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A - TYPE GRANITES OF WARSAK, KHYBER AGENCY, N. PAKISTAN: RIFT- RELATED ACID MAGMATISM IN THE INDIAN PLATE

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ABSTRACT

Three varieties of granite from Warsak have been analysed for their geochemical composition, particularly trace elements. Two of the three varieties contain aegirine and riebeckite and are thus peralkaline. The third variety comprises biotite and muscovite with rare garnet, and varies between meta- and peraluminous compositions. Irrespective of these differences in mineralogical and major-element characteristics, there is a close match in incompatible trace elements between all the three varieties of granite from the studied area. A close scrutiny of the trace-element composition reveals A-type nature of the Warsak granites. Palaeozoic fragmentation of Gondwana, involving breakaway of India, may be responsible for the generation of the Warsak A-type granites and other similar granites in the Peshawar plain at Ambela, Shewa-Shahbazgarhi, Malakand, and Tarbela.

INTRODUCTION

The Warsak granites are amongst the earliest recognised peralkaline granites in N. Pakistan (Coulson, 1936). Ahmad et al. (1969) mapped these granites in detail, while Kempe (1973) presented a comprehensive petrography and whole-rock chemistry (mainly the major elements). Kempe & Jan (1970, 1980) correlated these granites with peralkaline granites of Shewa-Shabazgarhi, Tarbela, and Ambela, and suggested that they formed an integral part of a Tertiary alkaline province located in and around the Peshawar plain.

In this paper we use trace-element geochemistry to show that the Warsak granites, irrespective of their peralkaline or peraluminous character, are a typical example of A-type granites (cf: Loislle & Wones, 1979; Collins et al., 1982; Whalen et al., 1987). Such granites are considered to represent final plutonic event in rift-related anorogenic magmatism of shield areas (Whalen et al., 1987). On the basis of a previously established correlation with the granites of Ambela and Shewa-Shabazgarhi (Kempe & Jan, 1970, 1980; Kempe, 1980; Jan & Karim, 1990), we suggest a Palaeozoic age for the Warsak granites and consider them to be a consequence of Late Palaeozoic fragmentation of the Gondwanaland.

FIELD RELATIONS AND PETROGRAPHY

The Warsak Igneous Complex (WIC) contains three varieties of granites distinguished from each other on the basis of texture, mineralogy, and geochemistry.

1) The Warsak main aegirine-reibeckite granite (WMARG)

This granite is medium to coarse grained, ranges in texture from equi-granular and non-porphyritic to inequi-granular and slightly porphyritic. The type alkaline minerals such as aegirine and riebeckite are important constituents of this granite. Previously this granite was termed as the Warsak Alkaline Granite (Ahmad et al., 1969; Kempe, 1973, 1983).

2) The Warsak porphyritic aegirine-reibeckite granite (WPARG)

This variety of granite is fine to medium grained and is characteristically porphyritic. It ranges from being fresh to slightly sheared and is mineralogically similar to the WMARG in that it contains sodic pyriboles such as aegirine and riebeckite.

3) The Warsak porphyritic biotite-muscovite granite (WPBMG)

This variety is texturally similar to the WPARG in that it is fine-grained and porphyritic, but is relatively much more deformed. The distinguishing feature of this variety, however, is the mineral assemblage lacking sodic pyriboles, and containing aluminous minerals such as biotite, muscovite and garnet.

The age relationship amongst the three granitic varieties is not clear in the field. Following Ahmad et al. (1969), the relatively deformed and garnetiferrous (and metamorphosed) WPBMG is considered older than the other two varieties, which are apparently contemporaneous on the basis of common mineral assemblage.

All the three varieties of granites are intimately associated with a suite of basic rocks, which occur as sheeted masses alternating with those of the granites (Fig. 1). Again there is little field evidence to deduce the relative age relationship between the granites and the basic rocks. Ahmad et al. (1969) noted, in addition to rare xenoliths of basic rocks in the granites, some granitic veins cutting across the basic rocks. On a limited scale similar field relations have been observed by us suggesting that the basic rocks may be slightly older than the granites.

Warsak Main Aegirine Reibeckite Granites (WMARG)

Field Features: The principal occurrence of the WMARG is at and around the Warsak Damsite (Fig. 1). The granite body at this place is a massive sheet which is about 1 km in width, and over 5 km in length. The sheet is apparently intruded into Palaeozoic metasediments. Ahmad et al. (1969) have shown it to be concordantly separating the phyllites and marbles of Upper Paleozoic age in the north and north-east, from a unit of pebbly quartz-biotite schists of Siluro-Devonian age in the south and south-west. The host metasediments and the enclosed WMARG sheet are folded together in the form of a synform (Ahmad et al., 1969; Ashraf Khan, unpublished data).

Whereas the abovementioned main sheeted mass of WMARG is emplaced at the contact of Lower and Upper Paleozoic sediments, a ~1.5 km long sill occurs entirely within the Upper Paleozoic phyllites at northern slopes of the Spera Ghar. This is in addition to several small stock-like bodies occuring within this metasedimentary unit.

