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Petrology of the Doda Granites, Jammu Lesser Himalaya, India

B.L. Dhar, A.K. Raina, B.K. Fotedar and R. Singh
Post Graduate Department of Geology, University of Jammu
Jammu-180 004, India

ABSTRACT

Granitic rocks in the Doda district of Jammu and Kashmir State, NW Himalaya are exposed at eight places. They are named as Dramman, Piparan, Kaplas, Khol Dedni, Chinta, Bhala, Kal Nala, and Nagin Dhar Granites. They occur in the form of irregular bodies of varying dimensions. These granites are mostly leucocratic, two-mica, porphyritic to aplitic, massive and highly jointed with crude foliation in some cases. The contact with the Older Metamorphics is sharp and thermal aureole is absent. These granites are monzo- to syeno-granitic in composition with peraluminous, S-type (equivalent to ilmenite series) and calc-alkaline affinity. These intrusive bodies are emplaced within the Older Metamorphics under tectonic influences at later stages of metamorphism. They have formed from highly evolved anatectic granites derived by partial melting of lower crustal material with diapiric situations. These processes had been operative at a temperature of 600-700°C at a depth of 20-30 km under 5 Kb Pressure. The emplacement of these granites is suggested to be due to transient dilation where the diapir is enhanced by sheeting mechanism.

INTRODUCTION

The eight irregular granite bodies of varying dimensions are exposed in the Doda district, Jammu and Kashmir Lesser Himalaya (Fig. 1). The westernmost body in the Ramban Tehsil is batholithic Dramman Granite. Previously, this has been named as the Sarkanth Granite by Geological Survey of India. This is followed by a huge body of the Piparan Granite in the Doda Tehsil (named after Piparan peak). The Dramman and Piparan Granites have strike continuation and mix up of their designations has been warranted by their large scale extension and delineation by geomorphologic characters with both forming separate orographic features (Jamwal, 1992 and Ghiasvand, 1994). The Piparan Granite has also been called Doda Granite by Guha (1985), and Guha and Gupta (1988). Another bigger granite body in the Bhaderwah Tehsil is known as the Kaplas Granite massif named after the famous Kaplas lake (Sharma, 1981). North of the Kaplas Granite, there are smaller closely occurring granite bodies called the Khol Dedni Granites after Khol peak (3390m) and Dedni village (2350m) in the Bhaderwah Tehsil (Chajgotra, 1994). The Chinta Granite is located towards east of the Kaplas Granite (Khajuria, 1989) and to its northwest lies the Bhala Granite. This has also been called the Doda Granite at village Pranu by Kwatra et al. (1987). East of the Bhala Granite is the Kal Nalla Granite in the Thatri Tehsil known after Kal Nalla that flows through this granite (Sharma, 1993). Northwest of the Kal Nalla Granite, there are the Nagin Dhar granitic bodies (Singh, 1995).

The present study aims to corroborate the petrographic and petrochemical inferences of the granites in the Doda area to draw a conclusion regarding evolution and mode of emplacement of these granite bodies.

GEOLOGICAL SETUP OF THE AREA

The kyanite-garnetiferous schists and gneisses are the oldest rocks in the study area. These schists are fine to medium grained, grey to dirty brown in colour and have well developed schistosity with an inclination of 25°-65° generally in NNE-SSW strike direction. The schists consist of mainly quartz, muscovite, biotite, garnet, andalusite, kyanite, and feldspars with zircon, sphene, rutile, apatite, epidote, and iron ores as accessory minerals. The general rock sequence is presented in Table 1.

