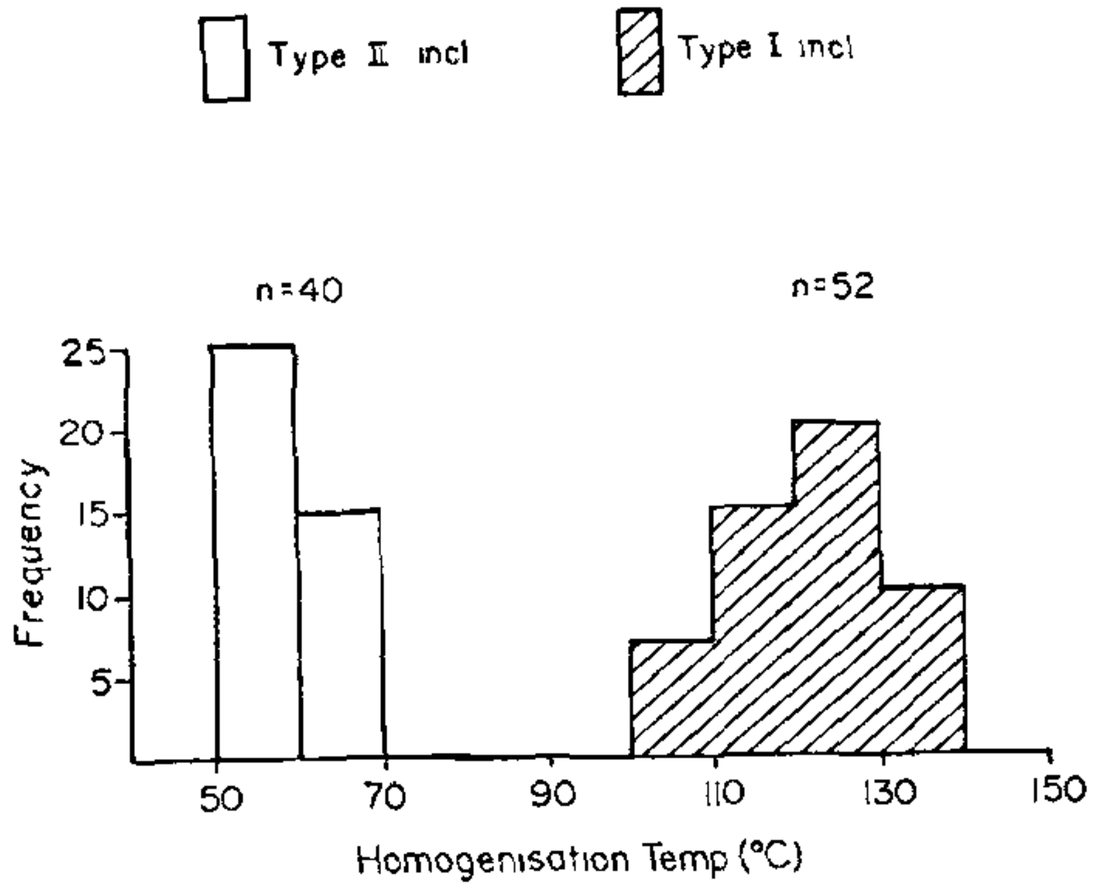

Figure 3. *Histogram showing trend of homogenization in Type I and Type II inclusions.*

cated by their mode of occurrence in the healed fractures and low homogenization temperature range (Figure 3).

The compositional and thermal data of fluid inclusions when compared with those from other genetic types of barite deposits[10] suggest that the present mineralization broadly corresponds to epithermal and stratabound type deposits. The results of this study are consistent with the inclusion data from limestone-hosted epithermal Pb–Zn deposit where barite is associated[11]. The mineralizing fluid, characterized by low temperature ($125 \pm 15^{\circ}$ C), low salinity and moderate density is also in support of its epithermal nature. A combination of field and petrographic evidences also suggest the epigenetic nature of this mineralization. The wall rock alteration substantiates a low temperature for the hydrothermal fluid. As mineralization is restricted to the Nagthat quartzite horizon, the source of mineralizing fluid appears to be local. This study emphasizes the role of low-temperature epithermal fluids in ore deposition, and classifies the Doon Valley barite mineralization as stratabound epithermal type.