The WMARG is mostly massive but foliated varieties are not uncommon. The massive variety is more common at the Warsak Damsite. In these rocks, the constituent feldspathic minerals (alkali and plagioclase feldspars and quartz) are equi-granular, and the dark minerals are either tabular or prismatic but rather randomly oriented. Foliated WMARG is principally found in the south in the vicinity of the Mula Gori road. Majority of the foliated rocks contain a single planar structure, which is apparently concordant with the strike of the adjacent country rocks. The foliation is mostly defined by tabular crystals of dark minerals such as riebeckite and aegirine, but tabular and prismatic crystals of feldspars also have a concordant orientation. This foliation has been interpreted to be a primary flow structure formed at the time of emplacement (Ahmad et al., 1969). Data recorded during the present work confirm this interpretation, as the foliation is found to be parallel to the strike of the sheets and the limbs of the major synform fold structure rather than the axial plane of the fold. At places, the WMARG is marked by a strong linear fabric, defined by lenticular crystals of dark sodic minerals. This linear fabric plunges northwards, apparently parallel to the orientation of the fold axis. It is suggested that this linear fabric developed in response to metamorphism accompanying the deformation which produced the major fold structure in this area.

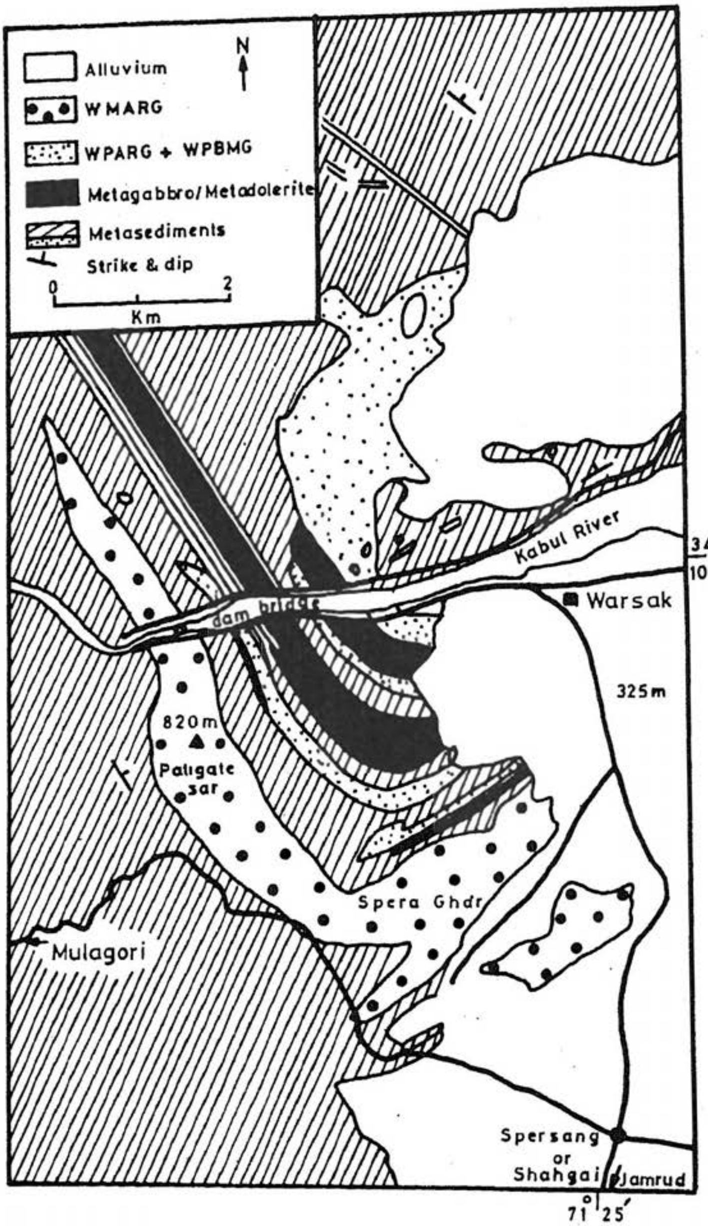

Fig. 1. Simplified geological map of the Warsak Igneous Complex, Khyber Agency, N. Pakistan (After Ahmad et al., 1969). WMARG = Warsak Main Aegirine-Riebeckite Granite; WPARG = Warsak Porphyritic Aegirine-Riebeckite Granite; WPBMG = Warsak Porphyr itic Biotite-Muscovite Granite.

Commonly the WMARG is homogeneous, both in terms of composition and texture. There is little grain size variation, and dark to light-coloured minerals ratio remains grossly same throughout the observed outcrops. Rarely there are linear bands which are relatively coarser grained, some reaching a grain size appropriate to pegmatites. Compositionally these coarser grained rocks, however, are similar to the main mass of the WMARG.