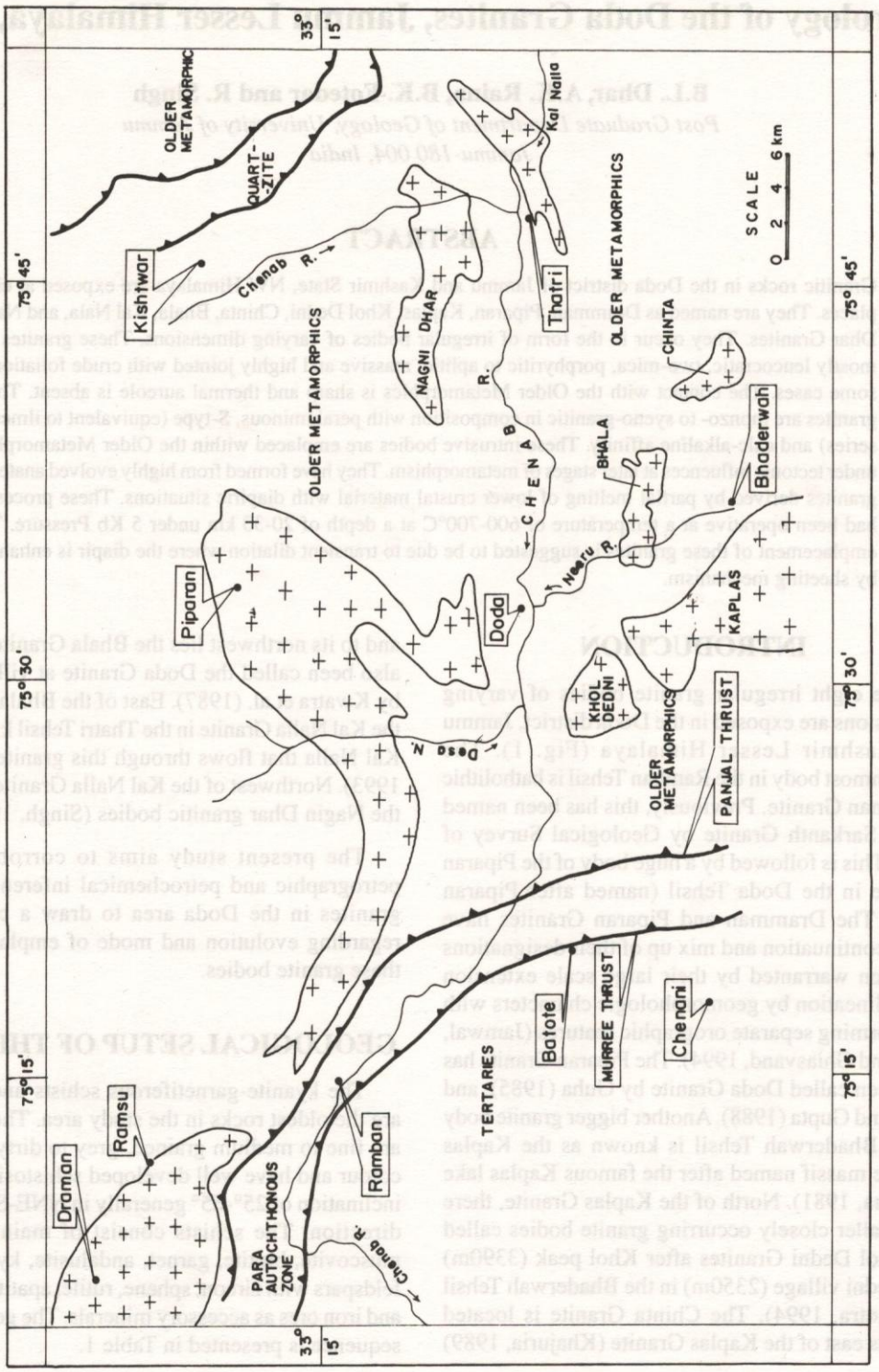

Fig. 1: Simplified geological map showing location of various Doda Granite bodies.

Table 1: Generalized lithostratigraphic sequence of the Doda area.

Age	Formation	Lithology
Recent	Terrace deposits	Boulder, sand, silt and clay
Cambrian (?)	Granite	Leuco- to sub-leucocratic, medium to coarse grained, two mica, two feldspar granite
		Unconformity
Precambrian	Ramsu	Slates/phyllites, diamictites, dolomites, quartzites, limestones, cherts, etc.
		Unconformity
	Dumgali Quartzite	Grey, greenish, buff, flaggy and massive quartzites, phyllites, schists
		Unconformity
	Older Metamorphics	High grade kyanite, garnetiferous schists, amphibolites, gneisses

FIELD CHARACTERS AND PETROGRAPHY OF THE GRANITES

Major field characters of the Doda Granites are summarized in Table 2. The rocks are leuco- to sub-leucocratic. A majority of them are coarse to fine grained in texture and massive in structure. The contact with the country rocks is sharp in every case, but the thermal effects are totally absent.

