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Unusual Ti, Fe, Mn and Ba silicates in alkaline granites from Mardan, Northern Pakistan

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ABSTRACT: *The Shewa-Shahbazgarhi complex is a late Paleozoic intrusion covering 80 km² area. It consists predominantly of silicic rocks (riebeckite ± aegirine gneiss, aegirine-riebeckite porphyry, porphyritic microgranite and local quartz monozonite) that have been intruded locally by metadolerite. One variety of the granitic rocks contains unusual barium-, titanium- and manganese-bearing phases resembling bafertisite from Mongolia. The mineral occurs in trace amount as fibers (up to 0.75 mm in length) in feldspar, biotite and rarely groundmass. It is faintly pleochroic from pale yellow to golden yellow. The mineral may be a product of hydrothermal process or autometasomatism related to residual fluids in the granitic magma.*

INTRODUCTION

Barium, titanium and manganese-bearing silicate minerals bafertisite, hejtmanite and delindiete were reported from alkaline to peralkaline granites from Mongolia (Peng Chi-Jui, 1959; Semenov and P' El-Shan Chang, 1960). Further analytical data for bafertisite and an unidentified bafertisite-like phase were provided from North Carolina by Mauger (1983). The occurrence and chemistry of the rare mineral bafertisite $(BaFe_2TiO_2\ (Si_2O_7)\ (OH,F)_2$ and its Mn analogue hejtmanite $Ba(Mn,Fe)_2\ TiO_2\ (Si_2O_7)\ (OH,F)_2$ has been reviewed by Vrana et al. (1992). We report unidentified bafertisite-like phases from alkaline granites of Shewa-Shahbazgarhi complex, Mardan, north Pakistan.

GEOLOGICAL SETTING AND LOCATION

The Shewa-Shahbazgarhi complex is an isolated, triangular outcrop, occurring about 12 km northeast of Mardan (longitude 72° 10' - 72° 20' E, latitude 37° 10' to 34° 30' N). Covering some 80 km² area, the complex resides 60 km south of the Indus suture and is a part of the Peshawar plain alkaline igneous province that was emplaced during the late Paleozoic rifting of the northwestern edge of the Indian plate (Jan and Karim, 1990). The complex has been investigated by several workers since Coulson (1936) described some of the rocks as porphyries of Mesozoic age and correlated these with the soda granite at Warsak 80 km to the west. Martin et al (1962) called these rocks as albite porphyries. Several other workers (Kempe and Jan, 1970,1980; Bakhtiar and Waleed, 1980; Kempe, 1983; Chaudhary and Shams, 1983; and Jehan, 1985) correlated these rocks with Koga alkaline complex occurring 40 km NE and with other alkaline and acidic rocks of the Peshawar plain alkaline igneous province.

The complex consists predominantly of silicic rocks (riebeckite gneiss, aegirine-riebeckite porphyry and gneisses, porphyritic microgranite and minor quartz monozonite) that have been intruded locally by metadolerite (Fig. 1, Ahmad et al., 1990). Isolated outcrops of similar rocks occur in the neighbor areas Ambela complex to the north and east (Rafiq, 1988).

PETROGRAPHY

The Ba-, Ti-, Mn-bearing mineral was identified in a couple of samples of riebeckite gneiss. The gneiss is prominently exposed north of Sherghund and at Gariala Kandao-Taja sections (Fig.1). In hand specimen it is a fine-grained rock, highly sheared, foliated and showing porphyroclasts (up to 3 mm) of quartz and feldspar. The major constituents of the gneiss are orthoclase (some perthitic), plagioclase, and quartz, with some riebeckite, biotite, epidote and opaque ore. Sphene, zircon, apatite and sericite are found as accessories. Silimanite needles have been noticed in a few thin sections.

Evidence of intensive cataclasization has been noticed in feldspars occurring as porphyroclasts, and in their surrounding groundmass. The porphyroclasts are deformed, rotated and show a high degree of alteration in some grains. The groundmass shows abrupt changes in grain size and in certain cases becomes very fine-grained, glassy looking, highly laminated and foliated, particularly around the porphyroclasts, indicating fluxion structure. Locally the mafic minerals are segregated into streaks.

