PETROCHEMISTRY OF SOME GRANITIC ROCKS FROM THE NANGA PARBAT MASSIF, NW HIMALAYA, PAKISTAN

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ABSTRACT

Petrographic notes and chemical analyses are given for ten granitic rocks from the Nanga Parbat massif, northwestern Himalayas. Chemical and normative variation diagrams are used to show that the granitic rocks originated through alkali metasomatism of metasediments, a specific chemical change being controlled by original composition of the particular lithologic facies Scanty previous data are included for comparison.

INTRODUCTION

The majestic Nanga Parbat (8131 m) massif, with a 140 km long northeastern extension as the Haramosh (7397 m) range, constitutes an unique orographic bulge in the northwestern part of the great Himalayas. Besides being inclined at a high angle to the Hazara syntaxis, the Nanga Parbat-Haramosh axis strikes as a wedge against the ESE-WNW oriented Karakoram range. (Bakr *et al.*, 1964).

The pioneer geological description of the Nanga Parbat massif and its environs was given in detail by Wadia (1933) alongwith a geological map on the scale of 1 inch to 4 miles. His map displayed an elongated gneiss dome of the massif, surrounded by isolated outcrops of quartzo-feldspathic material dispersed in the Precambrian Salkhala metasediments. The latter were described as composed of graphitic schists, phyllites, calc-schists and marbles, with regional metamorphism prograde towards the gneiss dome. Basic lavas, tuffs and argillites of Cretaceous to Eocene age overly the Salkhala formation with intrusive bodies of norites, hypersthene diorites and dunites. The region was reinvestigated in greater detail by Misch (1949) who gave

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lithological description of various formations of the area alongwith a geological map on scale of 1 inch to 10 miles. He reeorded a progressive sequence (Barrovian type) of metamorphism of the Salkhalas, culminating into quartzo-feldspathic gneissose and granitic material. On the basis of appearance and progressive increase in abundance of potash feldspar in the metasediments, after reaching kyanite grade, Misch (1949) advocated potash metasomatism as the effective cause of granitization; however, no chemical evidence was given in support. This position was supported also by Zennettin (1964) while describing granitic (migmatitic) rocks from northeastern part of the Haramosh massif; however, only three chemical analyses were given. Gansser (1964), on the other hand, ruled out the need for metasomatism and suggested chemical and textural reorganisation of the Salkhalas during metamorphism to change over to granitic nature. On the other hand, Matsushita *et al.* (1965) proposed straight differentiation origin of the granitic rocks from a Himalayan basic magma; however, the suggestion was based only on seven chemical analyses of rocks taken from locations separated by hundreds of kilometers and across some major rock complexes of the NW Himalaya Our studies show evidence of alkali metasomatism of metasediments with progressive transformation over to granitic compositions. In case of the Hazara granitic complex, ultimate product appeared as soda-rich aplites and albitites while, in the case of the lower Swat granitic complex, such compositions were produced that showed normative alkaline affinities.

PETROGRAPHY OF ROCKS

A large variety of specimens were collected during an excursion in the summer of 1974 by travelling along Bunji to Astor traverse across the Nanga Parbat massif, and Ashkandas to Sassi traverse accross the Haramosh range. The rocks are migmatitic gneisses composed of interwoven micaceous folia which alternate with quartzo-feldspathic material, displaying familiar structures of migmatites (Mehnert, 1968).

The plagioclase is mostly in the range of oligoclase to andesine while potash feldspar is perthitic to non-perthitic and may occur in variable grain size. Biotite, muscovite, chlorite and ore are the common minor minerals, alongwith remnents of garnet, kyanite and staurolite of metamorphic origin. Rare sillimanite needles are present in some specimens. Garnet appears to be of at least two generations, an earlier generation that has suffered minor alteration and a younger phase which is fresher; garnet is a common inclusion in potash feldspar porphyroblasts of the granitic gneisses. Modal analyses of 10 rocks are recast and plotted in the Strekeisen's (1967) classification trangle for quartzo-feldspathic rocks (Fig. 1).

