesce or interfinger or abut against each other. Such areas are difficult to map. Interceptions in Deccan Traps must be a common site if we truly believe in multiple fissure eruptions (please refer records of GSI vol. 127, Pt. 6, pp.14-17).

Intertrappean beds are found only in the peripheral parts because volcanism was submarine and the assemblage of sandstone, limestone, magnesium rich limestone, cherts, marls and gypsum indicates numerous paralic basins. These sedimentary beds unless associated with red beds, form poor marker horizons as these are not really beds but lenses. This problem was faced by Swanson & Wright (1981, Geol. Soc. India, Mem. 3, p. 71) while mapping Columbia River basalts. They termed such flows marked by sedimentary beds as invasive flows.

Like Hawaiian Flood basalts or the Barren Island Volcano, Deccan Traps too began as submarine eruptions.

2. A text book on Engineering geology, 1979, pp. 105-106 attributes bole formation to hydrothermal alternation of black tachylyte. If such is the origin then a gradational contact must be seen. In Osmanabad District (Rec. of GSI 1994, vol. 127, pt. 6, pp. 14-17) a bed of glass conformably overlies a brown clay bed, the two separated by a sharp contact. Glass breaks with a conchoidal fracture and concentric rings can be noticed at each point of breaking. In thin section numerous perlitic cracks further confirms the identity. Glass or glassy basalt (tachylyte) is totally different from red beds under study. It is quite strange that devitrification has not affected the glass even after 65 million years.

3. Red beds are not only confined to the surface but occur as continuous beds even below the surface as evident from well sections. The exposed part of the red bed sometimes is so hard that it gives a metallic sound with a hammer strike (Amaravati District).

The red beds under study are not tachylytes as the glass content is either not present or present as traces. Columnar structures and spheroidal weathering is not only a characteristic feature of basalts but is seen in some clays too.

4. A red tachylyte is quite different from a red clay both chemically, petrographically and in physical properties. Samples from dug wells can be preserved in their original form without covering. A sample from red bed showing columnar structures collected from a trench in Parbhani District in the year 1985 is still retaining its form, colour, etc.

In conclusion it must be said that the only one aspect of its origin which was not covered in the note, pertains to the possibility of these being umbers. Cyprus umbers (Robertson, 1975, Jour. of Geol. Soc. of London, vol. 131, pp. 511-531) are rich in Mn (5.8%) and Fe_2O_3 (28%) but in red boles these are very low.

A-9, Chaitanya Flats,
Shivaji Nagar, NAGPUR 440 010

P.M. INAMDAR

Comment - 4

(Comment on the paper **"The Jurassic Foraminifera from the Patcham-Chari Formations of Jhurio Hill (Jhura Dome), Kachchh, Western India"** by Niti Mandwal and S.K. Singh published in Journal of Geological Society of India, vol. 44, no.6, Dec. 1994, pp. 675-680.)

1. The same stratigraphic column, made by the same authors, has been grossly altered from 1989 to 1994 (present paper). The column above the NX/PX Zone between samples JP10 and JP11 is reduced in thickness up to JP 13, and there is a gross lithological change in the column. The authors must account for these changes.

2. Pandey and Dave (1991) have demonstrated that the top of Patchamian Stage, marked by Raimalro Limestone of Biswas (1977) or Patcham Limestone (s.s.) in the Patcham Island is stratigraphically for below the sequences exposed in the Jhurio Dome. It is necessary that Mandwal and Singh explain critically about their reason for extending the name Patcham Formation to the sequence of Jhurio Hill.

3. In the work of Pandey and Dave (1993), the Badian/Charian boundary is based on chronostratigraphy and not on the biostratigraphic criteria as viewed by Mandwal and Singh (1994).

4. A complete record of Dhosaian Stage is provided by Pandey and Dave (1993) for Jhurio Dome. The stage is seen to rest on an unfossiliferous sandstone and embodies Dhosa oolite as the top bed. Mandwal and Singh (1994) are unable to infer the Callovian/Oxfordian boundary in the Jhurio Dome because of a single sample control (JP-18) in the shale and a large NX below it.

Geoscience Research Group,
KDMIPE, ONGC,
Dehra Dun - 248 195

JAGADISH PANDEY
ALOK DAVE

References

BISWAS, S.K. (1977). Mesozoic Rock-stratigraphy of Kutch, Gujarat, Quart. Jour. Geol. Min. Met. Soc.India, vol.49 (3 & 4), pp. 1-52.

