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GEOCHEMISTRY OF DADELDHURA GRANITE AND ITS MINERAL POTENTIAL*

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ABSTRACT

Dadeldhura granite is a cordierite bearing two mica granite. It is S-type, leucocratic and rich in silica, alumina and potash and slightly low in soda. In this granite a remarkable evolutionary trend is marked by the general increase in SiO_2, Al_2O_3, K_{20}, Na_{20}, P_2O_5, Rb, Nb and depletion of CaO, MgO, Fe_2O_3, TiO_2, Ba, Sr, Zr, Zn and V etc. towards later phase. Mineral chemistry of biotite and feldspar and plot of chemical data on variation diagrams and triangular diagrams show a moderate to fairly strong differentiation trend from (i) granite gneiss (GGN), (ii) biotite granite (BGR) to (iii) muscovite granite (MGR) and (iv) aplitic tourmaline granite (TGR). Many physical, mineralogical and chemical characteristics of Dadeldhura granite resemble with world's average tin granite.

INTRODUCTION

A number of scattered disconnected granite bodies of variable sizes are located within a 1600 km long Lesser Himalayan belt extended from Pakistan to Nepal. Dadeldhura granite is one of the two mica cordierite bearing Lesser Himalayan granites which occurs in Dadeldhura area, Far- Western Nepal (Fig 1). It is an eastwest elongated lenticular body and extends from Seti River in the east to beyond Mahakali river in the west (Fig 2) and covers about 1400 km^2 area. It is emplaced slightly south of the axis of NW-SE trending Dadeldhura syncline of Almora Nappe. Field studies, chemistry and petrographic studies carried out by

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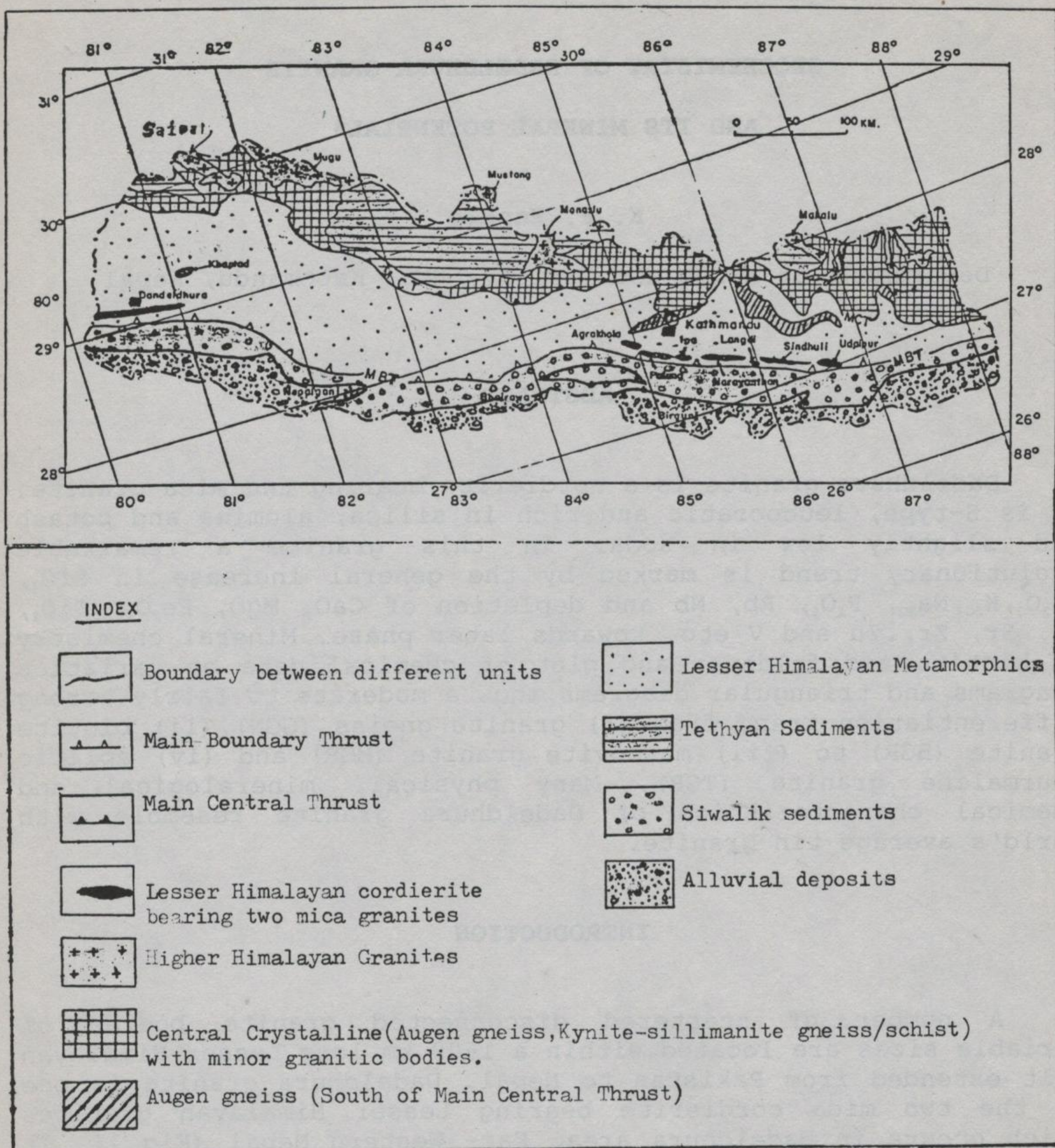