CHEMISTRY OF ROCKS

Table 1 gives chemical analyses of 10 granitic rocks from the Nanga Parbat massif. The variation ranges of various oxides are: SiO_2, 58.85 to 75.43%; Al_2O_3, 13.94 to 23.56%; Fe_2O_3, 0.18 to 4.48%; FeO, 0.14 to 6.05%; MgO, 0.39 to 2.12%; CaO, 0.10 to 1.68%; Na_2O, 2.20 to 5.60%; and K_2O from 0.90 to 10.00%. The minor oxides also show recognizable variation, such as: TiO_2 from nil to 0.24% and MnO from nil to 0.28%. Fig. 2 shows a plot of oxide values in a Larsen (1938) type diagram. It shows very regular increase in SiO_2 which was matched by fairly regular decrease in Al_2O_3, FeO, CaO, Fe_2O_3, however, developed a law hump in the region of intermediate Larsen Index values. Significantly, alkalies, Na_2O and K_2O, do not show recognizable variation trends, at the best very slight increase can be visualized for both the alkalies. The rock with the highest Larsen Index value in Fig. 2 represents a pegmatite, rich in potash feldspar. The variation curves for the Nanga Parbat granites ayply satisfactorily also to the data from Zenettin (1964), and Ahmad and Chaudhry (1976), and the average granite composition (Nockolds, 1954).

Due to quartzo-feldspathic nature of the rocks, their normative compositions were also plotted in the feldspar system, Or—Ab—An (Fig. 3) modified after Kleeman (1965). This area also includes the trend of variation shown by Zennettin's (1964) data. The clustering of positions in the thermal valley of the feldspar system is significant. While the Zennettin's (1964) compositions plotted in the low temperature valley, that from Ahmad and Chaudhry (1976) plotted nearest to the Ab-rich Nanga Parbat compositions.

DISCUSSION

There is enough field and structural evidence to show migmatitic nature of the Nanga Parbat massif with its interior occupied by more or less massive-looking granitic material, a sequence also supported by petrographic evidence for granitization of the Precambrian Salkhalas (Misch, 1949). Opinion has been sharply divided, however, regarding the nature of granitization. Misch (1949) advocated potash metasomatism by hot fluids, Matsusita *et al.* (1965) supported a purely igneous origin while Gansser (1964) proposed simply an internal reorganisation of the metasediments.

TABLE 1. CHEMICAL ANALYSES OF GRANITIC ROCKS FROM NANGA PARBAT.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	68.45	62.01	68.23	64.87	70.17	58.85	67.74	67.28	70.29	75.43	73.28	72.52	62.72	67.56
TiO_2	0.12	0.04	0.08	0.16	0.14	0.12	0.24	0.02	0.20	nil	traces	traces	1.61	0.88
Al_2O_3	19.25	23.56	16.43	17.94	17.28	21.17	13.94	17.97	16.97	15.66	15.21	14.75	18.86	18.46
Fe_2O_3	1.52	0.78	0.54	0.58	0.18	1.29	2.71	1.16	4.48	0.52	0.08	0.06	1.17	2.23
FeO	1.94	0.36	2.38	3.46	0.79	6.05	2.88	0.56	0.86	0.14	0.43	2.08	6.91	0.53
MnO	nil	nil	0.12	0.18	nil	0.28	0.18	nil	0.06	nil	traces	traces	0.07	0.37
MgO	1.17	0.69	1.18	1.02	0.51	1.62	2.12	1.24	0.39	0.77	0.18	0.06	1.66	0.33
CaO	1.13	0.10	0.88	1.56	0.82	0.95	1.45	1.68	0.92	0.29	1.16	1.35	0.44	0.96
Na_2O	2.80	2.20	4.20	3.80	4.20	3.60	5.60	3.60	4.40	5.60	3.84	3.62	1.08	5.20
K_2O	3.50	10.00	5.80	5.20	5.00	5.40	2.20	5.40	0.90	1.30	4.74	4.72	3.39	2.10
P_2O_5	...	...	...	...	...	...	...	...	...	...	0.24	0.28	0.12	0.28
H_2O^-	0.04	0.04	0.05	0.08	0.10	0.12	0.11	0.12	0.15	0.08	0.26	0.24	0.34	0.09
H_2O^+	0.10	0.08	0.07	0.64	0.48	0.43	0.66	0.38	0.46	0.10	0.22	0.26	1.55	0.87
Total	100.02	99.86	99.96	99.49	99.67	99.88	99.83	99.41	100.08	99.89	99.64	99.94	99.92	99.86

