Petrochemistry and petrogenesis of the Malani igneous suite, India: Discussion and reply

Discussion

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Pareek (1981) has provided a welcome contribution to the petrochemistry and petrogenesis of the Malani igneous suite, India. However, I have a few comments on certain aspects of his paper: Pareek mentioned that "These results form the first available set of chemical analyses for this province." On the contrary, Murthy and Venkataraman (1964) reported five chemical analyses of peralkaline Siwana granites from this province and discussed the petrogenesis of certain platform peralkaline and peraluminous granites of the world. I reported nine chemical analyses (Felsite, 7; ash bed, 1; muscovite biotite granite, 1) from the Tusham ring complex (Haryana) and arrived at the conclusion that the rapidly cooled calc-alkaline acid volcanic rocks do undergo post-emplacement modifications in their alkali content by devitrification and hydrothermal alteration (Kochhar, 1977). Interestingly, Pareek has also arrived at the same conclusions when he stated that "compared with the felsic lavas of other parts of the world, these are fairly comparable, but low in soda. The proportion of sodium could have been partially modified chemically during a post-eruptive cooling period."

My second comment pertains to the peraluminous character of these rocks as determined from the chemical analyses. My experience shows that the agpaiitic index ($Na_2O + K_2O/Al_2O_3$, molecular ratio) is not a very useful parameter of defining the alkalinity of the rocks, especially when there has been post-emplacement alkali modifications. Better results might be obtained by looking for soda amphibole and/or pyroxene in thin sections. Many rocks with an agpaiitic index of less than one have been reported to be characterized by the presence of aegirine, riebeckite, etc. Incidentally, Pareek has not mentioned if acmite or corundum occur in the norm of these rocks.

My last comment pertains to the supposed association of these rocks with the post-Delhi orogeny. My Table 1 shows that there has been no orogeny after the Delhi orogeny in the northern part of the Indian shield. These trans-Aravalli, non-orogenic peraluminous to peralkaline granites with the cogenetic carapace of acid volcanics of Malani suite are much younger than the Aravalli-Delhi geosynclinal deposits with which they are associated at Miniari (Rajasthan); Tusham (Haryana); and Kirana Hills (Pakistan) (Kochhar, 1974, 1976). No direct relationship to the Aravalli-Delhi orogenic cycles can be observed in the field.

The time gap between the Delhi orogeny and the emplacement of the Malani suite is 700 m.y., which is much more than the average span of an orogeny of 200 to 400 m.y. (Condie, 1976). The three periods of volcano-plutonic magmatism at Tusham, Kirana, and Malani are suggestive of episodicity of magmatism in the northwest part of the Indian shield. During this period, the nucleus for the development of Indogangetic rift was formed (Kochhar, 1973, 1982). It is interesting to mention here that Pareek reported the coexistence of acid-basic magmas, which is also indicative of rift environment.

I believe that the stresses released after the Aravalli-Delhi orogenic cycles gave rise to linear zones of crustal weakness and high heat flow, and along these northeast-southwest-trending weak zones, the magmatism of the Malani suite was triggered by mantle plume (Kochhar, 1973, 1981). This type of Precambrian (1.5 b.y. old) intracontinental hot-spot activity has been recently reported from the St. Francois terrane, mid-continent region, United States, and has been linked to continental doming and tensional tectonic environment (Kisvarsanyi, 1980).

TABLE 1. PRECAMBRIAN GEOCHRONOLOGY OF NORTH PENINSULAR INDIA

Jodhpur sandstone		Vindhyan System: 1400–500 m.y.
Malani Series:	Malani rhyolites and granites (Rajasthan)	745 ± 10 m.y.
	Kirana Hills (Pakistan)	870 ± 40 m.y.
	Tusham Hills (Haryana)	940 ± 20 m.y.
Delhi System		1650 m.y.
	unconformity	
	Raialo Series	
	unconformity	
Aravalli System		2000–2500 m.y.
	unconformity	
Bundelkhand granite and Berach granite		2500 m.y.
Banded gneiss complex		>2500 m.y.

Note: stratigraphy after Heron, 1953; isotopic ages from Crawford, 1970, Crawford and Compston, 1970, and Davies and Crawford, 1971.

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Reply

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Replies to the three comments made by N. Kochhar on my paper quoted (Pareek, 1981, Part I, p. 67–70) appear below, serially, giving relevant extracts from the text of the paper (Pareek, 1981, Part II, p. 206–273):

1. Chemical analyses of five samples of rocks from the "Malani System" were first recorded by Coulson (1933, Table VII, p. 117); the samples were composed as follows: one of quartz-feldspar-porphyry, one of dellenite, two of potash granite, and one of banded rhyolite, from Sirohi state, and variation in the percentages of their constituent oxides was graphically plotted (Coulson, 1933, Fig. 10, p. 138). These data were reproduced by Pascoe (1968, p. 534). Chemical composition and normative values of six samples of Siwana Granite from Jasai, Mungeria, Siwala, Bisala, and Taratra, district Barmer, were reported by Venkataraman and Sen Sharma (1964, Table 4, p. 66–67, Pl. 13). These form the only chemical data available previous to my paper.

In this paper, "Chemical analyses together with the CIPW norms of 26 tuffs (Table 2), 29 rhyolites of extrusive phase (Table 3), 3 granites of intrusive phase and 13 (not 3) rocks of the dike phase (Table 4) incorporate data on 42 (not 45) specimens from the northeastern part, 23 (not 20) from the northern part, 2 from the northwestern part, and 4 from the southern part of the Malani igneous province. Data from the southern part are still not complete, and data included here are 4 from the Sirohi district (Coulson, 1933) (Table 3) in Southern Rajasthan. These form the first *set* of chemical analyses that are now available" (Pareek, 1981, Part II, p. 227). This is self-explanatory. The omitted line "23 from northern, 2 from north-western" should succeed "42 (not 45) specimens from the north-eastern" in the 16th line on page seventy (Pareek, 1981, Part I).