Petrography: WMARG is fine to medium grained, even-grained to subporphyritic, and has a common flow fabric defined by alignment of the dark minerals aegirine and riebeckite. Feldspar is mostly microcline (~10 volume%) occurring both as phenocryst and in groundmass. Perthite is more abundant (~30 volume%), commonly occurring as phenocrysts. Albite makes 10 to 15% of the rock, concentrated mostly in the groundmass. Aegirine (~10 volume%) occurs as large tabular grains or in the form of irregular aggregates. Riebeckite occurs as small prismatic crystals disseminated in the rock with a weak alignment. Astrophylite, biotite, sphene, zircon, epidote, and opaque minerals occur in minor to trace amounts.

Warsak porphyritic aegirine-riebeckite granite (WPARG)

Field Features: This granite (WPARG) occurrs in the form of sill-like intrusions. The principal occurrence is near the Ali-Baba Ziarat where a 100 m thick sill is exposed in the road section. The northward extension of this sill is more voluminous, attaining a thickness of more than 1 km. Several thinner sills occur to the west of this main body alternating with the sheet-like intrusions of basic rocks and the WPBMG.

In hand-specimen, the WPARG has a general appearance similar to the WPBMG, particularly in terms of a flow structure in the groundmass which furnishes a well defined foliation to the rocks. Unlike the WPBMG, however, there are distinct euhedral phenocrysts of perthite, microcline and quartz, which can be readily observed in hand specimen.

Petrography: Under the microscope, the WPARG show a typical porphyritic igneous texture, with little evidence of mylonitisation so common in the WPBMG. There are euhedral to subhedral phenocrysts of perthite, microcline, and quartz set in a granular groundmass of fine grained quartz, microcline, and perthite. Albite is also locally present in the groundmass. There is an abundance of oxide-mineral phases (magnetite and ilmenite), reaching up to 12% (by volume) in some specimens. Both perfect euhedral and anhedral grains of oxide minerals are found. Ferromagnesian silicates include riebeckite, aegirine, and biotite. The aegirine is usually subordinate to riebeckite, and occurs either in stocky prismatic to stubby crystals, or in aggregates of lenticular shape. The riebeckite is typically in the form of needle-like prismatic crystals, generally oriented parallel to the foliation. Biotite occurs either in individual prismatic grains oriented parallel to the foliation or in aggregates associated with the oxide minerals. The accessory minerals include sphene, zircon, alanite, and astrophyllite.

Warsak porphyritic biotite-muscovite granite (WPBMG)

Field Features: The WPBMG has field relations similar to the WPARG, i.e., occurence in the form of sheeted bodies alternating with other lithologies of the WIC. Three such bodies of the WPBMG are shown on the map (Fig. 1). It is to be noted that the WPBMG occupies an intervening position between the main body of the WMARG at the damsite and the bodies of the Warsak Porphyritic Aegirine-Riebeckite Granite (WPARG) near the Ali-Baba Ziart.

A common feature of the WPBMG is a state of high deformation. There is a strong foliation defined by lenticular streaks of groundmass alternating with highly stretched phenocrysts of feldspars and ribbons of recrystallised quartz presumably derived from what were originally phenocrysts of quartz. Biotite, which is at places accompanied by muscovite, displays a shear fabric parallel to the foliation. The strongly foliated WPBMG gives a schistose appearance in the field and in the hand-specimen.

Petrography: In thin sections the WPBMG shows a texture comprising phenocrysts of microperthite floating in a fine-grained, polymineralic groundmass. The microperthite phenocrysts are generally euhedral to subhedral, without showing much effect of ductile deformation. Several of the phenocrysts, however, have an assymetrical lenticular shape with pointed ends merging with the foliation. A marked feature of the WPBMG is a scarcity of quartz phenocrysts, although there are aggregates of polygonal grains of quartz generally in the form of lenticular ribbon-like structures. The groundmass of the WPBMG is typically fine-grained equi-granular, and consists of grains with polygonal outlines. The textures in the WPBMG can best be explained considering a superimposition of ductile deformation on a porphyritic igneous texture. Deformation at temperatures appropriate to epidote-amphibolite and greenschist facies is capable of causing a ductile flow and recrystallisation in quartz, but may not ductily deform feldspar (see Brodie & Rutter, 1985 for relative strength of common rock- forming minerals in response to deformation at various temperature-pressure conditions). In the WPBMG, deformation under greenschist or epidote amphibolite conditions resulted in obliteration of all the quartz phenocrysts which were turned into ribbon like aggregates of polygonal grains. Since the groundmass was rich in quartz, most of the shearing was accommodated in there. The perthite phenocrysts retained their igneous shape because they floated in ductily flowing quartz-rich groundmass and thus suffered only a bodily rotation.

Compositionally the WPBMG shows a variation in mineral assemblage from one place to another. The main sheet just west of the Warsak bridge is composed of perthite, microcline, quartz, muscovite, biotite and garnet. The sheeted bodies of WPBMG, east of the bridge, lack muscovite and garnet and contain only biotite. None of the WPBMG is observed containing sodic ferromagnesian minerals.