Anal: 1—10 (Shafeeq Ahmad) Taken from road outcrops along Bunji-Astor and Hanuchal-Sassi sections.

Anal: 11—13 (Zennettin, 1964)

Anal: 14 (Ahmad and Choudhary, 1976).

(...) not determined.

TABLE 1. (Contd.). NORMS OF THE CHEMICAL ANALYSES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
qz	33.90	10.02	16 08	15.60	23.46	8.28	19.56	20.64	39.00	36.24	27.78	25.04	31.86	26,64
or	20.57	58.94	34.47	30.58	29.47	31.69	12.79	31.69	5.00	7.78	27.80	27.80	20.02	12.23
ab	23.58	18.34	35.63	31.96	35.63	30.39	47.16	30.39	37.20	47.16	31.96	30.39	9.43	44.01
an	5.56	0.56	4.45	7.78	4.17	4.73	7.23	8.34	4.45	1.39	5.84	6.67	1.95	4.73
C	8.87	8.98	1.53	3.26	3.37	7.65	...	3.16	7.14	4.59	1.73	1.22	12.44	5.92
hy	4.88	1.70	6.59	8.31	2.49	14.40	7.94	3.10	0.90	...	5.16	3.80	20.60	...
ol	...	...	...	...	...	...	...	...	...	...	...	...	...	1.12
$MgSiO_3$	...	...	...	...	...	...	...	...	...	1.90	...	...	...	...
mt	2.32	1.16	0.70	0.93	...	1.86	3.94	1.62	2.32	0.46	0.23	0.23	1.86	...
hm	...	...	...	...	...	...	...	...	2.80	...	...	...	...	2.24
il	0.30	...	...	0.30	0.30	0.30	0.46	...	0.30	...	...	...	3.04	1.67
ap	...	...	...	...	...	...	...	...	...	...	1.01	2.02	1.01	2.02

Norms calculation by Shafeeq Ahmad.

There is *irrefutable* textural evidence that potash feldspar prophyroblasts started to grow in the rock when kyanite grade metamorphism had set in. The question is whether potash of the feldspar was introduced into the rock or was made available internally, by magmatic differentiation or by ionic mobility. The spread of plotted positions in the normative feldspar diagram (Fig. 3) does not support an igneous origin by differentiation. The variation shown by Matsushita *et al.* (1965) cannot be taken as reliable due to its doubtful basis. The Larsen variation diagram (Fig. 2) also gives no conclusive evidence, as both the alkalies do not show any significant variation. Rather this diagram supports Gensser's (1964) view of internal chemical reorganisation without metasomatic addition. Considering feldspar as the most important constituent and quartz being the omnipresent excess phase, the spread of compositions (Fig. 3) shows progressive increase in alkali content towards low temperature valley. It also indicates that in case, where An (CaO) content was high, Ab (Na_2O) increased prior to increase in Or (K_2O). Chemical composition of Salkhala schist (No. 14 Table 1) shows that considerable chemical transference would be necessary to change its composition to granitic type. On the other hand, there remains the problem of volume ratio in the case of purely differentiation origin, as advocated by Matsushita *et al.* (1965). The present study suggests that the Salkhala metasediments suffered metasomatic metamorphism with the introduction both of soda and potash, their relative role and potential having varied according to original composition of a particular metasedimentary facies. No doubt, in case when rocks were near to granitic composition, there was no need for introduction of alkalies and mineral recrystalization could have been the dominant phenomenon attended by only minor chemical reorganization.