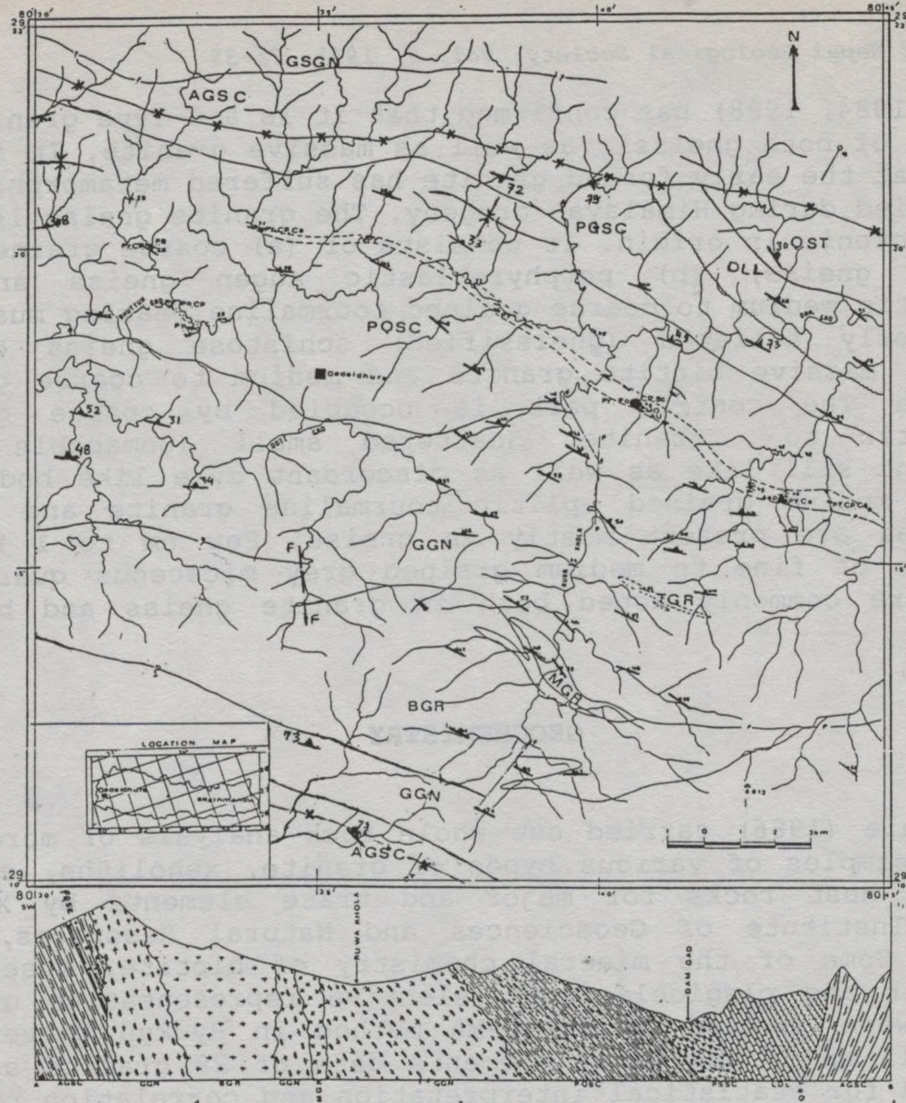
Fig. 1 Granitic Rocks Distribution in Nepal Himalayas

Kaphle (1984, 1988) has confirmed that it is a S-Type granite and consists of both gneissic as well as massive granite. It is also noted that the early formed granite has suffered metamorphism and gneissified during Himalayan orogeny. The granite gneiss is a pre or syntectonic in origin. It consists of (a) coarse grained well foliated gneiss, (b) porphyroblastic augen gneiss and (c) leucocratic medium to coarse grained tourmaline bearing muscovite rich poorly foliated (gneissified) schistose gneiss towards margin. massive biotite granite and medium to coarse grained muscovite The central part is occupied by coarse grained porphyritic to granite. Scattered small (unmapable size) concordant sill like as well as discordant dyke like bodies of fine to medium grained aplitic tourmaline granite and simple pegmatites are present mostly in gneiss. Few cm to 1 m size xenoliths of fine to medium grained grey micaceous quartzitic schist are commonly noted both in granite gneiss and biotite granite.

GEOCHEMISTRY

Kaphle (1986) carried out whole rock analysis of more than 45 rock samples of various types of granite, xenoliths, country rock and host rocks for major and trace elements by XRF in Federal Institute of Geosciences and Natural Resources, West Germany. Some of the mineral chemistry of biotite, muscovite, K-feldspar and plagioclase of selective representative granite samples were carried out by EPMA method in Ryukyu University, Japan. All major and trace elements data of 29 granite samples were used for statistical interpretation and correlation between different types of Dadeldhura granite.

The overall geochemical correlation coefficient between major oxides (Table 1) in various granite types of Dadeldhura massif showed that SiO_2 has significant positive correlation with Na_2O, K_2O, Al_2O_3, P_2O_5 and Rb (Fig. 3a, 3b, 3c, 3d and 3i) negative correlation with CaO, FeO, MgO, TiO_2, Sr (Fig. 3e, 3f, 3g, 3h and 3j). Various types of Dadeldhura granite show a narrow range of distribution pattern of major and trace elements (Table 1 & 3). The major and trace element composition of granite changes gradually from granite gneiss to biotite granite, muscovite granite, and tourmaline granite. This ultimately proves that these 4 different types of granite are the result of magmatic differentiation of the same parental magma at depth.



INDEX

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- Contact (normal)
- Contact (inferred)
- Contact (thrusted)
- Unconformity
- Syncline
- Cp. chalcopyrite
- Py. Pyrite
- Cs. Cassiterite
- Scheelite
- Po. Pyrrhotite
- Asp. Arsenopyrite
- Au. gold
- Mo. Molybdenum

Group	Formation (lithology)
Dadeldhura Granite Massif	Tourmaline Granite (TGR) Muscovite Granite (MGR) Biotite Granite (BGR) Granite Gneiss (GGN)
Damgad Metasedimentary Group	Quartzite and Sandstone (QST) Dolomites and Limestone (DLL)
Dadeldhura Crystalline Group	Phyllite, quartzite, slates, carbonaceous phyllite, chloritic mica schist and sericitic quartzite (PQSC).
	Phyllite, quartzite, very few fine grained garnet bearing chloritic mica schist and quartzite (PGSC).
	Garnetiferous mica schist, quartzite and sheared augen gneiss rarely with minor granite bodies (AGSC).
	Felspathic mica schist, gneiss, quartzite and few garnet bearing chloritic mica schist and amphibolites/minor basic rock bodies (GSGN).

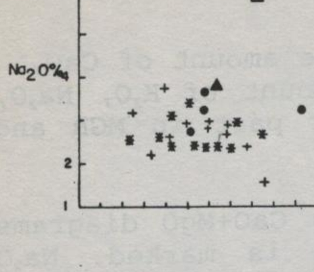
Fig. 2 Simplified Geological Map of Dadeldhura Area, Far - Western Nepal.