Riebeckite, biotite and epidote occur in close association with each other. The former two minerals are found as thin elongated tabular grains while epidote occurs as aggregates of small rounded grains. Riebeckite is pleochroic from light green to deep blue. Textural relationship suggests that the riebeckite apparently developed at the

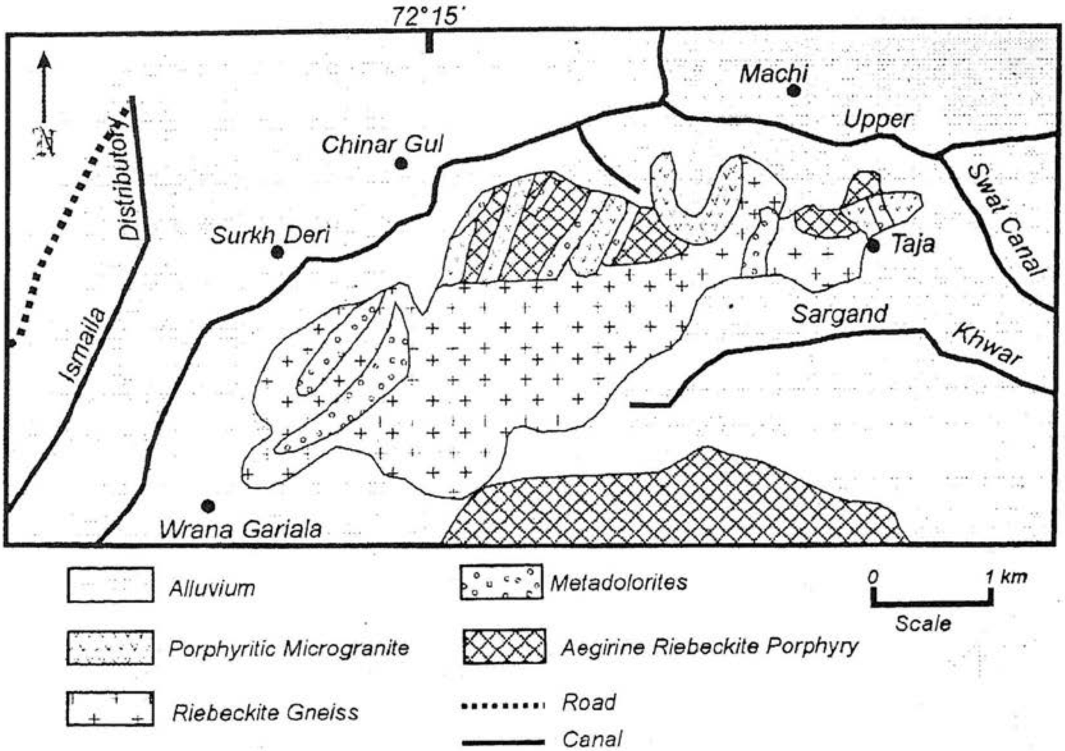

Fig. 1. Geological map of the Shewa-Shahbazgarhi Complex, Mardan.

expense of biotite, K-feldspar and magnetite. Opaque oxide itself occurs as irregular grains associated with biotite. Sillimanite occurs as thin needles and apparently developed after feldspars. The Ba-, Ti-, Mn-bearing mineral occurs as bundle of fibers in feldspar, biotite and rarely in groundmass. It appears to have grown after the main schistosity was developed in the rocks. It is faintly pleochroic from pale yellow to golden yellow in color, and up to 0.75 mm in length (Fig.2). It has moderately high relief, low interference colors up to first order red, length slow with extinction angle up to 22°. The end of a couple of crystals looks wedged (sphenoid) or spear shaped. It has similarities with bafertisite-like mineral in composition reported by Peng (1959) from Mongolia.

but smaller in quality as well as size: 1) euhedral to subhedral, elongated grains (prism + pyramids) showing pink pleochroism typical of peimontite from the Indus suture mélange to the north (Jan and Symes, 1977); 2) tiny granules of tourmaline showing pink to pinkish-chocolate colour and typical deep absorption; 3) orange red to yellow pleochroic fibres of (?) astrophyllite, locally cutting the yellow fibers of bafersite. These minerals could not be analysed during the present study, but would be taken up at a later date.

CHEMISTRY

Mineral compositions were determined using Jeol-733 (Japan) electron microprobe at the

