

## DISCUSSION

### (1)

**Comment on the paper "Geochemistry and Rb-Sr Chronology of Upper Jurassic A-Type Granite, Tangmarg region, Kashmir Himalaya" by D.Rameshwar Rao, Kewal K. Sharma and K.Gopalan published in Jour. Geol. Soc. India., v.46, pp.225-233.**

We would like to point out several inconsistent interpretations in the above paper and offer plausible explanations.

1. The Tangmarg granite occurrence is hardly 0.25 km x 0.50 km (approx.) in dimension and it is recorded along the road section (on way to Gulmarg). The occurrence is confined to a highly sheared zone of Agglomeratic Slate (Lr. Permian). Some other nearby granite bodies are: the Kangan granite (emplaced in Cambro-Silurian slates), the Kazinag granite (intruding late Precambrian to Eocambrian Dogra Slates) and the Hanti granite (confined to late Precambrian rocks). The Dudran body, possibly the closest similar granite, exposed near Buniyar along the Baramulla-Uri section also intrudes the Dogra Slates. In this context the Tangmarg granite occurrence appears to be a very small outcrop of an isolated age as reported by the authors.

2. In the section on petrography, K-feldspar and plagioclase (usually fresh) have been described to occur in a well developed mosaic of hypidiomorphic granular texture. Zoning does not appear to be present in the plagioclases. Since, from description it appears to be a typical subsolvus granite assemblage (even exsolutions in the plagioclases are of string and hair type indicating a limited ternary component) which is a characteristic of water-rich magmas (Tuttle and Bowen, 1958; Myron G. Best, 1986 at page 116). It is incorrect to interpret the Tangmarg granite magma as of low water content.

3. Several discrimination diagrams ( $10000 \cdot \text{Ga}/\text{Al}$  vs.  $\text{K}_2\text{O} + \text{Na}_2\text{O}$ ,  $(\text{K}_2\text{O} + \text{Na}_2\text{O})/\text{CaO}$ ,  $\text{K}_2\text{O}/\text{MgO}$ ,  $\text{FeO}/\text{MgO}$ , Nb, Zr, Y, Zn) have been used to designate these granites as typical 'A' (anorogenic) type. However, out of eight diagrams only Zr, Nb and to some extent Zn support this discrimination while in case of the rest five, nearly one third of the samples plot in the non-anorogenic field for which no explanation is offered.

4. Some other discrimination diagrams (Figures 6A and B) have been used to denote the Tangmarg granite as post-orogenic (at some other place same granite is considered anorogenic). At the same time, Rb/Sr chronology has been used for estimating the age as  $161 \pm 5 \text{ Ma}$ . Since these granites intruded into the Agglomeratic Slate and Pir Panjal Volcanics which record imprints of only much younger Himalayan orogeny it is difficult to envisage an orogeny which the Tangmarg granite post-date.

5. The presentation of the Rb-Sr isotopic data leaves a lot to be desired. The quality of the best fit line describing the isochron is not known in the absence of MSWD. The "good spread (Table III)" among the data points is primarily because of sample no. GG-24 and GG-34. The chemical composition of these (Table I), especially very high  $\text{SiO}_2$  even for an admittedly high silica suite, hardly conforms to the accepted values. The possibility

of petrogenetic heterogeneity amongst the selected samples needs, therefore, to be considered. This combined with the fact that there are hardly any evidence of acid magmatism in the Himalayas during the Jurassic time, makes the "unique" data to be more a case of a mixing line of two or more genetically dissimilar components.

6. Normative plots on ab-or-qtz face of the granodiorite tetrahedron have been used to interpret the crystallisation conditions of the Tangmarg granite. Though not mentioned in their paper, it can be assumed that the plagioclases are of low An-type. Besides, some amount of exsolution is also reported in K-feldspar. Since, the normative calculations do not take into account such solid solutions, it is quite clear that the normative 'ab' and 'or' values are unlikely to be close approximation of actual feldspar compositions. The interpreted crystallisation conditions, thus, needs to be further constrained.

7. The authors have interpreted from experimental studies of Ellis and Thompson (1986) and Naney (1983) in the system  $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$  that hornblende may decompose to produce a sodic, markedly water-saturated partial melt coexisting with plagioclase, quartz and pyroxene. It is a rather far fetched interpretation since the system quoted lacks alkalis. Further, the melt produced is markedly water saturated while in a paragraph earlier in the paper the granite has been considered to have low water content.