Because of progressive crystallization, the amount of CaO, MgO, TiO_2 decreases and correspondingly the amount of K_2O, Na_2O, Al_{203} and SiO_2 increases significantly in later part in MGR and TGR.

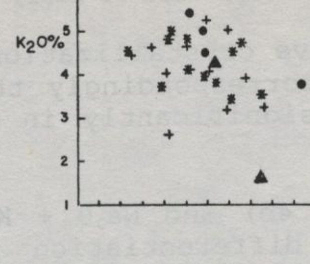
In Na_2O vs K_{20} (Fig. 4b) and Na_2O + K_2O vs CaO+MgO diagrams (Fig. 4a) a clear cut differentiation trend is marked. Na_2O increases with increase of K_2O. In all phases K_2O is always higher than the Na_2O. This is one of the characteristic of tin granite. In tourmaline granite specially in pneumatolitic stage the amount of soda and potash increases and volatiles like B,F, etc. become rich resulting in high amount of tourmaline. No free scheelite, wolframite or cassiterite are recorded except in some heavy concentrates and mineralized specimens. The felsic index also gradually increases in later phase with the increase of Na_2O, K_2O, Al_2O_3, SiO_2 and Al_2O_3 + SiO_2 (Fig. 5a, 5b, 5c, 5d, and 5e).

Table : 1. Chemical composition (Major oxides) of various phases of Dadeldhura granite.

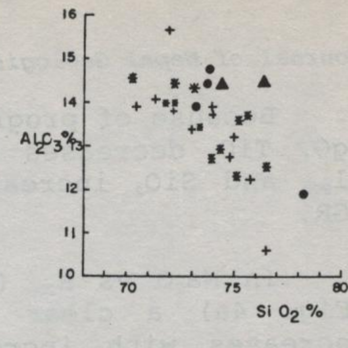
Rock type	Values (%)	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO3	LOI
GGN	Maximum	76.43	0.55	15.67	3.87	0.07	1.35	2.04	3.71	5.25	0.28	0.20	1.26
	Minimum	70.40	0.07	10.61	1.55	0.02	0.00	0.44	1.53	3.19	0.11	0.00	0.68
	Average of 11 samples	73.49	0.32	13.39	2.77	0.04	0.51	1.06	2.71	4.19	0.17	0.02	0.90
BGR	Maximum	76.42	0.50	14.67	3.55	0.06	0.81	1.33	3.42	5.01	0.23	0.19	0.76
	Minimum	70.26	0.07	12.37	1.19	0.02	0.08	0.52	2.38	3.45	0.15	0.00	1.20
	Average of 12 samples	73.58	0.31	13.57	2.46	0.04	0.48	0.90	2.70	4.24	0.19	0.04	0.94
MGR	Maximum	73.28	0.25	14.81	1.91	0.03	0.39	0.72	3.66	5.42	0.27	0.05	1.20
	Minimum	73.13	0.05	11.90	0.87	0.02	0.00	0.31	2.76	3.76	0.18	0.00	0.75
	Average of 4 samples	74.73	0.12	13.76	1.31	0.03	0.09	0.47	3.22	4.66	0.22	0.01	0.92
TGR	Maximum	76.37	0.11	14.51	0.97	0.03	0.17	0.53	5.84	4.35	0.29	0.00	0.51
	Minimum	74.31	0.06	14.39	0.66	0.01	0.13	0.43	3.80	0.57	0.21	0.03	0.68
	Average of 2 samples	75.34	0.08	14.45	0.82	0.02	0.15	0.48	4.82	2.48	0.25	0.02	0.59
Whole average		73.83	0.27	13.59	2.30	0.04	0.41	0.87	2.92	4.16	0.19	0.027	0.9