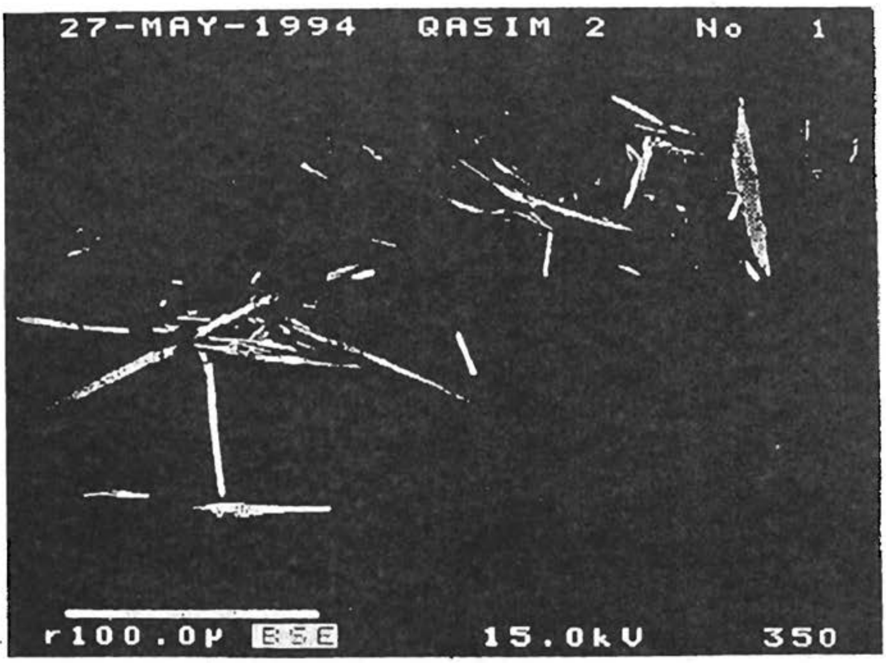

Fig. 2. Photomicrograph of Ba-, Ti- and Mn-bearing mineral from Rieeckite Gneiss.

The mineral occurs in only trace amounts (less than 0.001 volume percent of the rock). There appear to be other manganese-bearing minerals also in the rock,

Centre of Excellence in Geology, University of Peshawar and SX-50 electron microprobe analyser at Institute Dolomieu, University Joseph Fourier, France. Measurements were made at 15 kv accelerating voltage, 20 nA beam current, and a beam diameter of 5 µm. Two samples among the high barium rocks were selected for mineral analysis. A total of ten spot analyses were performed. Representative analysis are given in Table 1. Some of our analyses are clearly only partial. Nb was determined in only four analyses and BaO was not determined in three. More work is in progress and further details shall be presented in a subsequent communication.

TABLE 1. MICROPROBE ANALYSIS OF THE BARIUM-, TITANIUM- AND MANGANESE - BEARING PHASES FROM SHEWA - SHAHBAZGARHI COMPLEX, MARDAN

Elements	1	2	3	4	5	6	7
SiO_2	23.22	23.12	28.85	29.53	27.03	26.04	23.68
Al_2O_3	0.22	0.19	3.09	2.96	0.62	0.32	0.29
FeO	18.81	18.51	17.24	18.00	21.4	19.84	22.56
MnO	8.27	8.02.	4.77,	5.55	8.85	9.63	1.62
MgO	0.05	0.16	0.11	0.14	0.14	0.04	0.5
CaO	0	0	0	0.01	0.06	0.1	0.37
Na_2O	0.01	0.02	0.13	0.66	0.6	0.25	0.49
K_2O	0.27	0.26	1.65	1.15	0	0	0.12
TiO_2	13.24	13.39	14.74	15.09	19.51	19.81	15.39
BaO	25.06	25.55	25.43	25.41	ND	ND	29.98
Nb_2O_5	1.28	0.69	ND	ND	ND	ND	ND
Total	90.33	89.91	96.01	98.5	78.21	76.03	95.5

ND: Not determined 7: Bafertisite after Peng Ch'l-Jui (1959) from Mongolia

The analytical data can be divided into three chemical groups: Group I is represented by analyses 1 & 2, Group II by 3 & 4 and Group III by 5 & 6 in Table 1. Compared to Group I, Group II has higher SiO_2, Al_2O_3, Na_2O, K_2O, TiO_2 and lower MnO. Group III has intermediate values of SiO_2 and Al_2O_3, however it has higher FeO, MnO and TiO_2 than the other two groups. CaO and MgO are low in all the analyses (MgO ranging from 0.04 to 0.16 wt % and CaO from 0.00 to 0.07 wt %). The Nb_2O_5 content of the four analyses ranges from 0.7 to 1.3 wt %. Group II shows distinctly higher totals than Group I. Whether this is because of the lower volatile content of Group II or non-determination of other components in Group I is not clear at this stage.

Plots of major oxides (SiO_2, TiO_2, Al_2O_3, FeO, MnO, BaO) against each other (Fig.3) are scattered and not revealing systematic variation. However, some negative correlation is seen between TiO_2 and FeO, TiO_2 and MnO and more so, between MnO and FeO. The latter quite obviously suggests substitution of manganese for iron in the structure of the minerals. Our survey of the literature has failed to reveal the exact characterization of the three groups of analyses. However, there is some resemblance of the analyses with bafertisite ($BaFe_2TiO_2Si_2O_7$, analysis 7, Table 1). At this stage, we are not in a position to say whether the three groups represent a solid solution series or distinct mineral phases.