8. In the conclusion, the reactivation of faults has been ascribed as the reason for magma generation at 35 km depth. Such deep faults have possibly not been reported from the Himalayas. In light of the above it is more likely that all these bodies represent a major thermal event (Cambro-Ordovician) in this part of northwest Kashmir and probably manifest the widespread pan-African thermal episode (Valdiya, 1995 and the references therein). The magmatic activity was also associated with restricted volcanism towards upper Cambrian which also coincides with a major break in sedimentation (mid-Palaeozoic unconformity; Wadia, 1961). The structural position of the Tangmarg granite within the Agglomeratic Slates also appears to be somewhat anomalous. Regionally, the Panjal Volcanics - Agglomeratic Slates overlap the basement country rocks (the Dogra-Salkhala sequence) within which these satellite granites are mainly confined. The present position of the Tangmarg granite could be a consequence of post-solidification faulting.

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### Reply

We welcome the comments made by Pant *et al.* on our paper "Geochemistry and Rb-Sr Chronology of Upper Jurassic A-Type Granite, Tangmarg region, Kashmir

Himalaya". After going through the comments it appears that their thoughts are centered around to relate the Tangmarg granite to the widely observed 500 Ma event in Himalayas, ignoring the details of the data given by us. We, however, attempt to reply to comments made by them by giving some additional information.

1. Concerning this comment we would like to say that except the Dudran Body, we have studied most of the granite bodies like Hant (Rameshwar Rao *et al.* 1990), Kangan, Kazinag, Karzok and Polokangkala (Trivedi *et al.* 1986 and Sharma ; in press). The studies revealed that the Tangmarg Granite has distinct petrochemistry and field setting in comparison to the Lower Palaeozoic granites of Kashmir of Tso Morari.

2. It is true that increasing water pressure lower the solidus, but water is not a component in alkali feldspar and that the solvus is unaffected by the amount of water in the system, so the crystallization of the subsolvus granites does not reveal the water content of melts. Also, at H<sub>2</sub>O pressure as low as 2.3 kbars the two feldspars may exist together with quartz. The solvus surface climbs to higher temperature as small amount of anorthite is added. Consequently, the feldspar solvus is high enough to intersect the solidus at all values of PH<sub>2</sub>O in magmas having more than about 5 wt% of normative anorthite.

Most granite magmas are initially H<sub>2</sub>O undersaturated and during later stages the melts became H<sub>2</sub>O rich either by breakdown of crystalline hydrates or from supply of water from some external source. Our conclusion of high temperatures for melts and low water content is based on presence of minerals like biotite, amphiboles and rare pyroxenes in granites. The absence of muscovite, low normative corundum in these rocks and low melt content also support such a conclusion (cf. Clemens and Wall, 1981).

3. (i) Some elements in the A-type granite have overlapping compositions with orogenic granites (cf. Whalen *et al.* 1987); and (ii) good discrimination is shown by elements which show only moderate degrees of alteration like Zr, Nb, Y, Zn, Ce, *etc.*

Additional Rare elemental data (Zr, Ce, Y, Nb, Rb and Ba) generated on ICP-MS after publication of the paper also strongly point to the within-plate-A-type nature of the Tangmarg granites.

4. The post-orogenic granites are shown by Maniar and Piccoli (1989) to have overlapping composition with anorogenic to orogenic granites. As evident from Figs. 6a and b (in our published paper) the Tangmarg granite samples plot in post-orogenic field, within the anorogenic field. Further, Bonin (1990) who studied the alkaline granites found that they are both characterised by post-orogenic as well as anorogenic characters.

Our answer to the last part of the comment of envisaging an orogeny prior to Jurassic times does not arise as we are suggesting anorogenic origin for the Tangmarg granite.

5. The regressed isochron has an MSWD value of 2.92 and is a well spread linear isochron. As far as the rift-related acid magmatism, following the Panjal volcanism is concerned, we have data available from areas on either side of the Tangmarg body *i.e.* SE Zaskar (Spring *et al.* 1993) and from some regions of Pakistan. Such A-type granite bodies are usually small in size, as in the case of Tangmarg pluton.

6. The normative calculations are based on weight percentage of various oxides and they are very commonly used in deducing the crystallization temperatures. We, however, have not come across the quantitative effect of the perthite component on the norms and the norm based crystallization temperature.