MANDWAL, N. and SINGH, S.K. (1989). Bathonian age for the sediments of Jhurio Hill, Kachchh, Foraminiferal evidence, Jour. Pal. Soc. India, vol. 34, pp. 41-54.

MANDWAL, N. and SINGH, S.K. (1994). The Jurassic foraminifera from the Patcham-Chari Formations of Jhurio Hill (Jhura Dome), Kachchh, Western India, Jour. Geol. Soc. India, vol. 44 (6), pp. 675-680.

PANDEY, J and DAVE, A. (1993). Studies in Mesozoic Foraminifera and choronostratigraphy of Western Kutch, Gujarat, Paleontographica India, no.1, pp. 1-221.

Reply

The authors are thankful to Pandey and Dave for their comments to which they wish to submit the following:

1. During 1989 the authors did sampling near the contact of Bathonian, Callovian/ Oxfordian and resampling at places where a better section was exposed. On a subsequent field trip it was noticed that the angle of dip was variable and hence with low dips the correction in thickness had to be applied. The authors admit the error in not mentioning about this correction on re-examination (page 678, last para).

2. The nomenclature of Patcham, Chari, Katrol and Umia is widely accepted and is followed. Each dome in Kachchh has a differing lithology and the only persistent lithology is the Dhosa Oolite. In the absence of a standardised lithostratigraphic nomenclature, the authors have preferred to use the older nomenclature which is considered practical.

3. The Bathonian/Callovian boundary can be recognised with greater certainty on foraminiferal species and is certainly not conjectural.

4. The Callovian/Oxfordian boundary has been brought down based on the last record of *Epistomina regularis* and the first occurrence of *Trocholina nodulosa*. However, in the absence of more marked species, the boundary has been marked tentatively.

Department of Geology
University of Lucknow
Lucknow - 226 007

NITI MANDAL
S.K. SINGH

Comment - 5

(Comments on the paper **"Rb-Sr systematics of Granitoids of the Central Gneissic Complex, Arunachal Himalaya : Implications on Tectonism, Stratigraphy and Source"** by G.R. Dikshitulu *et al.* published in the Journal of Geological Society of India, vol. 45(1), 1995, pp. 51-56.)

1. Dikshitulu *et al.* (1995) reported three Rb-Sr isochron ages of granitoids from Arunachal Himalaya, where only a few earlier dates were recorded. They reported one each

such date from Bomdila, Saleri and Sapper area, West Kameng district, but seem to be unaware of similar dates reported from the granitoids of Kameng and Subansiri districts by Bhalla and Bishui (1989) and Bhalla *et al.* (1994).

2. The area of their study mainly corresponds to the Lesser Himalaya. The granitoids occurring beneath the Main Central Thrust are not referred to as the Central Gneissic Complex, and the one at Sapper is located at the border zone. The title and keywords thus may create some confusion.

3. The augen gneisses from Bomdila area have yielded Rb-Sr isochron age of 1914±23 Ma, whereas, the Saleri granite intruding the black phyllites (reported shales) have yielded isochron age of 1536±60 Ma. Bhalla and Bishui (1989) and Bhalla *et al.* (1994) have recorded Rb-Sr isochron ages one each from the Bomdila and Tenga granite-gneisses corresponding to 1650 Ma. Similar Rb-Sr isochron age was also recorded from the Kalaktang granite of the Bomdila unit, located further west (Rao *et al.* 1993). The granite-augen gneisses from Bomdila, Tenga, Kalaktang and Saleri appear to be genetically related and the 1900 Ma event recorded by Dikshitulu *et al.* (1995) represents the youngest possible emplacement age of the granite, whereas, the 1650 Ma possibly records a regional metamorphic event.

4. The presence of feebly metamorphosed phyllites at Saleri structurally below the Bomdila gneisses is significant. That the black phyllites are not the lower Gondwana rocks themselves were known earlier, but such rocks may occur in association with low grade Proterozoic rocks in a 'window' zone (Acharyya *et al.* 1975, p. 78). Such northern occurrences of the Gondwana rocks have been confirmed from Subansiri area further east.

5. The hornblende granite from the Sapper area, associated with migmatites, has yielded Rb-Sr isochron age of 481±23 Ma. This age has been attributed to reset Rb-Sr age due to "tectonic imprint of the Main Central Thrust", since the unit is "proximal to MCT" (Dikshitulu *et al.* 1995). This is a sweeping and unrealistic inference.