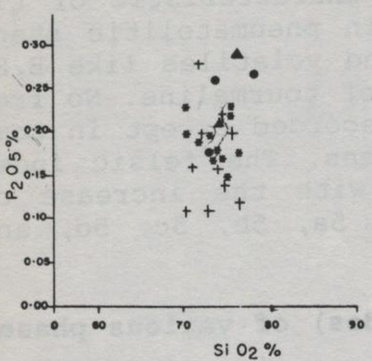
(3a) Na_2O vs SiO_2



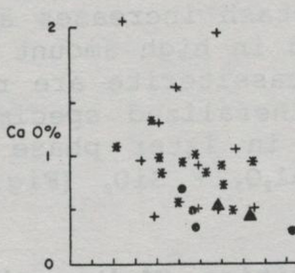
(3b) K_2O vs SiO_2



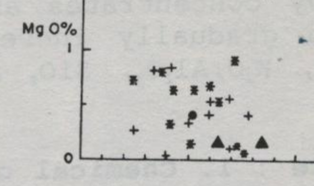
(3c) Al_2O_3 vs SiO_2



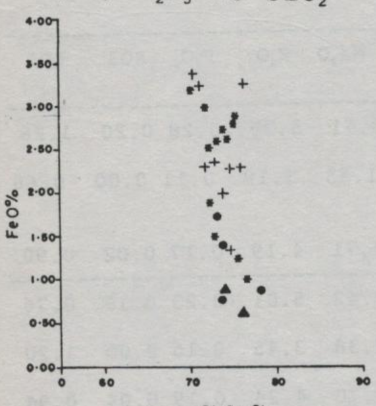
(3d) P_2O_5 vs SiO_2



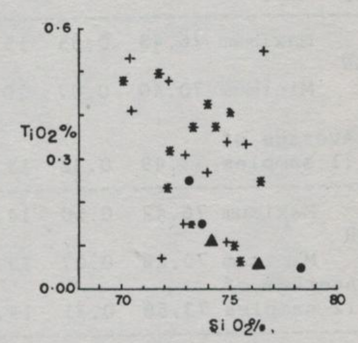
(3e) CaO vs SiO_2



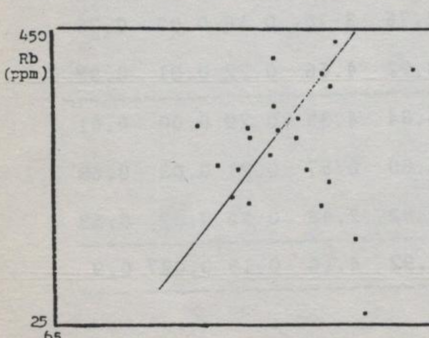
(3f) MgO vs SiO_2



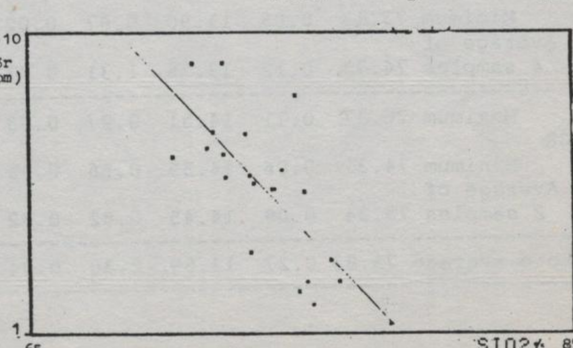
(3g) FeO vs SiO_2



(3h) TiO_2 vs SiO_2



(3i) Rb vs SiO_2



(3j) Sr vs SiO_2

Fig. 3 Variation Diagrams

Table 2. Trace Elements of Dadeldhura granite.

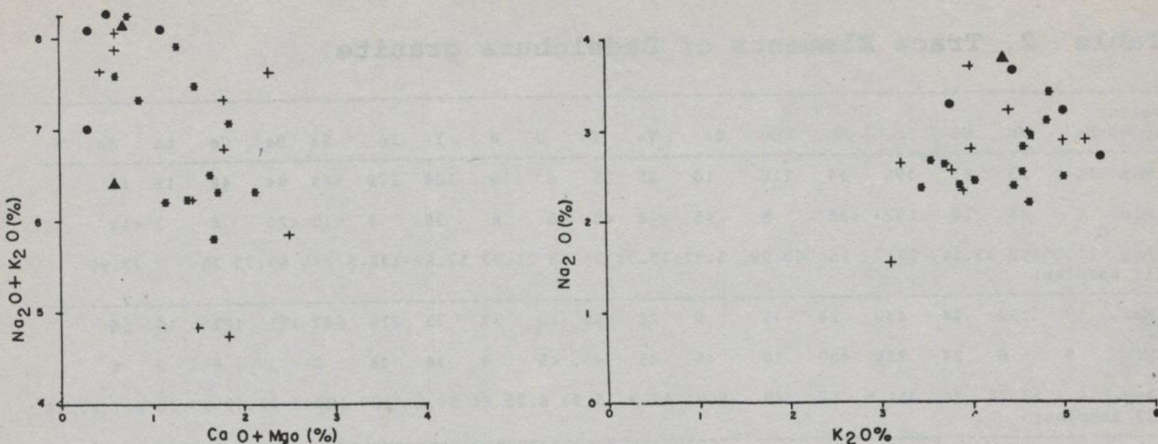
Value (ppm)	Na	Nb	Ni	Pb	Rb	Sn	Sr	Ta	Th	U	W	Y	Zn	Zr	Ba	Ce	La	Sc	V
Max.	16	23	42	396	34	110	10	25	35	6	36	108	272	669	84	48	12	63	
Min.	6	<5	19	192	<20	8	<5	8	<3	<5	6	38	9	<15	<20	8	3	<15	
Avg. (11 samples)	11.7	102	33.18	271	15	60.09	5.72	15.73	7	5	21.73	57.63	142.5	271	53.73	25	7	27.90	
Max.	19	30	44	430	24	75	9	24	12	12	37	73	219	227	111	121	10	56	
Min.	9	6	24	228	<20	10	<5	<5	<3	<5	8	34	48	0	3	6	2	8	
Avg. (12 samples)	14.1	13.75	34	311.5	17	49	5.91	16.3	5.33	6.25	24	54.6	137	129.2	52.42	57.33	5.7	25.08	
Max.	27	8	40	602	21	59	8	19	5	19	24	62	121	343	39	57	7	45	
Min.	10	<5	18	338	<20	<3	<5	<5	<3	<5	<3	28	<5	0	0	5	3	1	
Avg. (4 samples)	16.25	6	31.75	420	15	22.25	6.9	8.36	3.5	8.5	11.75	46	59.12	113.7	-	-	4.25	10.00	
Max.	10	5	29	245	41	61	8	7	4	10	14	49	38	140	20	74	8	18	
Min.	5	5	<5	34	<20	19	<5	<5	<3	<5	8	33	21	6	4	17	7	8	
Avg. (2 samples)	7.5	5	17	139.5	30.5	40	6.5	6	3.5	7.5	11	41	29.5	70	12	45.5	7.5	13	
Whole Avg. (29 samples)	13.03	10.31	32.1	299.41	14.89	48.83	5.97	14.03	5.59	6.24	22.14	53.62	120.93	169.5	41.31	40.12	6.07	24.12	

Table 3. Average Chemical Compositions of various granites of the world

Major elements %	World Avg. Tin granite	Daily Avg. granite	Kinta Valley Malaysia	Alaska	Cornwall S.Austell	Boheman Mass Cze choslovak	Potgietrsr S.Africa	Dadeldhura Granite Nepal	Palung Granite Nepal	Manserah Granite Pakistan
SiO_2	73.44	69.92	74.02	74.10	71.30	73.67	76.40	73.83	74.51	71.07
TiO_2	0.22	0.39	0.25	0.11	0.34	0.12	0.08	0.27	0.16	0.58
Al_2O_3	13.61	14.78	12.93	13.70	14.80	13.36	12.00	13.59	13.49	14.39
Fe_2O_3	0.92	1.62	0.35	0.31	0.25	0.59	1.53	2.30	1.44	1.99
MnO	0.06	0.13	0.04	0.04	0.06	0.05	-	0.04	0.05	0.06
MgO	0.47	0.97	0.32	0.42	0.48	0.26	0.18	0.41	0.31	0.79
CaO	1.30	2.15	0.87	0.77	1.05	0.75	1.07	0.87	0.43	1.49
FeO	1.38	1.67	1.87	1.01	1.82	1.24	1.15	2.07	1.30	1.74
Na_2O	3.13	3.28	3.32	3.80	3.20	3.17	3.00	2.92	4.68	2.48
K_2O	4.76	4.07	5.00	4.70	5.15	4.19	4.96	4.16	3.24	4.07
P_2O_5	0.12	0.24	0.06	0.02	0.06	0.21	0.01	0.19	0.25	0.19
H_2O	-	-	-	-	-	-	-	-	0.71	0.77
Average of	42 tin granites (Kholminsky & Groves, 1970)	All period granites	6 samples tin granites	6 samples tin granites	6 samples ...	4 sample tin granites	5 samples ...	29samples Kaphle 1984	27samples le. Forte 1983	5samples Rahaman Shams1983