WHOLE-ROCK GEOCHEMISTRY

General statement

The following discussion is based on 31 samples, of which 10 were analysed for both major and trace elements, and the rest for only trace elements. The analyses were done on a Philips XRF (at the Leicester University), using pressed powder pellets.

Classification

The granites from the Warsak area have all the major-element characteristics typical of alkali granites., such as high SiO_2 and alkalies, and low CaO and MgO. On the De La Roche et al. (1980) classification diagram (Figure 2), the aegirine-riebeckite bearing varieties (i.e., WMARG and WPARG) plot as a coherent group in the field of alkali granites. The two-mica porphyritic granites (WPBMG) plot as a separate group in the field of granite proper.

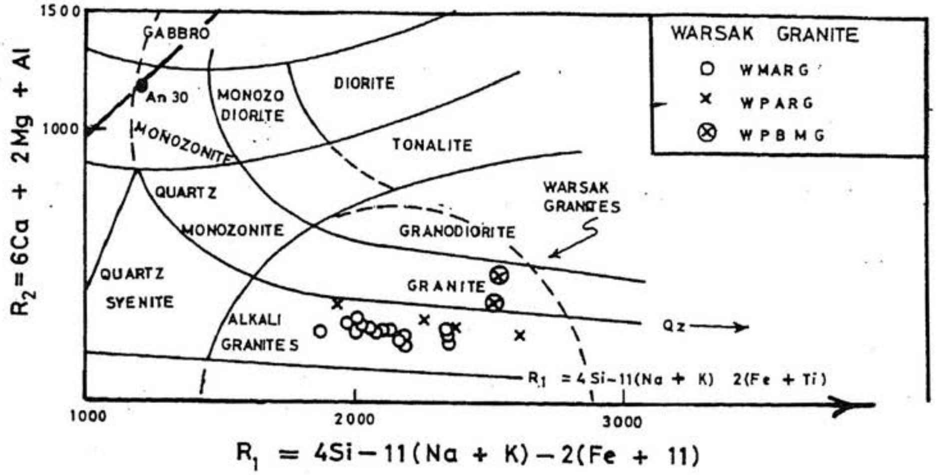

Fig. 2. The Warsak granites classified using the scheme of De La Roche et al. (1980). WMARG = Warsak Main Aegirine-Riebeckite Granite; WPARG = Warsak porphyritic Aegirine-Riebeckite Granite; WPBMG = Warsak Porphyritic Biotite-Muscovite Granite.

When classified on the basis of Shand's indices ($Al_2O_3/CaO+Na_2O+K_2O$; Al_2O_3/Na_2O+K_2O), the WMARG is typically peralkaline having both the A/CNK and A/NK ratios typically <1. WPBMG is mostly peraluminous, whereas WPARG is metaluminous.

TABLE 1. REPRESENTATIVE MAJOR AND TRACE ELEMENT DATA FOR WARSAK GRANITE.

	1	2	3	4	5	6	7	8	9	10
Sampl	W1	W2	W3	W4	W7	W21	W23	W42	W51	W53
SiO2	72.80	72.90	73.20	73.00	75.00	66.00	67.00	73.00	75.00	68.00
TiO2	0.29	0.32	0.36	0.32	0.18	0.55	0.48	0.42	0.50	0.61
Al2O	10.65	10.60	10.10	13.00	11.00	14.00	15.00	13.00	12.00	13.00
Fe2O	4.75	4.80	5.80	3.00	4.00	3.00	2.00	3.00	3.00	4.10
MnO	0.14	0.14	0.15	0.10	0.07	0.14	0.08	0.10	0.08	0.12
MgO	0.10	0.10	0.00	0.10	0.00	0.30	0.90	0.30	0.40	0.65
CaO	0.26	0.25	0.10	0.30	0.07	0.80	0.80	0.20	0.03	0.50
Na2O	4.70	4.70	4.30	5.34	4.40	5.60	1.30	4.00	4.00	5.50
K2O	4.60	4.55	4.60	2.05	4.48	4.30	6.80	5.00	5.00	2.90
P2O5	0.02	0.02	0.02	0.03	0.01	0.11	0.11	0.04	0.04	0.08
Total	98.31	98.38	98.63	99.24	99.21	94.80	94.47	99.06	100.1	95.46
TRACE ELEMENTS (ppm)										
Nb	134	143	295	119	185	104	120	123	121	110
Zr	989	976	2487	929	1768	802	770	990	1098	813
Y	126	126	279	88	131	72	81	80	86	69
Sr	6	6	.4	25	8	107	164	10	12	36
U	3	1	8	1	4	0	2	2	3	1
Rb	150	151	199	102	122	107	138	121	122	69
Th	26	29	156	17	23	18	18	20	35	16
Pb	9	12	21	13	25	11	27	19	11	20
Ga	34	34	30	32	34	28	30	32	28	29
Zn	216	247	175	166	149	137	48	164	110	141
Ni	2	2	6	0	2	2	2	2	3	4
Cr	3	1	4	3	4	4	4	3	8	9
V	4	3	1	5	11	12	15	6	10	17
La	124	125	174	94	85	151	147	100	0	97
Ce	236	242	388	204	210	310	286	215	384	207
Nd	132	129	181	96	108	134	129	97	189	93
Ba	203	204	165	541	171	947	1618	454	491	728