Table 2: Field characters of the Doda Granites, Jammu Lesser Himalaya. Legend: 1 - Dramman, 2 - Piparan, 3 - Kaplas, 4 - Khol Dedni, 5 - Chinta, 6 - Bhala, 7 - Kal Nalla, 8 - Nagin Dhar.

Property	1	2	3	4	5	6	7	8
Colour	@	#	#	@	@	@	@	#
Grain size	*	*	$	$	$	$	$	*
Foliation	Absent	Feeble	Absent	Feeble	Absent	Absent	Feeble	Feeble
Contact with country rocks	Sharp	Sharp	Sharp	Sharp	Sharp	Sharp	Sharp	Sharp
Contact thermal effects	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Index: @ = Light to dark # = Light * = Coarse $ = Fine to coarse

The granites consist of perthitic feldspars and plagioclase in addition to undulose quartz. Biotite and muscovite are invariably present in all, whereas garnet is not found in number 3, 5, 6 and 7 (Table 3). Major structural features exhibited by individual minerals include the common undulatory extinction of quartz showing sutured contacts; mostly unaltered K-feldspar predominates the plagioclase which are zoned in many cases. Exsolution perthite and intergrowth textures are also noticed.

On the basis of analytical data binary and ternary diagrams of varied nature have been used (Fig. 2 and 3) and an attempt has been made to classify these rocks and find out the evolutionary trends of different elements during the formation of these granites. Genesis of these granitic bodies is also studied using various parameters. These granites have a peraluminous affinity, classify as monzo- to syeno-granites, show calc-alkaline chemistry and follow S-type source characters (Fig. 2 to 6) equivalent to ilmenite series (Ishihara, 1977). They are emplaced within the Older Metamorphics under the tectonic influences at later stages of magmatism during Ordovician to Cambrian. These are highly evolved anatectic granites, derived from the partial melting of crustal material (Fig. 4).

Recently similar anatectic crustal remelting granite in a continental collision environment have been described by Hussain et al., (1994) in the Uttar Pradesh Lesser Himalaya (Champawat Granite suite). The comparative study of different granite bodies data of the Doda district (Table 2 to 6) clearly indicate a close relation between them. The field

Table 3: Mineralogical characteristics of the Doda Granites in Jammu Himalaya. 1 - Dramman, 2 - Piparan, 3 - Kaplas, 4 - Khol Dedni, 5 - Chinta, 6 - Bhala, 7 - Kal Nalla, 8 - Nagin Dhar Granites.

Minerals	1	2	3	4	5	6	7	8
K-feldspar	Perthite	Perthite	Perthite	Perthite	Perthite	Perthite	Perthite	Perthite
Plagioclase (An)	12-20	13-28	13-15	12-28	15-25	15-25	28-24	12-27
Biotite	Present	Present	Present	Present	Present	Present	Present	Present
Muscovite	Present	Present	Present	Present	Present	Present	Present	Present
Garnet	Present	Present	Absent	Present	Absent	Absent	Absent	Present