Geochemistry of Major Elements

The chemical characters of various types of Dadeldhura granite are also correlated with one another (Table 1 & 2). In



4a) $Na_2O + K_2O$ vs $CaO + MgO$ (4b) Na_2O vs K_2O

Fig. 4 Variation Diagrams

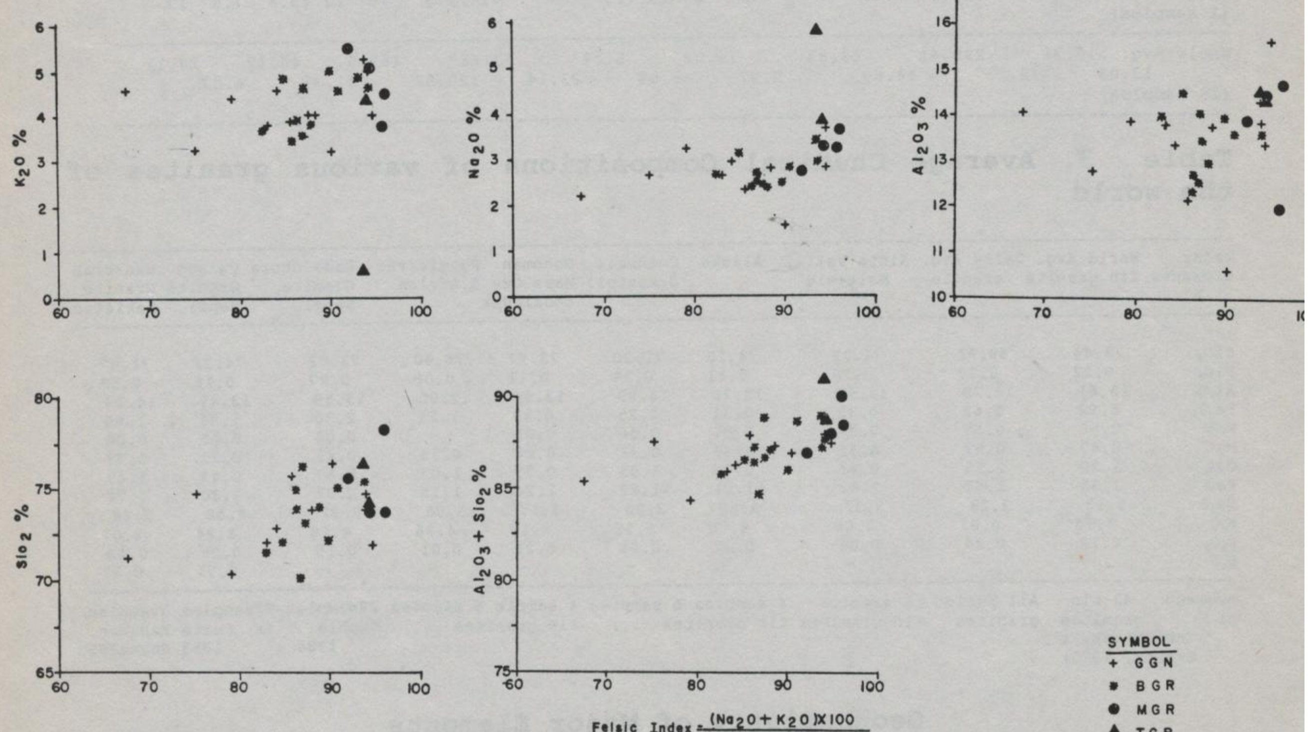


Fig. 5 Felsic Variation Linear Diagrams.
Felsic Index vs Major Oxides in different types of Dadeldhura massif

case of granite gneiss the average SiO_2 content is 73.48% which gradually increases to 73.58% in BGR, 74.73% in MGR and 75.34% in TGR. This indicates that during differentiation the amount of SiO_2 increases, although the range is narrow. Similarly the average amount of Al_2O_3 in GGN, BGR, MGR and TGR are 13.39%, 13.57%, 13.76% and 14.45% respectively. This shows a slow increasing trend of Al_2O_3 towards late granite. The average amount of Na_2O in GGN is 2.71% which remains almost constant (2.70%) in BGR but increases to 3.22% in MGR and 4.82% in TGR. In case of K_2O the range is very narrow. It increases gradually from 4.19% in GGN, 4.21% in BGR, to 4.66% in MGR and irregular in TGR.

The average amount of Fe_2O_3 in GGN, BGR, MGR and TGR are 2.54, 2.46, 1.31 and 0.82% respectively. The decreasing tendency towards the late crystallized granite is due to predominance of light coloured minerals over the dark colour minerals. Similarly the average TiO_2 content is comparatively high 0.32% in GGN and gradually decreases to 0.31, 0.12 and 0.08% in BGR, MGR and TGR respectively. MgO is fairly high in xenolith (2.82%) and in the country rock (6.02%) but less significant in the granite as a whole. However, because of the presence of few chlorite and biotite it is comparatively high in GGN 0.51% and BGR 0.48% and very low in MGR 0.10% and in TGR 0.15%. Average CaO content in GGN, BGR, MGR and TGR are 1.06%, 0.90%, 0.47% and 0.48% respectively. Although TiO_2, MnO and P_2O_5 form the minor constituents of granite, there is a tendency of decreasing in the contents of TiO_2 and MnO from granite gneiss to tourmaline granite, whereas, P_2O_5 shows increasing trend in the same.