The rocks provide a good opportunity to study the distribution of manganese in a range of minerals. In addition to bafertisite like minerals, mention was made of other Mn-bearing silicates (e.g.,) piemontite, tourmaline, astrophyllite) in petrography.

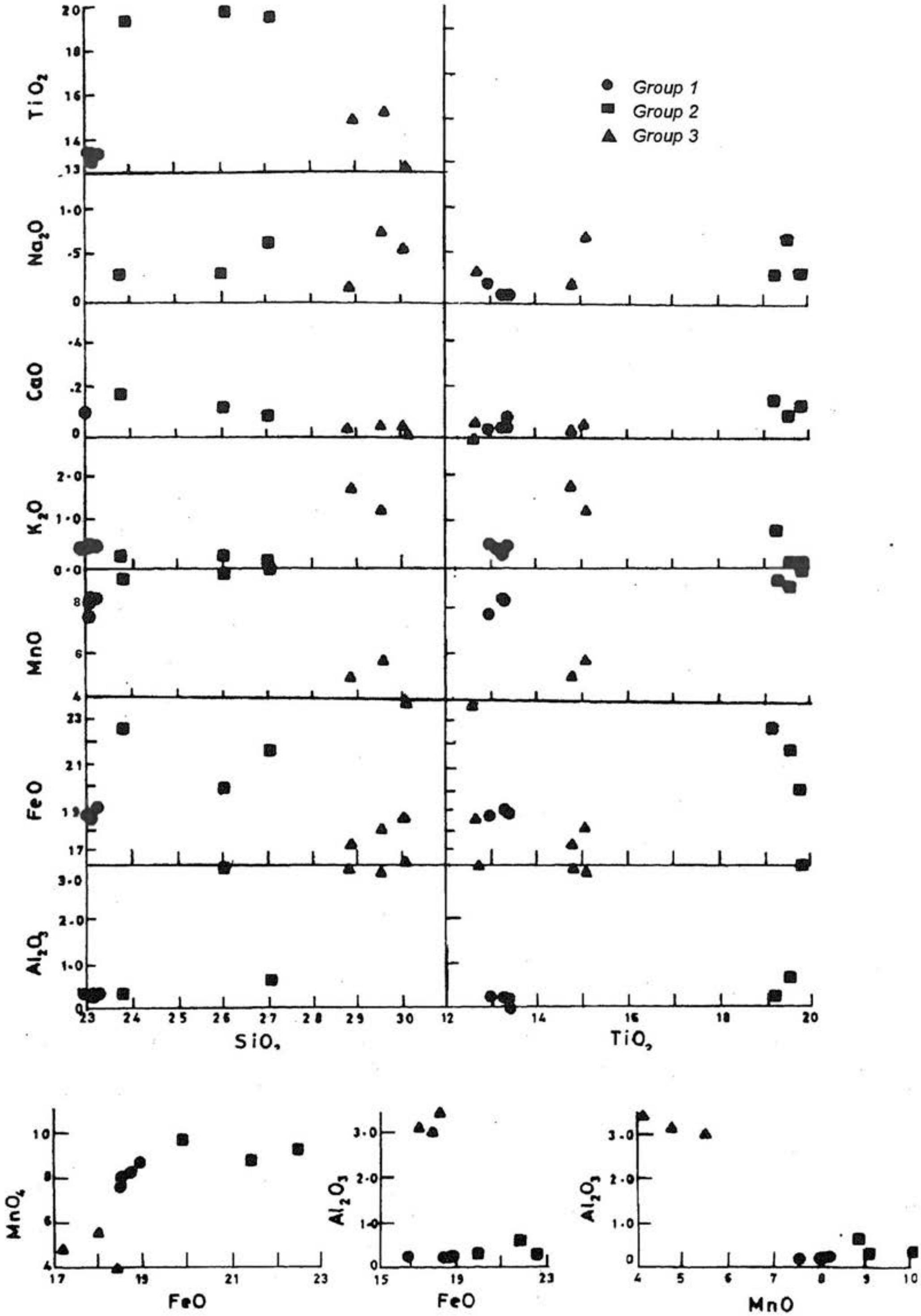

Fig. 3. Plots of various oxides against SiO_2 & TiO_2 in the bafertisite-like analyeses. Also shown are FeO against MnO & Al_2O_3 and MnO against Al_2O_3 for the Ba-, Ti-, and Mn-bearing phases from Mardan.