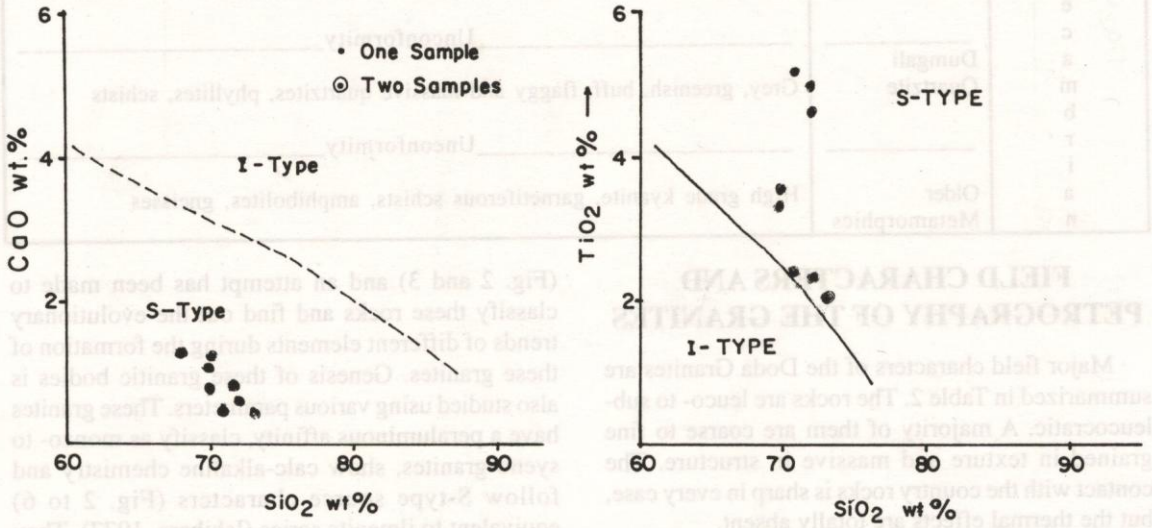

Fig. 2: SiO_2 vs. CaO and TiO_2 variation diagram for various Doda Granite bodies.

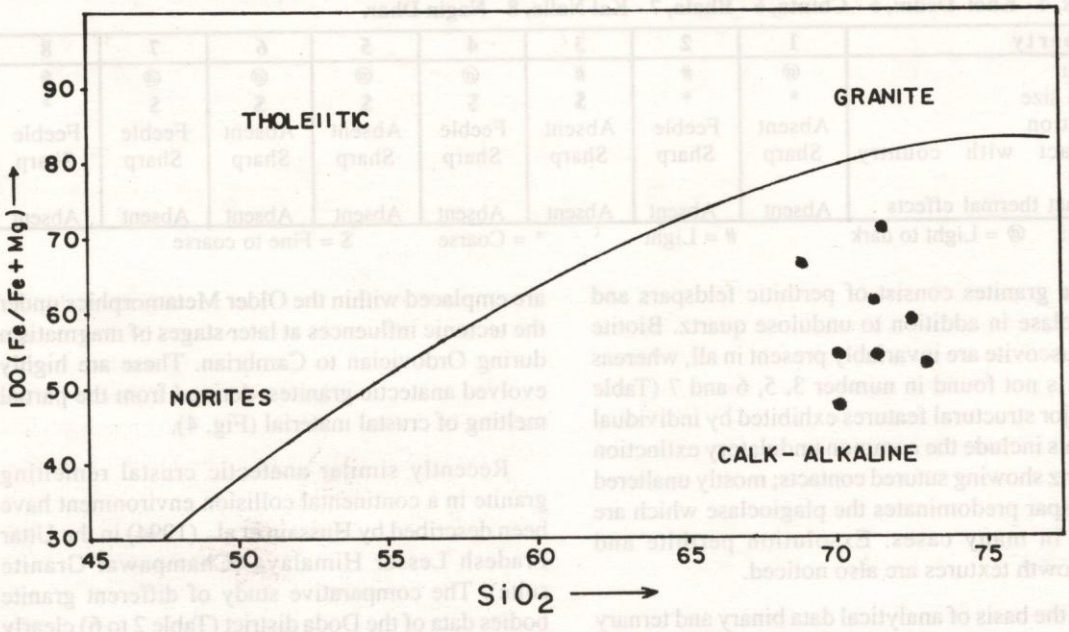

Fig. 3: SiO_2 vs. 100 (Fe/Fe+Mg) variation diagram for various Doda Granite bodies.