Trace Elements

Trace elements like Rb, Ba, Sr, Zr, Zn show a wide range of distribution pattern. A clear cut differentiation trend is marked by the increase of the average amount of Rb and correspondingly decrease in Sr, Ba, Zr, and Zn from early crystallized GGN, BGR to MGR - TGR. This is also supported by the result obtained from a triangular plot of Rb - Ba - Sr (Fig. 6). Increase in the ratio between Rb/K takes place during differentiation (Table-2). Rb can coexist in close association with K that is why during differentiation Rb increases along with K (Fig. 7). The average Rb content in GGN, BGR, and MGR are 271, 312 and 420 ppm respectively. Similarly Sr is often a close associate of Ca. Therefore its average amount is comparatively higher in GGN (60ppm) and BGR (49 ppm) than in MGR (22 ppm) and TGR (40 ppm). In general it increases only if Ca bearing minerals like sphene, apatite and epidote exist.

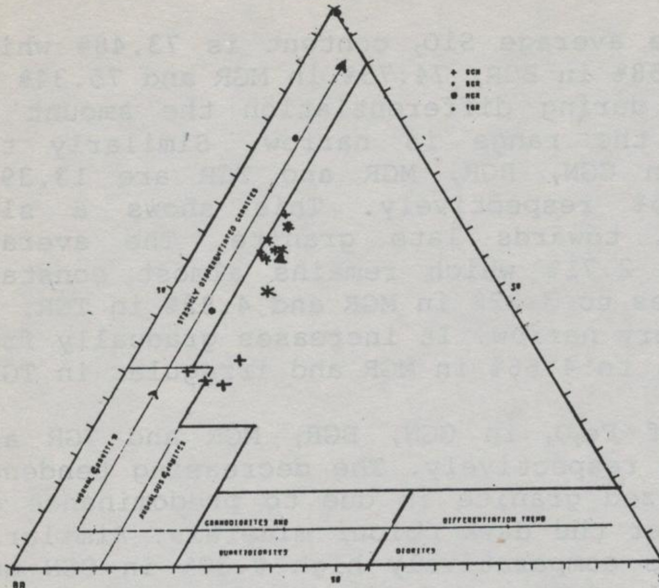
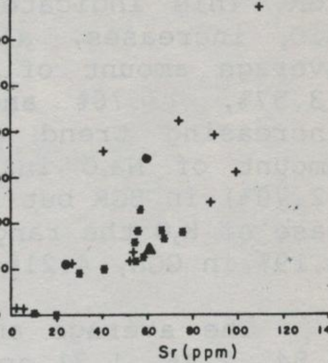
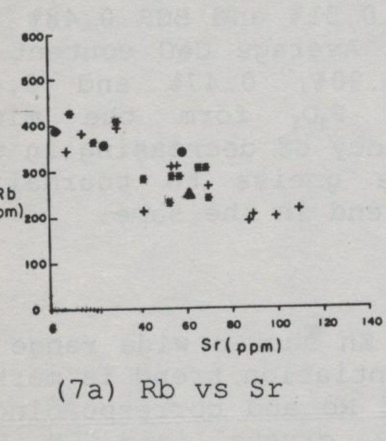


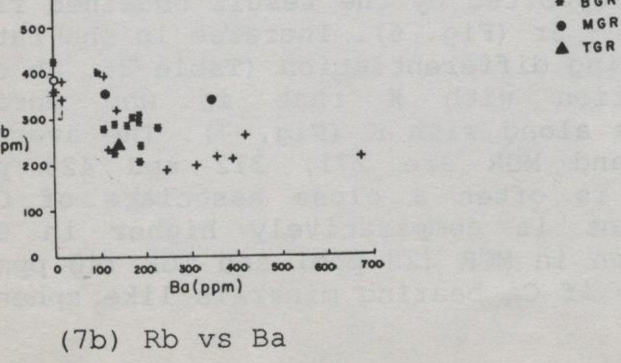
Fig. 6   The Application of Different Fields of the Ternary Relation Rb - Ba - Sr on Dadeldhura Granite



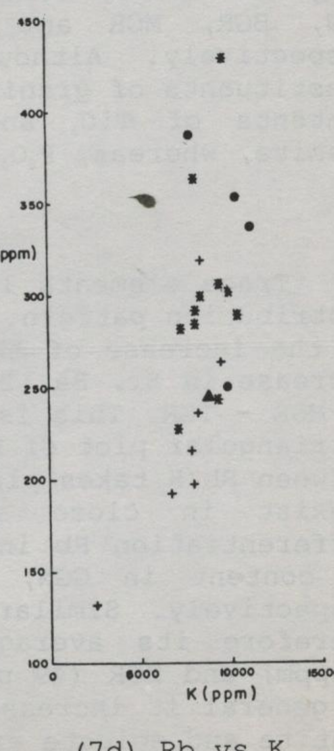
(7c) Ba vs Sr



(7a) Rb vs Sr



(7b) Rb vs Ba



(7d) Rb vs K

Fig. 7   Variation Diagrams

The average amount of Zr is comparatively high in GGN (142 ppm), BGR (137 ppm) and low (i.e. below 60 ppm) in MGR and TGR. Similarly average Zn content in GGN, BGR, MGR and TGR are 58, 55, 46 and 41ppm respectively. Lithium may be present in muscovite produced during pneumatolitic stage. Tin content on average is below 20ppm except in TGR where it reaches upto 31 ppm. Because of low detection limit of XRF tin value below 20 ppm cannot be shown. Average tungsten is below 10 ppm. The highest value is 6 ppm in GGN, 12 ppm in BGR, and 19 ppm in MGR. Y and V are below 28 ppm on average and irregular in distribution. U and Th content are irregular, however, generally they are below 10 and 17 ppm respectively. Cu, Mo, Pb, Ni, Nb and Ta show least fluctuation in distribution pattern from granite gneiss, biotite granite to leucocratic muscovite and tourmaline granite. The initial ratio of Sr^{87}/Sr^{86} is 0.7269 ± 0.0016.

Mineral Chemistry

Triangular plot of Dadeldhura granite on Ab - An - Or diagram revealed that the composition of K- feldspar becomes more sodic in MGR and TGR. Their approximate composition of liquid coexistence in equilibrium with two feldspar are distinct in 4 different types of granite (Fig. 8). In a single K- feldspar crystal the rim is more sodic than the core as it is commonly recorded in most of GGN, BGR, MGR and TGR. Similarly soda content in almost all plagioclase grains of all phases of granite increases in rim than in core.