Analyses 1-5 are from Warsak Main Aegirine Reibeckite Granite (WMARG),
6-8 from Warsak Porphyritic Biotite Muscovite Granite (WPBMG),
and 9-10 are from Warsak Porphyritic Aegirine Reibeckite Granite (WPARG)

In summary, the Warsak granites range from peralkaline, through metaluminous to peraluminous in their chemistry. A peculiar feature of the Warsak granites is their restricted composition; i.e., unlike common granitic suites having compositions ranging from diorite or granodiorite through granite to alkali granite, the Warsak granites do not have any associated intermediate or more felsic rocks.

Trace element characteristics

The three petrographic varieties of the Warsak granites are compared in terms of mantle-normalised incompatible trace elements in Fig. 3. The most striking feature apparent from this plot is the close similarity in the trace element patterns of all the three granite varieties. Interestingly even the porphyritic granites devoid of sodic minerals are not substantially different in terms of incompatible trace-elements from the other two granite varieties. This is suggestive of close petrogenetic relationship between the granite varieties of Warsak irrespective of their current mineralogical and major-element composition.

The major and trace element contents of the Warsak granites unambiguously classify them as within-plate A-type (defined by Loiselle and Wones, 1979; further characterised by Collins et al., 1982 and Whalen et al., 1987). A comparison between the Warsak granites and granitic rocks from various tectonic settings such as island arcs, mid-oceanic ridges, collision zones, and within-plate is shown in Fig. 4. There is a close match in the trace-element patterns of the Warsak granites and in those of the granites from within-plate settings (Fig. 4e). Pearce et al. (1984) have further classified the within-plate granites in terms of dominance of mantle or crustal components. This is reflected in differences in enrichment of elements such as K, Rb, Th, Ce, and Nd relative to high field strength elements (HFSEs) such as Zr and Nb. The Mull and Skaergaard granites in Fig. 4f are type example of trace element pattern with a dominantly crustal component reflected in negative anomalies for Nb and Ta, whereas the granites from the Ascention Island (Fig. 4e) represent within-plate granites with a dominantly mantle component in the parent magma, marked by the positive anomalies of Nb and Ta. When compared, the Warsak granites (Fig. 4a) are closely similar in trace element pattern to that of the Ascension Island characterised by mantle-normalised Nb/Rb and Nb/Th ratios close to 1 or higher (i.e., positive anomaly for Nb), suggesting a dominance of mantle over crustal component.

The major and trace element characteristics which suggest A-type nature of the Warsak granites include high SiO_2, Na_2O+K_2O, Fe/Mg, Zr, Nb, Ga, Y, and REE contents and low CaO, Ba, and Sr contents (Table 1). The A-type nature of the Warsak granites is clearly exhibited in Fig. 5, which is specially devised for the discrimination of A-type granites from the granites of other types such as M-, I-, and S-type (Whalen et al., 1987).