7. The experimental studies of Ellis and Thompson (1986) and Nancy (1983) are only considered as a supporting evidence to suggest the high T of melt derived from partial melting of amphibole relative to biotite. As far as the last part of the comment is concerned we sincerely apologize for the typing mistake which was overlooked by us, it is infact "*water under saturated*" and not "*water saturated*" as published (refer to experimental studies of Clemens and Wall, 1981 and Clemens and Vielzeuf, 1987).

8. The reply to the comments 1 to 5 clearly indicate the unique nature of the Tangmarg granite. Just because the Cambro-Ordovician granites surround the Tangmarg body, Pant *et al.* (1996) claim that it should also be of Cambro-Ordovician age. This is not justified.

As far as deep seated faults in the region are concerned refer to the work of Kaila *et al.* (1984).

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## (2)

**Comment on the paper "The granitoids of Pindar-Sarju-Ramganga and Goriganga valleys of higher Kumaon Himalaya" by Manudip Kaur and L.S. Chamyal, published in Jour. Geol. Soc. India, 1996, v.47, No.6, pp.665-674.**

I would like to compliment the authors for providing geochemical details of granitoids from a difficult Himalayan terrane. It makes an interesting reading, however, there are certain conceptual inconsistencies that need to be clarified.

1. Peraluminous nature of granitoids ( $A/CNK > 1.1$ ) has been considered as the basis for calling these as 'S-type' granites, derived from a sedimentary source. It is not a conclusive evidence as the 'I' type granites can also be peraluminous. The peraluminous nature should be reflected in diagnostic peraluminous mineralogy i.e. presence of cordierite (White *et al.*, 1986).

2. Table I, which does not show modal muscovite is inconsistent with the authors' statement of "preponderance in muscovite over biotite". There is no room to accommodate muscovite in Table I. Is the muscovite reported by authors primary or secondary?

3. 'S-type' granites are characterized by a high  $K_2O/Na_2O$  ratio. The statement, " $K_2O$  is more than  $Na_2O$ " is not supported by their own chemical data (Table II) which shows that in 9 out of a total of 24 samples, it is *vice versa*.

4. The author's contention that high Rb (Table III) indicates a sedimentary source, is not consistent with low to moderate Nb abundances (below the average crustal abundance). In a few cases the Zr concentration is also below the average crustal values of 165 ppm (Taylor and McLennan, 1985; Mason and Moore, 1982). It is unusual to see Zr values as low as 1 ppm in granitic rocks, particularly when modal zircon is reported.

5. The author's contention of 'compatible nature of Sr and Rb' contests their own data. A covariance between K and Rb (Fig. 9), between CaO and Sr (Fig. 8) and an antipathic relationship between MgO and Rb (Fig. 7) indicates compatible nature of Sr and incompatible nature of Rb, a common feature of granitic system.

6. The REE data given in Table IV shows considerable variation in elemental abundances. Dissimilar REE patterns do not indicate 'similar' source. The authors have not substantiated the similarity of REE patterns with continental crustal rocks. The REE data (Table IV), in a few cases, shows elemental abundances below the average continental crustal values.

Besides these, there are certain factual errors which the authors could have avoided.

1. Table II shows  $SiO_2$  ranging from 63.97 to 77.73% whereas in the text it is mentioned as 63.97 to 75.05%.

2. In the  $Na_2O-SiO_2$  diagram (Fig. 4a) two sample plots show  $Na_2O$  values below the lowest value of 2.54%.

3. In the  $K_2O-SiO_2$  diagram (Fig. 4b) two samples (Nos. 5 and 20, Table II) have not been plotted or plotted incorrectly. Incidentally these two samples have the highest silica

and lowest  $K_2O$  among the data and should plot distinctly away from the 'trend' marking a covariance.

4. In the  $SiO_2$ -MgO diagram (Fig. 4g) there are 26 dots for 24 samples.

5. What is the unit of 'K' in the K-Rb diagram (Fig. 9). If it is reported in ppm, the 'K' should have been much higher than 200-500 range.