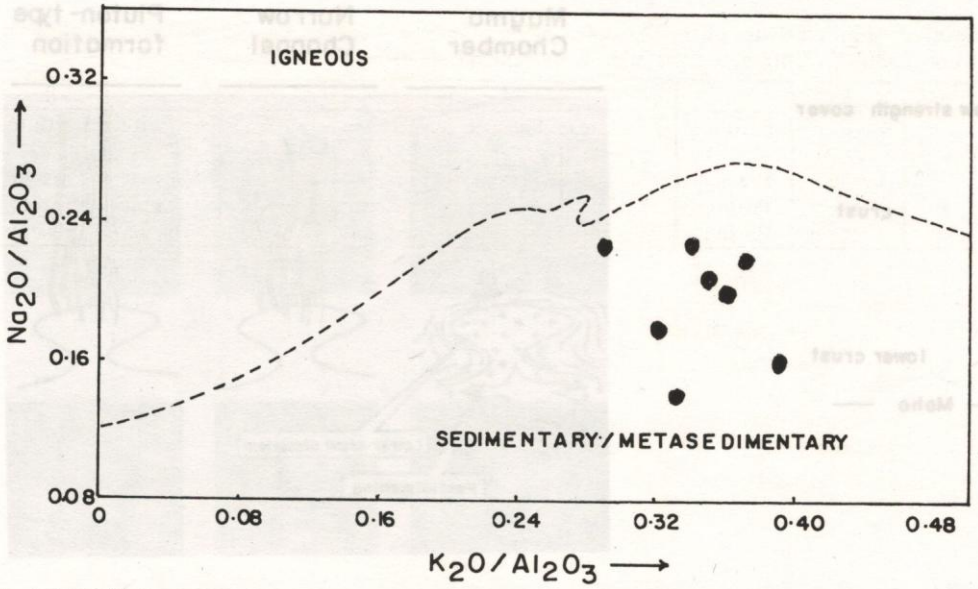

Fig. 4: K_2O/Al_2O_3 vs. Na_2O/Al_2O_3 variation diagram for various Doda Granite bodies.

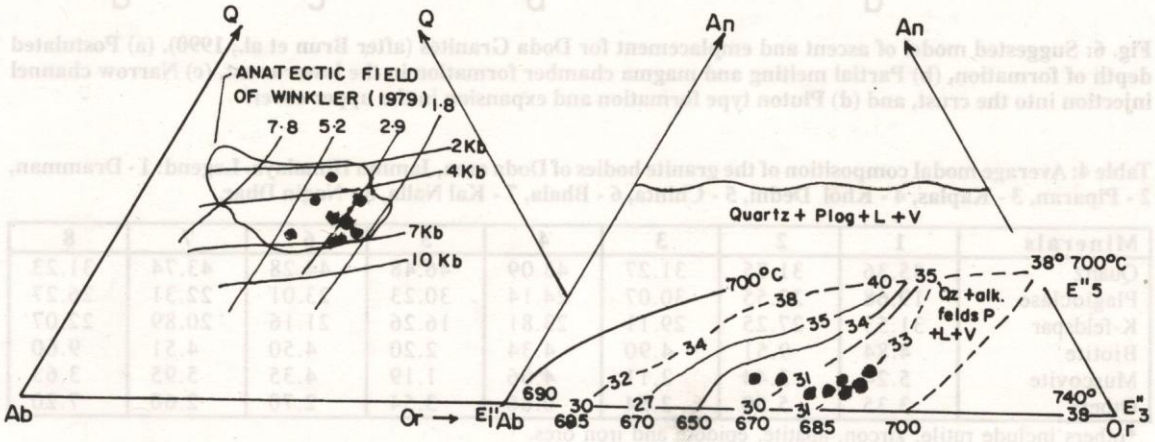

Fig. 5: Q-Ab-Or and An-Ab-Or diagrams for various Doda Granite bodies.

relations and similar petrographic, petrochemical and petrogenetic characteristics distinctly point out to the common genesis of these rocks which might have been initiated by the tectonic process during the orogenic episodes. These, in particular, indicate a common source of the magma that must have derived material from a sedimentary crustal material.

EMPLACEMENT MODEL

Le Fort (1975, 1989) has suggested that the Eurasian plate has been thrust over the Indian plate (represented by the Lesser Himalaya) giving a double thickness to the continental crust. The lower slab (Lesser Himalaya) was heated up by the base of the upper slab as indicated by regional metamorphism that reaches up to kyanite-grade. The upper slab has undergone extensive melting and contains several types of granites. Blattner et al. (1983) have proposed that the melting could have been supported by the fluids released by dehydration in the lower slabs. Voshage et al. (1990) have indicated that majority of granitic magmas are generated by the underplating of lower crust during continental collision. A