Plot of the composition of the biotite of various granite in phlogopite biotite compositional diagram also show that they are of biotite in composition. However, as the differentiation proceeds from GGN - BGR - MGR and TGR the biotite becomes rich in alumina and poor in silica, as a result the biotite of TGR and MGR tends to shift towards the siderophile corner (Fig. 9). Plot of $Al^{(iv)}$ vs $Al^{(vi)}$ diagram for biotite of 4 different types of granites (Fig. 10) revealed that $Al^{(vi)}$ increases towards late crystallized muscovite granite and tourmaline granite.

MINERAL POTENTIAL

According to Tischendrof (1977), Stemporк and Skvor (1974), complex factors like the role of tectonics, temperature, the composition of the original melt and chemical interactions with host rocks, volatiles in the melt, crystal cummulate and fractional crystallization mechanism in transportation and deposition may affect the degree of mineral concentration. Due to the presence of residual fluids at the late stage of differentiation of the magma, lots of changes can take place. As a result of prolong hydration and reequilibrium of preexisting minerals may cause enrichment in various rare elements as Sn, W, Rb, Cs, Li, Be, Nb, Ta, F, B, etc. In this way tin concentration can take place by tin rich hydrothermal fluids.

Tin and tungsten mineralization are related to acid magmatism and being granitophile elements, the favourable depositional sites for them are the skarn zone, exocontact, the greisenised endocontact, pegmatites and quartz and tourmaline veins with or without beryl, fluorite and some sulphides. From the literature studies it is also well known that most of the world's known mineable tin and tungsten deposits are related to both older granites (eg. Proterozoic in Australia) as well as the younger granites (eg. Mesozoic in south China, Malaysia, Indonesia, Thailand, and Burma). Several large and low grade tungsten deposits were discovered around Hercynian granites of French Pyrenees. Minor tungsten (scheelite), copper, zinc, mineralization related to the effects of the nearby leucogranites is located in carbonate bands in gneissic sequence near Chitre in Sikkim (Chakraborty et al. 1976). Poulouse (1975) has reported that the pegmatites associated with tourmaline granites bear beryl, fluorite, barites, chalcopyrite, pyrite, sphalerite and minor amount of cassiterite and scheelite in the Himalaya of Bhutan. Tungsten occurrences are also reported from north of MBT in Bhutan (Mining Journal Dec. 21, 1979).

Recent Himalayan granites are related to Himalayan orogeny (Gansser, 1964). Ali (1964) has reported small alluvial scheelite occurrences derived from the Manserah granite. One wolframite prospect has also been reported by Calkins et. al. (1975) in the northern area of Manserah granite.

Occurrence of scheelite in Pharika, Jaurasi, Malsakhet, Koerali, Kaphaltana, Barakham and Jalali in Almora district and in Lakheri, Dharapani, Simli in Chamoli district are reported. Indictions of scheelite were also reported from the surrounding areas of Ramganga, Pindar and Gagas river valleys (Shukla et. al, 1983). Occurrences of tin at Meddi, tungsten-copper-molybdenum at Bamangaon lead, zinc and iron sulphides (mainly pyrite and few arsenopyrite and pyrrhotite) at many places in the exocontact zone adjoining Dadeldhura granite and also occurrence of visible cassiterite grains in the greisenised quartz and tourmaline veins and pegmatites in the quartz schist along southern contact of

Palung granite in Mandu Khola (Bhandary and Kononov, 1978) are the supporting examples to demonstrate that some of the Lesser Himalayan granites may be tin poor but they are not tin barren.

Similarly py, cp in border zones of tourmaline granite (Joshi, 1973/74) and high As, Bi and also occurrence of some Pb - Zn in the skarned zone of Narayanthan granite (Jnawali, personal discussion), occurrence of upto 20 ppm Sn and 30 ppm W in stream sediments from the granite schist contact zone of Ipa granite suggest that they are not tin barren granites. Few ppm W and Sn are also reported in the stream sediments derived from the peripheral zone of the Agra granite and Udayapur granite (upto 15 ppm W and 35 ppm Sn, Koziminisky, 1977 and Adhikary, 1980) and occurrence of cassiterite grains in the heavy concentrate samples from Dadeldhura granite and Palung granite etc. are the example of tin, tungsten and copper, molybdenum, lead, zinc mineralization in the Lesser Himalayan granitic area.

All these examples clearly indicate that the Lesser Himalayan granite (at least some) are not barren granites. Some of them could be the possible sources of economic tin, tungsten, copper, molybdenum, lead, gold, Uranium, Thorium, niobium, tentalum, beryllium, lithium etc. deposits.

Considering their importance to Sn, W and other sulphide mineralization, a comparative study of chemical characteristics of Dadeldhura granite with world's tin granites is carried out with a view to know whether the Dadeldhura granite is a tin potential granite or tin barren granite.

COMPARISON

Ferguson and Batman (1912) and Edward and Goskin (1949), Hosking (1968) believed that tin granite are rich in silica, high in alkalies and abnormally low in lime and magnesia. In all cases K_2O is always more than Na_2O. These chemical characteristics are similar in Dadeldhura granite (Table 1).

Presence of high ratio of $Na_2O + K_2O : CaO + MgO$ (av. 5.53%), high silica (av. 73.83%), high alkalies (av. 7.08%) and high ratio of silica to alkali (10.43), high differentiation index (90.73), existence of well differentiation trend of Dadeldhura granite are in favour of the characteristics of tin granite. According to Saavedra (1982) the relative sodic enrichment corresponding to parallel increase in tin and tungsten

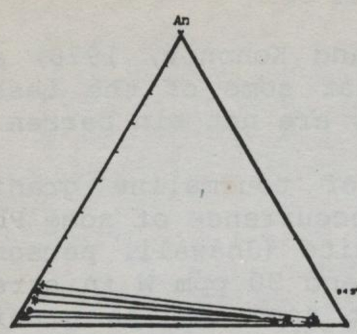


Fig. 8 Composition of feldspar of Different Types of Dadeldhura Granite on An - Ab - Or Triangular Diagram