6. In figure 3 the fields are after Barker (1979) who modified those proposed by O'Connor (1965).

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### Reply

The authors thank Dr. Pandit for his comments and appreciate the interest that he has shown in our paper. The following are our views on the points raised:

1. The peraluminous nature of the granitoids ( $A/CNK > 1.1$ ) has not been the sole criteria for identifying these granitoids as 'S-type' granites, derived from a sedimentary source. Various other evidences in support of our above conclusion include; absence of basic intermediate plutonic rocks, a characteristic feature of many Himalayan peraluminous 'S-type' granites (Le Fort *et al.* 1987), presence of muscovite and biotite, absence of hornblende and presence of garnet, tourmaline, subrounded zircon and ilmenite. The high values of normative albite and orthoclase (Hussain *et al.* 1994) and normative corundum,  $A/CNK$  value ( $> 1.1$ ) and  $Al/(Na+K+Ca/2)$  ratio ( $> 1.1$ ) also confirm their 'S-type' characteristics. Further, the high concentration of K, Rb and Rb/Sr ratio, low Sr concentration and K/Rb ratios and  $< 675$  ppm of Ba concentration and depletion in Nb, Ti and Zr (in some cases) are strong enough to suggest that the granitoids are of metasedimentary source (Harris *et al.*, 1994). Thus, considering all these facts and the evidences given on pages 672 and 673 of our paper clearly show that the granitoids are strongly peraluminous, formed from crustal source and are 'S-type'. Clarke (1981) linked the

peraluminous granites genetically to metapelitic source rocks and Barbarin (1990) with the granitoids of crustal origin. In 'S-type' granites geochemical and isotopic characteristics are primarily inherited through partial melting of a crustal sedimentary (or metasedimentary) source (Chappel and White, 1974; White and Chappel, 1977, 1983; Clemens and Wall, 1981). The 'S-type' is commonly equated with muscovite-biotite ("two-mica") granite (Barker, 1981). The granitoids of Higher Kumaun Himalaya contain primary muscovite; the absence of cordierite in these rocks could be due to its replacement by phyllosilicates (White *et al.* 1986). The occurrence of this mineral in most peraluminous 'S-type' granites of Kumaun Himalaya have not been reported (Islam *et al.* 1991; Hussain *et al.* 1994; Rashid and Zainuddin, 1995). As these rocks are strongly peraluminous, their being 'I-type' is remote, because the 'I-type' are weakly peraluminous (White *et al.* 1986).

2. The muscovite is interlayered with biotite and hence confirms its primary nature (Sevigny *et al.* 1989). In Table I, modal muscovite is included with biotite which by oversight has escaped mention in the heading.

3. The granitoids of the Higher Kumaun Himalaya are formed due to metasomatic transformation of metasediments. This is supported by enrichment of potash and soda. The first stage of granitisation is marked by the development of plagioclase due to Na<sub>2</sub>O metasomatism in the metapelites. The Na<sub>2</sub>O metasomatic phase was followed by K<sub>2</sub>O and thus plagioclase grains were replaced by K-feldspars. The last and late Na<sub>2</sub>O metasomatism once again formed plagioclases and resulted in the formation of myrmekitic rim around the K-feldspar grains. So, in the lower grades there is an accession of soda; in higher grades the accession of alkalis continued with domination of potash. Our original statement was "K<sub>2</sub>O is found to be generally predominant over Na<sub>2</sub>O". As seen in the majority of the samples, K<sub>2</sub>O is more. Wherever Na<sub>2</sub>O is found more it could be due to the late Na<sub>2</sub>O metasomatism.

4. As pointed out earlier the low to moderate Nb abundances and low Zr concentrations along with high K and Rb are all indicative of metasedimentary source (Harris *et al.* 1994). As such, the syn-collisional granites have generally low Zr values (Pearce *et al.* 1984). In some cases the very low Zr concentrations perhaps correspond with the low solubility of zircon in peraluminous melts (Harrison and Watson, 1983; Watson and Harrison, 1983).

5. The sentence pointed out on page 670 of our paper be read as "Both Rb and Sr", hence confirm their incompatible and compatible natures respectively.

6. The deviation from average continental crustal concentration and variation in elemental abundances are attributable to mobility of the REE during metamorphism (Hanson, 1980). The REE mobility under metasomatic conditions could be one of the main reasons. Thus, only those showing similar REE patterns were considered and plotted in Fig.11. More data on REE patterns is necessary to verify the facts.

The errors 1 to 4 are due to oversight and regretted. The unit of 'K' is in ppm and the ordinate values are to be multiplied by 10<sup>2</sup>. Omission of this and Barker's reference in the caption of Fig.3 are also regretted.

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## ANNOUNCEMENT

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