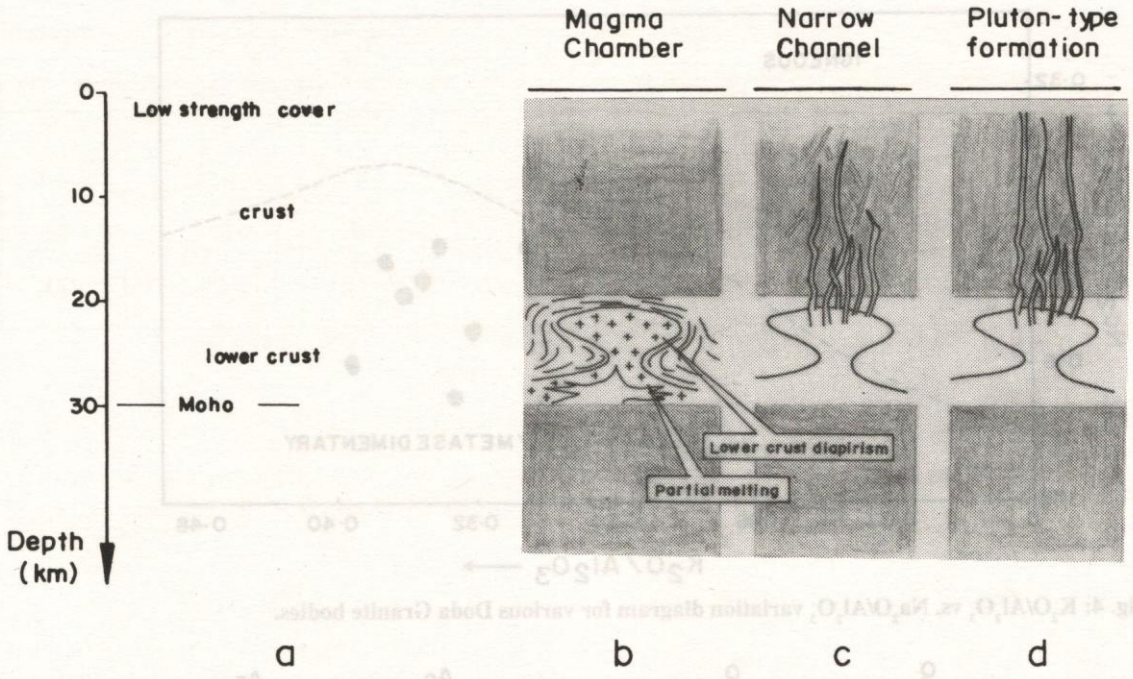

Fig. 6: Suggested model of ascent and emplacement for Doda Granites (after Brun et al., 1990). (a) Postulated depth of formation, (b) Partial melting and magma chamber formation in the lower crust, (c) Narrow channel injection into the crust, and (d) Pluton type formation and expansion in the upper cover.

Table 4: Average modal composition of the granite bodies of Doda area, Jammu Himalaya. Legend: 1 - Dramman, 2 - Piparan, 3 - Kaplas, 4 - Khol Dedni, 5 - Chinta, 6 - Bhala, 7 - Kal Nalla, 8 - Nagin Dhar.

Minerals	1	2	3	4	5	6	7	8
Quartz	35.36	31.75	31.27	43.09	46.48	44.28	43.74	31.23
Plagioclase	19.68	22.55	30.07	24.14	30.23	23.01	22.31	26.27
K-feldspar	31.53	27.25	29.11	23.81	16.26	21.16	20.89	22.07
Biotite	4.84	9.51	4.90	4.34	2.20	4.50	4.51	9.60
Muscovite	5.24	3.44	2.11	4.06	1.19	4.35	5.95	3.63
Others	3.35	5.50	2.54	0.66	3.54	2.70	2.60	7.20

*others include rutile, zircon, apatite, epidote and iron ores.

Table 5: Average chemical composition of the granite bodies of Doda area. Legend: 1 - Dramman, 2 - Piparan, 3 - Kaplas, 4 - Khol Dedni, 5 - Chinta, 6 - Bhala, 7 - Kal Nalla, 8 - Nagin Dhar.