2. "The presence of normative acmite as 5.54 and 8.32, respectively, in the rhyolite samples confirms their peralkaline character, due to deficiency of alumina, over alkalies" (Pareek, 1981, Part II, p. 251).

3. The geochronological data of the relevant igneous intrusives and extrusives of western Rajasthan appear sequentially in Table 1; this can be compared with Table 1 of Kochhar. Occurrence of repetitive intrusive and extrusive igneous activities, intermittently, in the Delhi orogeny and the post-Delhi orogeny can be inferred. All of these Precambrian volcanic rocks have also undergone post-eruptive chemical modification (Pareek, 1981, p. 253).

TABLE 1. SEQUENTIAL GEOCHRONOLOGICAL DATA OF IGNEOUS INTRUSIVES AND EXTRUSIVES OF WESTERN RAJASTHAN, INDIA

Geochronological age (m.y.)	Rock formation	Source of data
428	Jalor Granite	Crawford and Compston, 1970, p. 365
600 < 70	Jalor Granite	Sharma and others, 1975, p. 207, Table 3
735	Close of Delhi orogeny	Holmes, 1955, p. 96
745 < 10	Malani Rhyolite	Crawford and Compston, 1970, p. 364
428–794	Malani Rhyolite, Tuff, and Granite	Crawford and Compston, 1970, Table 6, p. 365
850	Sendra Granite	D. K. Paul (personal commun.)
870 < 40	Kirana Hills Volcanic Rocks	Davies and Crawford, 1971, p. 244
940 < 20	Tosham Hill Volcanic Rocks	Kochhar, 1974, p. 317
935	Erinpura type–granite, Ajmer	Crawford, 1970, p. 99, Table II
900 < 50	Muscovite from "Erinpura" pegmatite near Ajmer	Vinogradov and others, 1966, *in* Crawford, 1970, p. 107
1,100 < 50	Zircon age for Siwana Granite	Vinogradov and others, 1966, *in* Crawford, 1970, p. 107

.e lithostratigraphic classification in Table I (Pareek, 1981, p. 215) does not show Berach Granite (Table I of N. Kochhar), as it does not appear in the area under description. The granite is dated at 2,585 m.y. (Crawford, 1970, p. 102, Table IV). The Raialo Group of rocks exposed at Raialo in the northeastern part of Rajasthan "separated from the Delhi System and elevated into a 'Series,' intermediate in position between the Delhi System and the Aravalli System" (Heron, 1953, p. 13), have been placed as the basal part of the Delhi Supergroup, in the recent mapping work of the Geological Survey of India (Banerjee, 1975). An equivalent of this group is, however, not found in southern Rajasthan.

The Malani igneous suite does not have a direct contact with the Delhi Supergroup, and the Malani Granite cuts through the Erinpura Granite and is also intrusive into the Delhi Supergroup. The lava flows exhibit high dips, and the "association of felsic rocks with folded sedimentaries in northeastern Rajasthan is suggestive of the Malanis having undergone tectonism in the Aravalli region" (Pareek, 1981, Part II, p. 223).

he peraluminous rocks dominate over peralkaline rocks; the emplacement of peralkaline rocks could be related to epeirogenic doming and rifting. Peralkaline magmatism can occur during all of the three known stages of rifting: pre-rifting, initial rifting, and continued rifting. The peralkaline granites are restricted to the pre-rifting stage and are displayed as subvolcanic ring structures. Emplacement of the granite body in the Dutson-Wai ring complex has been noted beyond the outcrop limits in different directions; the emplacement is by near-surface lateral spreading of an intrusive diapir; horizontally directed tensile stresses are created in the overburden, leading to the formation of ring fractures above the spreading intrusive (Ajakaiye and Sweeney, 1974).

"Tectonic structures in the form of rifts or grabens took shape in north-northeastern trends, forming the locales for development of a fissure system, along which the Malani lava originated." "The Precambrian extrusion would thus have been governed by the tensional stresses developed during the post-Delhi orogeny" (Pareek, 1981, Part II, p. 261). The Malani emplacement represents by itself the post-Delhi orogeny.

The Malani igneous activity is recorded only to the west of the Aravalli range (see Pareek, 1981, Part II, Fig. 1, p. 208), and is unknown in the east. The "Delhi-Aravalli lineament" is of arcuate shape and is associated with ultramafics for the entire length of this chain; these are possibly related to the concept of plate tectonics (Banerjee, 1975, p. 18). In that context, the emplacement of the massive granite bodies along this chain is related to the melting of the sialic crust in the zone of subduction, the Malani rocks occurring west of this folded terrain (Banerjee, 1975, p. 18–19). Mixing up of crustal material with the upwelling of magma of mafic composition, which in itself was a derivative from the mantle, and rise in the mantle could only be ascribed to stresses generated due to an uplift of the Aravalli block on the east and the "Champaner" on the south, according to S. K. Ramaswamy (1981, personal commun.), who considers these events to be confined to the cratonic shield and the Malani-Marwar crust, which subsequently acted as the platform on which younger geosynclines developed westward.

Whether these could be possible explanations of the origin and emplacement of the Malani effusives and intrusives needs to be evaluated and examined further, with emergence of the present data and accumulation of further data, in the background of evolution of the crust and related tectonism of this part of the Indian sub-continent.

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