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An assessment of the rare metal potential of the granitoids of Siwana, Jalor, Jhunjhunu and Tosham, North Western Peninsular India

Ramanathan Baskar*† and Rajni Sharma

*Wadia Institute of Himalayan Geology, 33 General Mahadeo Singh Road, Dehra Dun 248 001, India
Centre of Advanced Study in Geology, Panjab University, Chandigarh 160 014, India

The rare metal contents of the plutons of Siwana, Jalor, Jhunjhunu and Tosham have been assessed. The peraluminous Tosham and Jhunjhunu granites are of high mineral potential, the peralkaline Siwana granites are also of high mineral potential whereas the metaluminous to peraluminous Jalor granites are of low mineral potential. According to the extant petrological, mineralogical and geochemical criteria, the Siwana granites are classified as rare metal granitoid of 'agpaitic' type, the Tosham and Jhunjhunu granites as 'plumasitic' type and the Jalor granites as 'calcic' type.

METALLOGENETICALLY specialized felsic plutonic rocks are those having a spatial and genetic association with ore deposits of rare elements such as Be, Cs, F, Li, Mo, Nb, Rb, Ta and W. They are distinguished from ordinary felsic plutonic rocks by a number of gelogic, petrographic and chemical pecularities, the most obvious being the commonly enhanced contents of Be, F, Li, Mo, Nb, Pb, Rb, rare-earth elements (*REE*), Sn, Ta, Th, U, W, Y, Zn, and / or Zr[1]. It may be emphasized here that these criteria cannot be used individually to characterize

†For correspondence

specialized rocks because many have quite ordinary concentrations of some elements. Four chemically specialized plutons have been recognized, of these three are granitic (the agpaitic, plumasitic and calcic types) and one is syenitoid (the miaskitic type)[2].

The high level granites of Siwana, Jalor, Jhunjhunu and Tosham were emplaced around 750 Ma at the end of Aravalli thermal event[3] and represent a significant period of anorogenic magmatism in the geological history of the Indian craton. The investigations of Narayan Das *et al*[4] revealed that the microgranites of the Siwana area contain high Y fixed in the mineral xenotime and all the alkalic rocks contain high Zr, Ba, and Sr. Bhushan and Mohanty[5] also reported abnormally rich concentrations of Sn, Be, Nb, Zr, Y, La and Ce in the Siwana granites. Recently, Kochhar[6] on the basis of surface abundances of U, Th and K and selected trace elements, identified the granites of the Malani igneous suite as high heat producing (HHP). An important implication of the identification of these granites as high heat producing is their bearing on the ore potential of these rocks, since they act as 'heat engines' and prolong the circulation of the ore-bearing fluids. Such fluids can be responsible for the deposition of Nb, Sn, W and Zn as is the case in the Nigerian younger granites[7] and Nb, Zr, REE, U and Th mineralization as is the case in the Saudi Arabian granites[8]. Except for Tosham[9,10], no mineral deposits have been located in these plutons, though the high level nature of these plutons might have provided more favourable conditions for the accumulation of rare metals. Therefore, this report aims to assess the rare metal potential of these plutons and classify them as

Table 1. A comparison of average rare metal contents of the granitoids of the Malani Igneous Suite with that of Arabian Shield

Peralkaline granites			Peraluminous granites			High-calcic peraluminous granites	
Agpaitic specialized			Plumasitic specialized			Calcic specialized	
Siwana*	Siwana**	Arabian Shield***	Tosham*	Jhunjhunu**	Arabian Shield***	Jalor*	Arabian Shield***
Major oxides (wt%)							
SiO_2	69 42	71 03	74 18	72.17	75.34	75 41	65.48	71.29
Al_2O_3	10.98	8.59	11.10	13 57	12.34	12.82	14 42	14.29
FeOt	7.34	8.34	4.07	4.58	2.04	1.36	4.69	2.37
MgO	0.23	0.04	0 08	0.38	0.31	0.09	1.12	0.50
CaO	0.61	0.47	0.50	0.67	0.99	0.62	2.62	1.65
Na_2O	4 89	3.51	4.23	2 62	2.21	4.19	3.97	4 04
K_2O	4.46	4.69	4.61	5.04	5.53	4.51	4 20	4.29
TiO_2	0 36	0.37	0.32	0.13	0.34	0.10	0.50	0 50
MnO	0.11	0.29	0.09	0.01	0.05	0.04	0.05	0.05
P_2O_5	0.08	0 05	0.04	0.10	0.02	0 02	0.30	0.11
Trace elements (ppm)								
Ba	113	ND	99	1090	185	79	800	700
Ce	624	314	182	339	144	95	111	112
Co	1	ND	4	4	2	3	10	4
Cu	66	42	13	9	1	5	82	9
La	267	134	71	179	64	41	51	46
Nb	157	223	62	23	18	56	16	26
Nd	332	181	91	126	48	36	50	40
Ni	10	16	13	5	8	6	6	12
Pb	76	40	14	40	ND	32	32	31
Rb	341	156	169	343	497	386	168	135
Sc	1	ND	3	9	4	4	14	4
Sr	23	8	20	143	25	38	134	248
Ta	15	ND	1	9	4	9	1	1
Th	36	39	14	82	95	31	20	15
U	10	ND	4	10	19	8	4	2
V	8	18	10	25	11	9	34	22
Y	548	563	91	74	48	62	69	35
Zn	442	365	137	51	41	83	138	48
Zr	3474	1572	795	296	187	211	552	245