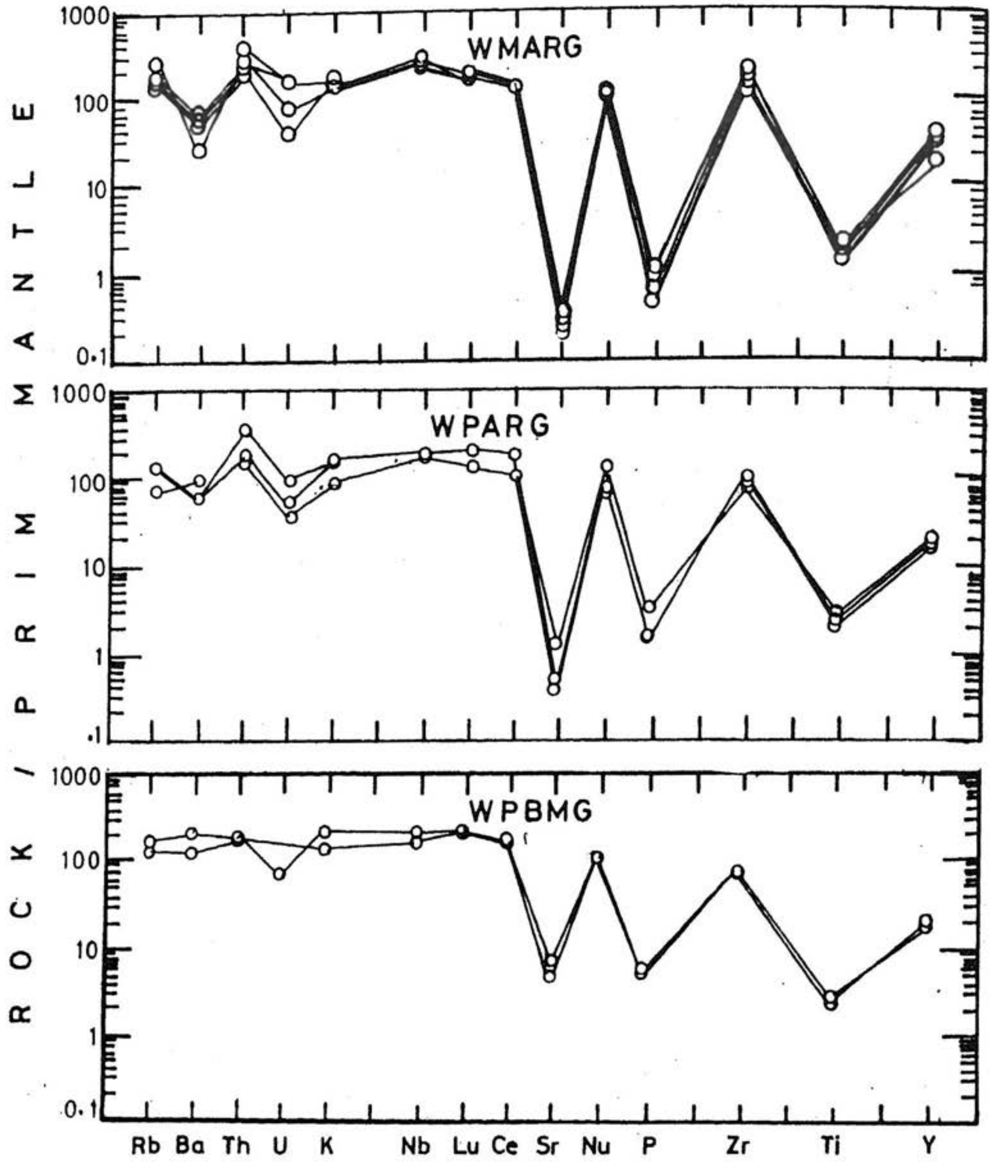

Fig. 3. Mantle-normalised trace-element patterns of the three petrographic varieties of granites from Warsak for mutual comparison.

n summary, the incompatible trace element contents suggest that the Warsak granites are: 1) closely related despite differences in mineral assemblages, and major-element contents, 2) A-type in nature, and 3) derived and emplaced in within-plate, anorogenic settings with a considerable contribution from the mantle in their petrogenesis.

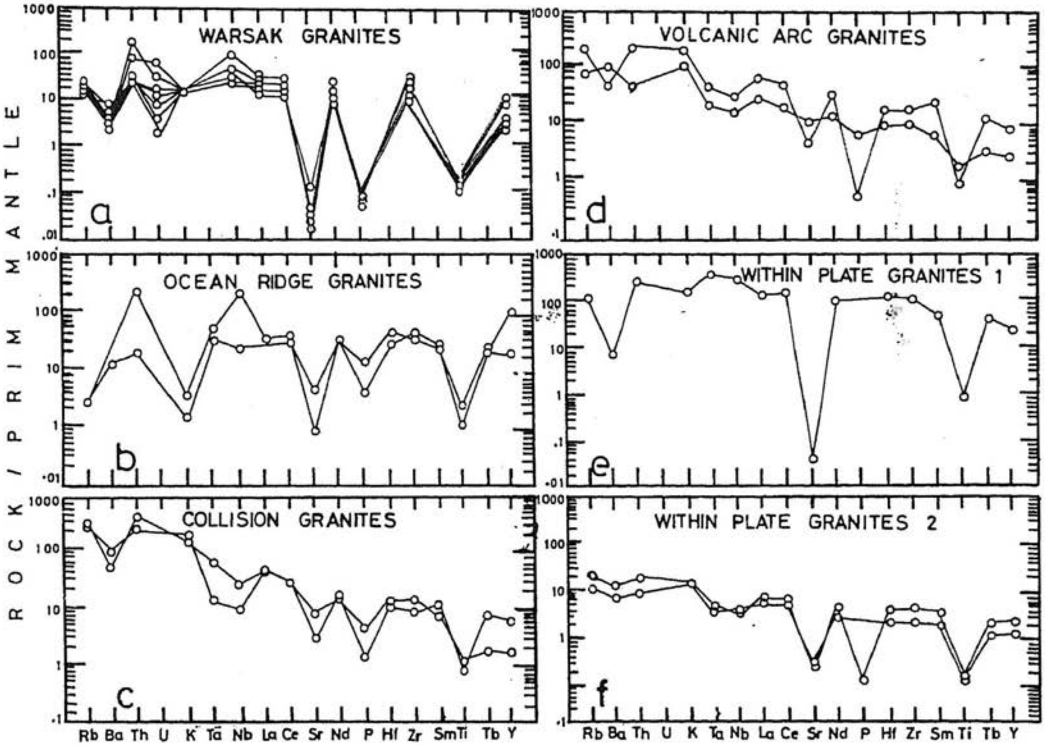

Fig. 4. Warsak granites compared with type ocean-ridge, volcanic-arc, collision, and within-plate granites (adopted from Pearce et al., 1984) in terms of mantle-normalised trace element patterns.