Oxide	1	2	3	4	5	6	7	8
SiO_2	71.50	70.55	70.01	71.13	71.63	69.92	71.07	70.25
TiO_2	0.30	0.35	0.30	0.28	0.35	0.69	0.24	0.33
Al_2O_3	14.27	15.11	14.67	14.87	14.41	16.42	15.03	14.71
Fe_2O_3	0.94	0.93	0.86	0.86	0.82	1.10	1.31	0.95
FeO	1.48	1.34	1.27	2.80	1.43	1.35	2.05	1.20
MnO	0.13	0.08	0.04	0.08	0.12	0.12	0.06	0.04
MgO	0.68	0.81	0.78	0.56	0.88	0.58	1.60	0.75
CaO	0.74	1.17	1.00	0.80	1.50	1.63	1.90	0.85
Na_2O	3.05	3.65	4.38	2.40	3.93	3.36	2.49	2.90
K_2O	4.83	4.98	4.29	3.18	4.67	4.44	4.84	5.17

Table 6: Chemical parameters of the Doda Granites, Jammu Lesser Himalaya. 1 - Dramman, 2 - Piparan, 3 - Kaplas, 4 - Khol Dedni, 5 - Chinta, 6 - Bhala, 7 - Kal Nalla, 8 - Nagin Dhar.

Parameter	1	2	3	4	5	6	7	8
Affinity	PA	PA	ND	PA	ND	PA	PA	PA
Alkalinity	CA	CA	A	CA	ND	A	CA	CA
Compositio	MS	Monzo	ND	Monzo	ND	ND	MS	Monzo
n	S	S	ND	S	ND	ND	S	S
Type	Anatectic	Anatectic	Anatectic	Anatectic	ND	ND	Anatectic	Anatectic
Origin	Cambrian	Cambrian	PC	Cambrian	ND	ND	Cambrian	Cambrian
Age	ND	ND	ND	ND	ND	496±21	499±57 Ma.	ND
Isotopic age						Ma		

Index: PA - Peraluminous CA - Calc-alkaline MS - Monzo to syeno
PC - Post Carboniferous ND - Not determined

generalized sketch of the formation of the Doda Granites in the geodynamic model is envisaged to be similar to one suggested by Bonin (1990).

The physical conditions in the upper crust that have resulted in the formation of granite magma by partial melting can be assumed from the study of regional metamorphism as the mineral association and sequences are an indicator of the geothermal gradient in such cases (Hall, 1987). Hyndamn (1985) is of the opinion that regional metamorphism associated with major batholiths and other granitoids show highest metamorphic grades close to the granitic bodies and lower grade further away even when an aureole is absent. Besides, while metamorphic rocks are strongly foliated the granite may be massive or nearly so (Hyndman, 1985) as in the area of the study also.

The model of ascent of emplacement of the Doda Granites (Fig. 6) is offered as has been suggested by Brun et al. (1990) for Flamanville Granite. The anatectic melt is proposed to have risen through the crust along narrow channels. McCaffrey (1992) has suggested that the formation of granitic bodies in high tectonically active areas undergoing contractional deformation as a result of creation of transient dilation in which a diapir could be emplaced by a sheeting mechanism. His sheeting mechanism can be employed to explain the present surface disposition of the Doda Granites.

In such cases where the contact between country rocks and the granite is sharp and the thermal effects not noticeable the granite intrusion is always diapiric. In fact diapirism is a favoured hypothesis to explain the rise of granitic magma through the crust (Grout, 1945; Fyfe, 1971; Pitcher, 1979; Marsh, 1982; Castro, 1978; Brun et al., 1990). The formation of diapir as suggested in Fig. 6, model can be easily initiated by a thermal gradient of about 15° to 20° C per km that corresponds to the temperature of about 625° to 725°C at depths of average 25 km (Wilson, 1989).

Orogenic and inorogenic processes for the formation of granite have been widely proposed and the possibility of more than one mechanism responsible for the continental crust granites is subject to new insights on the basis of petrological evidences. As such, understanding the evolution of granite, more so, in tectonically sensitive zones, like the Doda granites remains a challenge as ever.

CONCLUSIONS

Petrographic and petrochemical investigation of various granite bodies in the Doda area reveals their cogenetic nature. They are S-type of granite belonging to the ilmenite series with calc-alkaline affinity. The muscovite/biotite ratio (>1), presence of two feldspars, predominant perthite and garnet favour the sedimentary nature of the percursor rock belonging to the crustal regime. They have been formed from highly evolved anatectic melts which in tectonically active zone rose through narrow channels. Further to their emplacement, the rocks as a result of transient dilation were manifested in the form of diapiric bodies.

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