Our studies show that the biotite and amphibole contain 1.0 to 1.6 and 0.8 to 1.2 wt % MnO, respectively.

DISCUSSION

The most significant feature of the rocks of the Shewa-Shahbazgarhi complex is the severe impact of cataclasis. Fluxion structure and mortar texture superimposed on "flow" type of texture, broken and elongated grains of quartz and feldspar, the laminated groundmass showing abrupt variation in grain size and, in some cases, recrystallization and neo-minerallization, all provide ample evidence of this phenomenon. Ahmad (1986) has attributed the formation of certain new minerals, (including biotite, epidote, aegirine, riebeckite and sillimanite) in the aegirine-reibeckite and riebeckite gneisses and porphyries to the mobility of elements (release of alkalies and concentration of Al_2O_3) during cataclasis. Cataclasis is, however, generally referred to brittle deformation at shallow levels of low temperature with a minimum degree of recystallization. The Ba-, Ti-, Mn-bearing mineral occurs as bundle of fibers in feldspar, biotite and, rarely, in the groundmass and it is locally seen crosscutting these minerals. This relationship suggests that it has developed later by hydrothermal process or metasomatism.

REFERENCES

Ahmad, I., 1986. Petrochemistry of the Shewa-Shahbazgarhi complex, Mardan. Unpub. M. Phil. Thesis, Univ. of Peshawar, 130 p.

Ahmad, I., Hamidullah, S. & Jehan, N., 1990. Petrology and petrochemistry of the Shewa-Shahbazgarhi complex, Mardan, North Pakistan. Geol. Bull. Univ. Peshawar, 23, 135-159.

Bakhtiar & Waleed, A. K., 1980. Geology of the Shewa-Shahbazgarhi formation, Distt. Mardan, N.W.F.P. Pakistan. Unpub. M. Sc. Thesis, Univ. Peshawar.

Chaudhry, M. N. & Shams, F. A., 1983. Petrology of the Shewa porphyries of the Peshawar plain alkaline igneous province, NW Pakistan. In: Granites of Himalayas, Karakorm and Hindukush (F. A. Shams, ed.). Institute of Geology Punjab Univ., Lahore, 171-177.

Coulson, A. L., 1936. A soda granite suite in the North West Frontier Province. Proc. Nat. Inst. Sci. Ind. 2, 3.

Jan, M. Q. & Karim, A., 1990. Continental magmatism related to late Paleozoic-Early Mesozoic rifting in northern Pakistan and Kashmir. Geol. Bull. Univ. Peshawar, 23, 1-25.

Jehan, N., 1985. Geology of a part of the Shewa-Shahbazgarhi complex, district Mardan. Unpub. M. Sc. Thesis, Univ. Peshawar.

Kempe, D. R. C., 1983. Alkaline granites, syenites and associated rocks of the Peshawar plain alkaline igneous province, NW Pakistan. In: Granites of Himalayas, Karakoram and Hindukush (F. A. Shams, ed.). Institute of Geology Punjab Univ., Lahore, 121-158.

Kempe, D. R. C. & Jan, M. Q., 1970. An alkaline igneous province in the North West Frontier Province, West Pakistan. Geological Magazine, 107, 395-398.

Kempe, D. R. C. & Jan, M. Q., 1980. The Peshwar plain alkaline igneous province, NW Pakistan. Geol. Bull. Univ. of Peshwar, 13, 71-77.

Martin, N. R., Siddiqui, S. F. A. & King, B. H., 1962. A geological reconnaissance of the region between the lower Swat and Indus river of Pakistan. Geol. Bull. Punjab Univ., 2, 1-14.

Mauger, R. L., 1983. Bafertisite and unidentified BaCaMnFeTi silicate from Fountain Quarry, Pitt County, North Carolina. Southeastern Geology, 24, 13-20.

Peng, Chi-Jui., 1959. The discovery of several new minerals of rare elements. Amer. Mineral., 45, 754.

Rafiq, M. & Jan, M. Q., 1988. Petrography of the Ambela Granitic Complex, NW Pakistan. Geol. Bull. Univ. of Peshawar, 21, 27-48.

Semenov, I. E., & P'ei-Shan Chang, 1960. New mineral bafertisite. Amer. Mineral., 45, 1317.

Vrana, S., Rieder, M. & Gunter, M. E., 1992. Hejtmanite a manganese-dominant analogue of bafertisite, a new mineral. Eu. J. Mineral, 4, 35-43.