It is well known that the MCT activity is genetically linked to the Himalayan tectonism of Tertiary age. Besides, there is dispute regarding the location of MCT in the studied section. Based on correlation of the quartzite-calcsilicate-marble-graphite-schist assemblage exposed around Dirang with the Central Crystallines, the MCT is placed east of Dirang by some workers and not at Sapper as shown in the Fig. 1. Further, the MCT also is a low dipping feature and thus would not have straight line map disposition.

The 481 Ma recorded from the hornblende granite from Sapper area, thus, is unrelated to and unaffected by MCT or Himalayan tectonism and corresponds to the regional acid-magmatism event occurring around 500 Ma which had involved domains presently constituting the foreland and the Himalayan belt in NE India. The same event had also affected other peripheral parts of the Indian shield. Temporally it corresponds to the Pan-African activity.

Coal Wing S.K. ACHARYYA
Geological Survey of India, Calcutta - 700 016

References

ACHARYYA, S.K., GHOSH, R.N. and SHAH, S.C. (1975). The continental Gondwana Group and associated marine sequences of Arunachal Pradesh (NEFA) Eastern Himalaya. Himalayan Geology, v. 5, pp. 60-82.

BHALLA, J.L. and BISHUI, P.K. (1989). Chronology and geochemistry of granite emplacement and metamorphism in Northeastern Himalaya. Rec. Geol. Surv. india, v. 122(2), pp. 18-20.

BHALLA, J.K., BISHUI, P.K. and MATHUR, A.K. (1994). Geochronology and geochemistry of some granitoids of Kameng and Subansiri districts, Arunachal Pradesh. Indian Minerals, v. 48, (1 & 2), pp. 61-76.

RAO, SRINIVASA, P., KWATRA, S.K., SINGH, V.P. and BHANOT, V.B. (1993). Reconnaissance Rb-Sr ages of Kalktang Granite from Bomdila Group of Arunachal Himalaya (NEFA). 6th Nat. Symp. 'Mass Spectrometry', Indian Inst. Petroleum, Dehradun, Preprint vol., pp. 495-497.

Comment - 6

The authors presented Rb-Sr whole-rock isochron age data on three suites of granitic rocks from the Central Crystallines (Heim and Gansser, 1939) (the *Central Gneissic Complex* of the authors, italics mine) of Arunachal Himalaya (Bomdila augen gneiss : 1914 ± 23 Ma; Salari granite: 1536±60 Ma and Sela hornblende gneiss : 481 ± 23 Ma). The isotopic age data on these granitic rocks are welcome additions to the geochronological data bank of the Himalayan orogen. However, many of the inferences and conclusions drawn by the authors regarding the interpretative aspects of the age data are totally unconvincing and are briefly enumerated below:

1. The authors interpret the Early Palaeozoic (Ordovician) age of the Sela hornblende granite gneiss (481 Ma) as an imprint of tectonometamorphic rejuvenation along MCT. This interpretation is indeed baffling and appears to have stemmed from a wrong notion about the tectonic significance and age level of the MCT. MCT is an intra-crustal thrust along which the middle-crustal Central crystalline rocks are thrust over the upper-crustal little-metamorphosed Lesser Himalayan Formations. MCT (and for that matter other thrusts in the Himalayan orogen as well) has developed as a result of collision and persistent convergence of the Indian plate against the Asian plate during the Himalayan orogeny. This collisional orogeny, which led to the formation of the Himalayan fold and thrust belts, have occurred between 65-40 Ma (Cainozoic). Thus, relating a Cainozoic tectonic element MCT to an Early Palaeozoic (Ordovician) tectonothermal rejuvenation, leading to the resetting of the Rb-Sr isotopic clock of the Sela hornblende granite gneiss, is simply preposterous, to say the least.

Early Palaeozoic granitoids constitute a significant and major component of the Central Crystalline Zone of the Himalayan orogen and have been extensively dated from virtually every segment of the orogen. Although controversies exist regarding the exact nature of tectonic environment, which accompanied such widespread Palaeozoic granite plutonism (Fuchs, 1967 in 1992; Le Fort *et al.* 1986), there is no dichotomy of opinion that the isotopic ages of these granitoids signify emplacement/generation events. The Rb-Sr isochron age of the Sela hornblende gneiss (481 Ma) is, thus, likely to represent a generation/emplacement event during the ca. 500 Ma event. There is no denying that most of the Palaeozoic granitoids (Sela gneiss included) are variably tectonised during the Cainozoic collisional orogeny. However, available isotopic age data show that the tectonometamorphic impact of the Cainozoic Himalayan orogeny on these granitoids are manifest only in mineral (Rb-Sr, K-Ar and Fission Track) and sometimes in whole-rock K-Ar ages.