PETROGENESIS

Several models have been suggested for the origin of A-type within-plate granites including metasomatism, crystal fractionation, and partial melting (see Whalen et al., 1987 for a detailed review). Any model accounting for the petrogenesis of the Warsak granites should take into consideration the following characteristics. 1) There are peralkaline and subalkaline (metaluminous to peraluminous) granites in close association. 2) The Warsak granites are closely associated with basic rocks, which have complex field relations with the granites, i.e., at places basic rocks appear to be enclosed in the granite sheets whereas sometime veins and dykes of granites cut across the basic rocks. 3) The Warsak granites irrespective of their petrographic varieties are closely similar in incompatible trace-element contents suggesting a close petrogenetic relation. 4) The Warsak granites are closely similar to A-type granites of within-plate origin. In particular, they resemble granites from the Ascension Island and Oslo Rift.

A generally uniform and restricted composition of the Warsak granites negates any major role of processes such as metasomatism and crystal fractionation in their petrogenesis. This leaves partial melting as the most important process in the origin of the Warsak granites. A high SiO_2 content (67 to 74 wt%) necessarily implies that direct melting of upper mantle (of a dominantly mafic composition) was not involved in the origin of the parent melt for Warsak granites. The partial melting of lower continental crust, capable of yielding felsic melts such as those of Warsak, however, needs a mechanism to induce melting

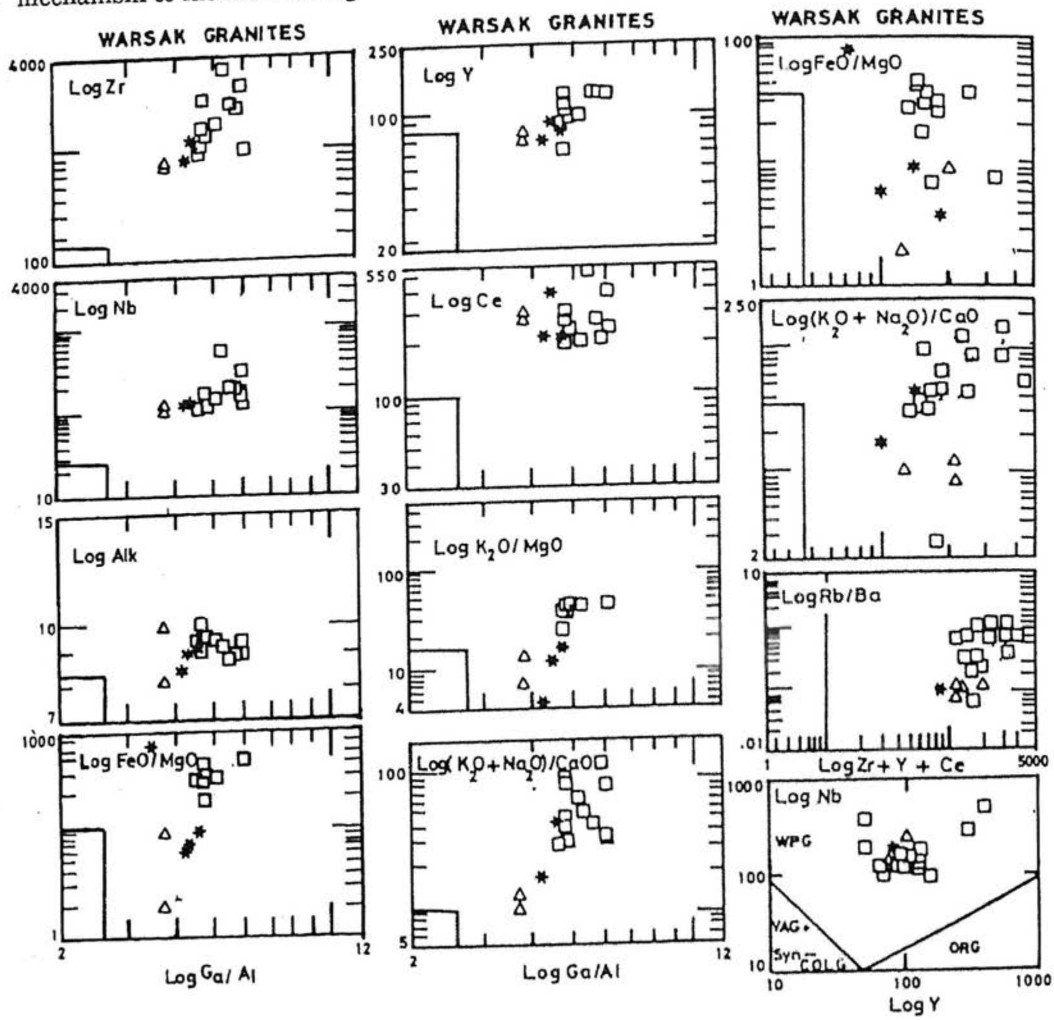

Fig. 5. Discrimination diagrams (after Whalen et al., 1987) for the Warsak granites suggestive of their A-type within-plate origin. The box at bottom left in each diagram encloses the position of M-, I-, and S-type granites. VAG = volcanic arc granites, Syn-COLG = Syn-collision granites; ORG = Orogenic granites; WPG = Within-plate granites. WMARG = open boxes, WPARG = stars; WPBMG = triangles.