*Data from Eby and Kochhar[19].
**Unpublished data from Baskar[20] (Siwana area) and Rajni Sharma[21] (Jhunjhunu area).
***Data from Arabian Shield (Ramsay)[2].

having: (i) high mineral potential, where further investigations are required (ii) moderate to low potential and (iii) low potential.

The peralkaline, A-type Siwana granites mineralogically consist of perthite, quartz, alkali amphiboles and sodic pyroxenes. Chemically, they have low contents of CaO, MgO, Al_2O_3 and high contents of FeOt, absolute alkali abundances. Regarding trace elements they have high REE (except Eu), Zr, Nb, Ta, Y, Zn and low concentrations of Co, Sc, Cr, Ni, Ba, Sr and Pb (Table 1) and are classified as agpaitic specialized granites[2]. Agpaitic specialized granites are associated with substantial polymetallic Nb-Zr-REE deposits as exemplified in the Hijaz region[11, 12]. The Siwana granites are classified as having high rare metal potential, where further investigations are required.

The Tosham and Jhunjhunu granites are peraluminous and of A-type. Mineralogically, the Tosham granites consist of quartz, potash feldspar, plagioclase, biotite and accessory zircon, apatite, iron oxides and chlorite. The leucocratic alkali feldspar Jhunjhunu granites consist of perthite, alkali feldspar, biotite, ilmenite, titanite and secondary tourmaline. The geochemical signatures of the Tosham and Jhunjhunu granites, relative to other specialized granite types are: high SiO_2, Rb, Sn, Th, U, Rb/Sr; low FeOt, MgO, CaO, TiO_2, P_2O_5, Ce, Cu, La, Ni, Zr and K/Rb (Table 1). These granites are classified as plumasitic specialized granites[2]. It may be important to point out here that the major-oxide composition of plumasitic specialized granites is subtly different from that of the agpaitic type. Both types have very low MgO, CaO and sub-equal Na_2O and K_2O contents, but plumasitic rocks commonly have higher SiO_2 and substantially lower FeOt. Plumasitic specialized rock are associated with the most important examples of Sn–W–Ta–Nb mineralization in the Arabian shield. Accessory cassiterite occurs in a number of plutons in the southeastern shield[13, 14]. The Tosham[9, 10] and Jhunjhunu[15] granites have high mineral potential.

The metaluminous to peraluminous A-type Jalor granites are less conspicuous because of their ordinary geochemistry. Mineralogically they consist of perthite, alkali feldspar, plagioclase, hornblende and biotite. A comparative study between Siwana and Jalor granites by Bhushan[16] reveals that Siwana granites have higher $K_2O + Na_2O$, TiO_2 and FeOt and is impoverished in SiO_2 and Al_2O_3 than Jalor granites. Jalor granites have an average CaO content higher than 1.65%. They contain more MgO and less SiO_2 than other specialized granite types but have sub-equal amounts of Na_2O and K_2O. Their main geochemical features, compared to other specialized granite types are high Al_2O_3, CaO, MgO, P_2O_5, Ba, Sr, V; and low Nb, Rb, Sn, U, Y, Zn, Rb/Sr (Table 1). They are classified as calcic specialized granites[2]. Calcic granites differ from plumasitic rocks in their substantially higher CaO contents. Calcic specialized granites are associated with mineralization of Mo-Bi-W type, such as the vein systems at Jabal Thaaban[17], Wadi Sidarah[18].

In conclusion, the Siwana, Tosham and Jhunjunu areas are good targets for detailed mineral explorations whereas the Jalor granites have the lowest mineral potential.

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