2. The authors' comment on the age of the Sela hornblende granite gneiss (414 Ma) 'this young age from the oldest group of the Precambrian CGC is rather intriguing' (p 53). My question : is it unusual or intriguing to find an younger granite intrusion in an older terrain?

3. While interpreting the age data on Bomdila gneiss (1914±23 Ma), the authors state 'This middle Proterozoic age for the augen gneiss may represent either its emplacement date or the *latest* metamorphic imprint' (italics mine) (p. 54). The use of the word 'latest' is not appropriate as for all rocks of the Central Crystalline zone, the latest thermotectonic event is the Cainozoic Himalayan orogeny.

4. The authors provide a table (Table III, p. 55) compiling some age data on the granitoids of the *Indian* Himalayas (italic mine). The compilation is hardly a comprehensive one even for the Indian Himalayas as it does not include several ages of Early Proterozoic and Palaeozoic granitoids (Pandey *et al.* 1981; Raju *et al.* 1982; Rao *et al.* 1990, to quote a few) and totally exclude several age data reported within the range 1100-1300 Ma and ca. 700 Ma. Despite these limitations of their data base, the authors make a sweeping

generalisation 'The data in Table III point to three main events in the Indian Himalaya: (i) 2315 - 1811 Ma (2060±250 Ma) (ii) 1620-1445 Ma (1530±90 Ma) and (iii) 601-453 Ma (530±75 Ma)' (p. 55). One would like to know what the figures in the parentheses following the ranges in ages (defining temporal groups of the authors) stand for.

It may be noted that available isotopic age data on Himalayan granitoids broadly belong to five (not three as concluded by the authors) temporal groups, viz. I. Early Proterozoic (ca. 2300-1800 Ma) II. Mid Proterozoic (ca. 1600-1000 Ma) III. Late Proterozoic - Early Palaeozoic (700-400 Ma) IV. Late Palaeozoic - Late Mesozoic (300-100 Ma) and V. Cainozoic (65-20 Ma).

Lastly, I object to the use of the term 'Central Gneissic Complex' by the authors to denote the 'Central Crystallines' (Heim and Gansser, 1939). The term 'Central Crystallines' is deeply entrenched in literature on Himalayan geology and stood the test of time for more than half a century. Several reasons can be given to prove its usefulness over terms such as 'Central Gneissic Complex' but that is beyond the scope of the present communication. Such renaming of well - established stratigraphic nomenclature is not desirable and should be avoided (*see* Anon, 1977, p. 9).

Geochronology and Isotope Geology Division AMITABHA SARKAR
Geological Survey of India
15 A & B, Kyd Street
CALCUTTA - 700 016

References

ANNON (1977). Code of stratigraphic nomenclature of India. Misc. Publ. Geol. Surv. Ind., No. 20, 28p.

HEIM, A. and GANSSER, A. (1939). The Central Himalayas : geological observations of the Swiss expedition of 1936. Mem. Soc. Helv. Sci. Nat., 73, pp. 1-245.

LE FORT, P., DEBON, F., PECHER, A., SONET, J. and VIDAL, P. (1986). The 500 Ma magmatic event in Alpine southern Asia, a thermal episode at Gondwana scale. In 'Mem. Sci. Teri (Ed. Fond. Sci. de la Geol et de ses Appl), Nancy, v.47, pp.,191-209.

PANDEY, B.K., SINGH, V.P., BHANOT, V.B. and MEHTA, P.K. (1981). Rb-Sr geochronological studies of the gneissic rocks of the Ranikhet and Massi area of Almora crystallines, Lesser Himalaya, Kumaon, U.P. (Abs.) 12th Him. Geol. Seminar, 70p.

RAJU, B.N.V., CHHABRIA, T., PRASAD, R.N., MAHADEVAN, T.M. and BHALLA, N.S. (1992). Early Proterozoic Rb-Sr isochron age of Central Crystalline rocks of Bhilangana valley, Garhwal Himalaya. Him. Geol., v.12, pp. 196-205.

RAO, R.D., SHARMA, K.K., SIVARAMAN, T.V., GOPALAN, K. and TRIVEDI, J.R. (1990). Rb/Sr dating and petrochemistry of Hant granite (Baramulla area), Kashmir Himalaya. Jour. Him. Geol., v.1, pp.57-63.

Reply

We thank Drs. S.K. Acharyya and A. Sarkar for their valuable comments on our paper. As many of the points raised by them in their separate comments are more or less the same, a reply common to both is given below, pointwise.