.Some of the suggestions are summarised in the following:

1) Harris & Marriner (1980) invoked a high flux of mantle-derived halogen-rich volatiles to induce melting and to provide the high concentration of alkalies and high-field strength elements in A-type granites.

2) Barker et al. (1975) proposed a reaction-melting model in which mantle-derived mafic magma was considered causing partial melting of granulite-facies lower continental crust followed by various stages of contamination and differentiation.

3) Collins et al. (1982) postulated the formation of A-type granites by partial melting at elevated temperatures of an anhydrous source which was previously depleted in water by extraction of a minimum-melt I-type magma. The granulite source they proposed is expected to be high in F- and/or Cl due to enhanced thermal stability of micas and amphiboles rich in these elements. This origin has been supported by Cleman et al. (1986) in the light of their experimental work.

4) Anderson & Thomas (1985) suggested that muscovite bearing A-type granites may be derived from a dehydrated S-type source in the lower continental crust.

Assuming that the Warsak basic rocks are not substantially different in age from the granites, the heat for the partial melting might have been provided by their passage through the lower continental crust. Alternatively a release of pressure in rifting extensional environments might have caused partial melting in a granulite source in the lower continental crust. The high content of HFS elements in the Warsak granites is acquired from the breakdown of accessory minerals in the source, further enhanced by crystallisation under high F- and Cl content (see Whalen et al., 1987 for the role of halogens in enrichment of HFS elements in magmas).

The presence of peralkaline and metaluminous granites in Warsak suggests derivation from a source with mainly I-type but locally S-type protolith, a lithological feature expected in lower continental crust. The important feature, however, is the comparable contents of HFS elements in two types of granites suggestive of a similar dehydrated nature of the two source types. Coexisting peraluminous and peralkaline A-type granites in N. America were considered to be derived from a similar dehydrated interlayered I- and S-type source (Anderson, 1983; Anderson & Thomson, 1985).

DISCUSSION

Granites are found in almost all the major tectonic settings, including mid-oceanic ridges, island arcs, continental margins, and within plates (see Pearce et al., 1984 for an exhaustive review). The granite magmatism in the Peshawar plain, on the basis of its geological position at the northern margin of the Indian plate, can be of several different origins. Some possibilities are: 1) magmatism in Andean-type continental margin; the Tethys ocean subducted southward below the Indian plate, produc ing calc-alkaline granitic plutons of granitic composition similar to those formed in the Kohistan and Asian plates due to northward subduction of the Tethys (see Petterson and Windley, 1985; Le Fort et al., 1983); 2) collision granites, formed by thickening of the crust of the Indian plate after its collision with Kohistan-Karakoram. Such granites are reported from the northern margin of the Indian plate such as the famous Mansulu granite of Nepal (Le Fort, 1981). 3) Within-plate A-type granitic magmatism, related with an episode of rifting, which could be simultaneous with the India-Kohistan collision (Kempe & Jan, 1980; Butt et al., 1980), or earlier (Le Bas et al., 1986; Mian, 1987). Obviously, for a precise determination of tectonic setting of magma generation for the Warsak and other granites in the Peshawar plain (Such as Ambela, Malakand, Shewa Shahbazgarhi and Tarbela; see Kempe & Jan, 1980, for the basis of correlation) a two-fold approach is required: firstly the chemistry of granites, in particular in terms of incompatible trace elements, needs evaluation in order to ascertain the type of magma. Secondly, radiometric age data are required in order to determine relationship between various granites in the context of changing plate tectonic history of the Indian plate.

The radiometric age dating is out of scope of this study, but it is now possible to assign a Late Palaeozoic age to the Warsak granites on the basis of pre-established correlation with the Ambela granite and the Shewa-Shabazgarhi for which both radiometric and stratigraphic dates of this age are now available (Le Bas et al., 1987; S. R. Khan et al., 1990). This, when combined with the A-type nature of the Warsak granites, one is compelled to relate the granite magmatism of the Peshawar plain with the famous Late Palaeozoic fragmentaion of the Gondwana and separation of India. There is a possibility that the deformed two-mica granite of Warsak is equivalent to the acid volcanic event such as that documented by S. R. Khan et al. (1990) from the Carboniferrous Jaffar Kandao Formation from the Swabi area, while the aegirine-riebeckite bearing granites are equivalent to Late Palaezoic-Early Triassic Ambela granite (Rafiq, 1988). It has to be noted that Kempe (1978) pointed out the possibility of basic extrusives in the Warsak area. The close association of the Warsak granites and the basic rocks is a characteristic feature of the Peshawar plain failed rift, as described by S. R. Khan et al. (1990) and Jan & Karim (1990).

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