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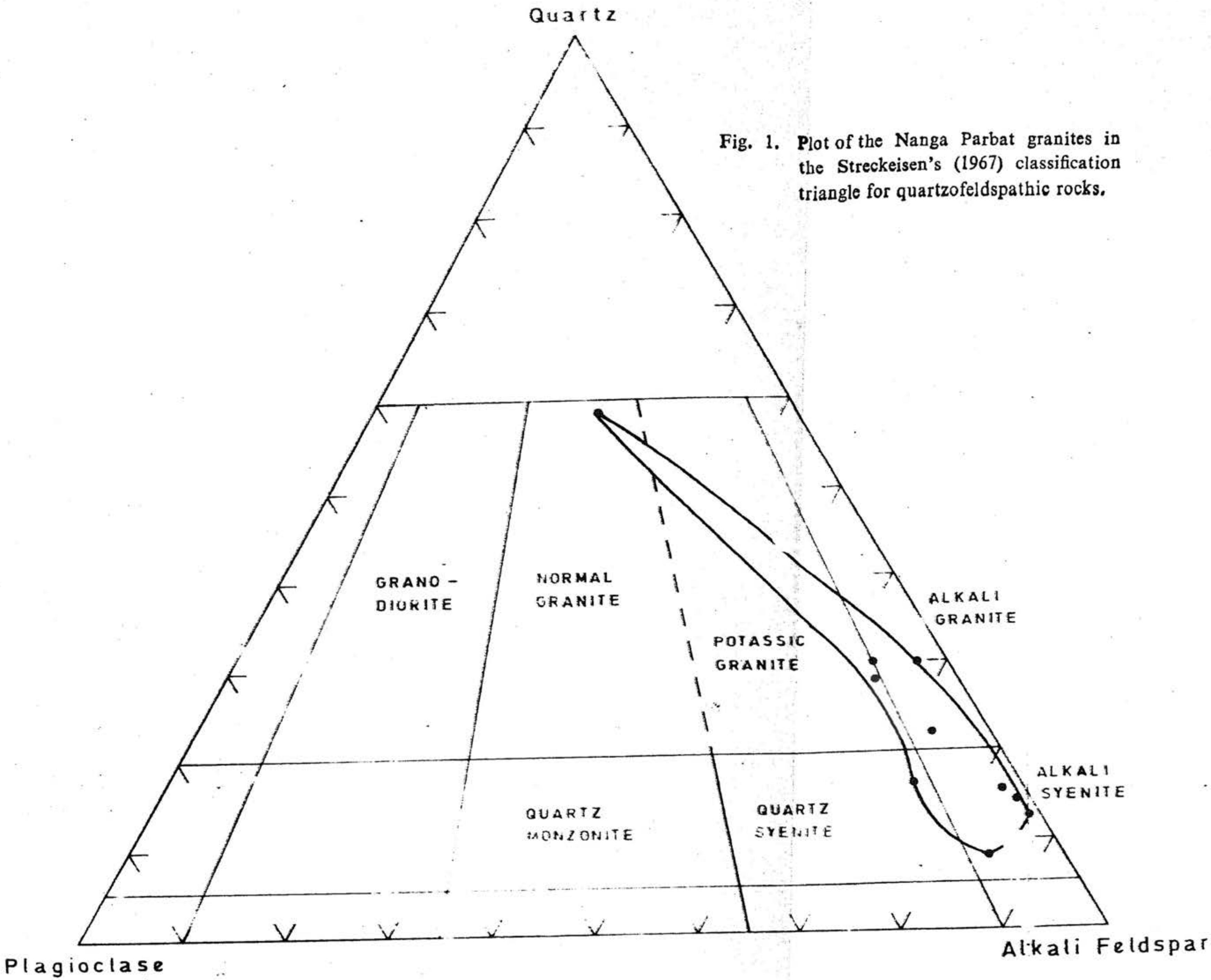

Fig. 1. Plot of the Nanga Parbat granites in the Streckeisen's (1967) classification triangle for quartzofeldspathic rocks.