1. *Use of the term 'Central Gneissic Complex (CGC)'*: This term, not synonymous with that of the 'Central Crystallines' of Heim and Gansser (1939), is used to cover both the dominant metamorphic rocks (mostly gneissic) and lesser sedimentary rocks in the study area. The term 'Central Crystallines' is usually restricted to rocks north of the Main Central Thrust (MCT), whereas the study area consists of rocks occurring both north and south of MCT and, hence, preference of the term 'CGC'. (*cf.* Peninsular, Banded and Chotanagpur Gneissic Complexes in other parts of India).

2. *Implication of 481 Ma of Hornblende Granite Gneiss*: This granite gneiss is spatially and temporally a part of the oldest Sela Group of the Precambrian rocks in

Arunachal Pradesh (Das *et al.*, 1975; Tripathi *et al.*, 1980). In the absence of supporting field and petromineralogical data, it cannot be considered as a younger (Palaeozoic) intrusion. Its date of 481±23 Ma cannot, therefore, be taken as its emplacement age, rather it denotes the time of resetting of Rb-Sr clock, possibly related to a major tectonometamorphic event that is correlatable only to MCT, in the absence of other major tectonic features nearby, as noted in the field. No doubt MCT has developed as a result of collision and persistent convergence of the Indian plate against the Asian plate during the Cainozoic Himalayan orogeny, but a possibility exists for such a major tectonic event to have longer duration with its initial forces being much older, say Palaeozoic. We feel that this needs further detailed study.

3. *1914 Ma of the Bomdila Gneiss*: In the statement that 'this middle Proterozoic age (1914±23 Ma) for the augen gneiss may represent either its emplacement date or the latest metamorphic imprint', the word 'latest' is used as a precaution since some Rb-Sr dates, compared to the Sm-Nd or Pb-Pb dates, on the same suite of granitic rocks are found to be younger in which case the Rb-Sr dates do not represent the emplacement age (*cf.* Closepet Granite - 2.2 Ga by Rb-Sr against 2.52 Ga by Sm-Nd). Relating 1914 Ma age of the augen gneiss to latest metamorphic imprint refers only to that high grade metamorphism that can reset the Rb-Sr clock but not to any metamorphic imprint. For example, many granitoids in the Himalaya like the Palaeozoic ones though were subjected to tectonometamorphic impact of the Cainozoic Himalayan orogeny, the latter was not manifested on whole-rock Rb-Sr isochron ages, as noted by Dr. Sarkar in his comment.

4. *Major temporal events from data in Table III*: Geochronological data, more or less coeval to the three dates on the granitoids of study area, are compiled from literature on others parts of Indian Himalaya only to show three major temporal events in the Indian Himalaya represented by the given dates. Incidentally, these three temporal events tally very closely with the first three given by Dr. Sarkar in the comment. This does *not* mean that there are no more major temporal events as we ourselves have mentioned that the tourmaline granite, which is widespread, is Tertiary. The figures in parenthesis of the three main events given in the paper refer to almost the midpoint of the range of ages. We regret for a few omissions of the contributions of earlier workers, while compiling data in Table III.

5. *Location of MCT*: For this, we have taken into account the following major field observations: occurrence of high-grade metamorphites at higher altitudes, overlying relatively low-grade metamorphites of lower altitudes; the base of MCT is essentially composed of migmatites (Misra and Bhattacharya, 1976). The given location of MCT is also in accordance with the observations of previous workers from Geological Survey of India, e.g. Das *et al* (1975) and Tripathi *et al.* (1980). The contention of Dr. Acharyya that MCT could be located east of Dirang is not borne by facts and also goes against the very understanding of the Himalayan thrust theory.

6. *Black Shales/Phyllites*: These have no Gondwana affinity as palaeontological evidence for such affinity is totally absent. Though the possibility of black shales occurring below the tectonic zone of Central Crystallines in a window structure is very much there, the same is ruled out by Bhusan *et al.* (1980). According to us, the northern limit of Gondwana rocks in the Kameng district is around the village Kuppi, which is south of the study area, and this is in conformity with the observations of Das *et al.* (1975) and Tripathi *et al.* (1980).

Atomic Minerals Division,
Department of Atomic Energy,
Nagarabhavi, Bangalore - 560 072

G.R. Dikshitulu

References

Bhusan, S.K., Bindal, C.M. and Aggarwal, R.K. (1990). Geology of the Bomdila Group in Arunachal Pradesh. Seminar on 'Himalayan Geology', Wadia Institute of Himalayan Geology, Dehra Dun, Abst. p. 28.