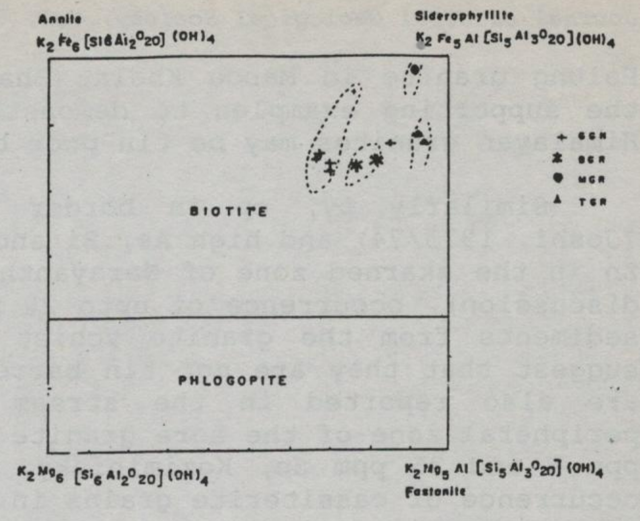


Fig. 9 Composition of Biotites of Different Types of Dadeldhura Granites of Phlogopite - Biotite Compositional Field (the division between them is arbitrary where Mg:Fe = 2:1)

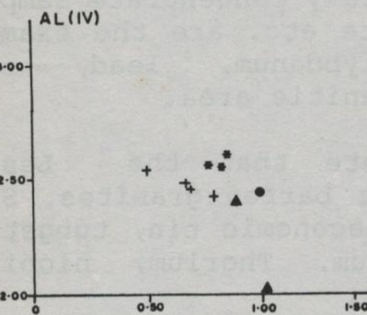


Fig. 10 Al^{IV} vs Al^{VI} Diagram for Biotite of 4 Different Types of Dadel. Granites

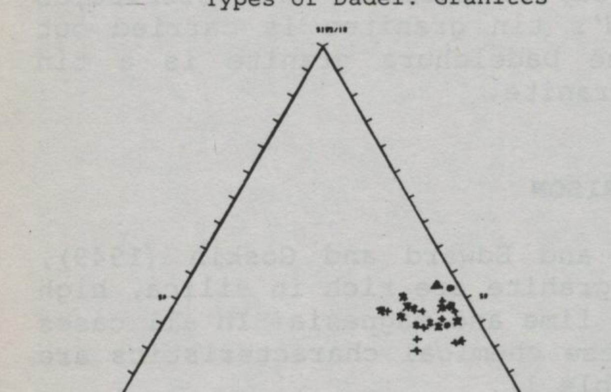


Fig. 11 Triangular Plot of $SiO_2/10$: $CaO + MgO$: $Na_2O + K_2O$ of Dadeldhura Granite

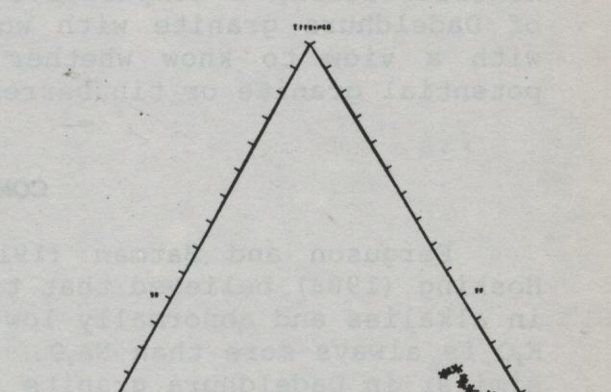


Fig. 12 Triangular Plot of $FeO + MgO$: CaO : $Na_2O + K_2O$ of Dadeldhura Granite

is related to microclinization.

According to Sullivan (1948) the tin mineralizing granites have higher than normal concentration of tin. In general, granite responsible for tin deposits consists of 3 ppm tin (Clarke value). However, Baukovel (1958) and Rottigan (1963) recorded 6-35 ppm tin in granites of USSR and 4 - 45 ppm tin in eastern and southern Australia. Stempork (1969) believed that tin content varies appreciably with depth from the apex. Tin content in Dadeldhura granite varies from 20 to 41 ppm but not more than 20 ppm in average. Tin content in biotite is another criteria to identify which of the granite is tin bearing.

SiO_2: Edward and Goskin (1949) and other suggested that SiO_2 content of tin granite is mostly high, ranging from about 71% in south west England to over 76% in South Africa (Table-3). In Dadeldhura granite, it is 73.83% (in average) which is almost same as in world's average tin granite (73.44 %).

$Na_2O + K_2O : CaO + MgO$: This ratio varies considerably in tin granites as it is noted from 3.59 to 17.76%. It is always higher than in Dalys average granite but in several tin granites it is less than Nockolds average alkali granite. In Dadeldhura granite it is always higher than 5.53% in average (varies from 2.35 - 23.85%).

$SiO_2/10 : Na_2O+K_2O : CaO+MgO$: High content of silica and alkali and impoverishment in lime and magnesia as shown in triangular diagram (Fig. 11) are the common characteristics of tin granites.

$K_2O : Na_2O$: The ratio between K_2O and Na_2O in Dadeldhura granite ranges from 0.51 to 1.55 (avg. 1.42). Like other tin granites of the world Dadeldhura granite also contains more K_2O than Na_2O.

$FeO + MgO:CaO:Na_2O + K_2O$: Triangular plot of FeO + MgO:CaO:Na_2O + K_2O of Dadeldhura granite shows a clustering tendency towards the alkali corner of the triangle (Fig. 12). It indicates a normal calc alkaline differentiation trend.

As in other tin granite, the Dadeldhura granite specially the tourmaline granite always contain above average (330 ppm) Rb and less than 100 ppm Sr. K/Rb ratio (61.3 - 171) and Rb/Sr ratio (2-10) are high. Dadeldhura granite contains 5 ppm tin.

Most of the above characteristics of Dadeldhura granite are quite similar to other worlds average tin granite (Table - 3). Therefore the mineral potential specially tin in Dadeldhura granitic area appears to be fairly high. Further investigations may lead to discovery of an economic tin tungsten reserve in Dadeldhura granitic area and other Lesser Himalayan granitic areas.

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