

Mineralogy of a carbonatite – related fenite in Lower Swat, Northern Pakistan

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ABSTRACT: *The Precambrian-Cambrian Manglaur formation contains several small bodies of carbonatite and fenite to the SE of Mingora. Their composition and close association with late Paleozoic granitic rocks is similar to these of the Naranji Kandao area in Buner. The entire suite may be related to Late Paleozoic rifting. The carbonatite is sugary sovite comprising calcite and clinopyroxene, with minor amounts of primary (?) clinozoisite, cancrinite- vishevite, apatite, sphene, opaques and zircon. The fenite consists of pure albite (abundant) calcite, biotite with > 3% MgO and minor magnetite.*

INTRODUCTION

The first discovery of carbonatite occurrence in Pakistan was made by Siddiqui et al. (1968) from Naranji Kandao area of Buner, Swat. This small carbonatite body is associated with alkaline rocks of the Ambela granitic complex emplaced in early Paleozoic lesser Himalayan rocks. Additional carbonatite occurrences were reported from Loe Shilman in Khyber Agency, Sillai Patti in Malakand Agency, and west bank of Tarbela (for references see Jan & Karim, 1990).

There also are several occurrences of minor bodies of carbonatite and fenite around Jambil, located some ten kilometers SE of Mingora in Lower Swat. These were first reported by Butt and Shah (1985). They identified two varieties: 1) Sugary white, with small amounts of unevenly distributed grains of mafic minerals, and 2) earthy brown with more uniformly distributed mafic minerals and showing a more consistent radioactivity than the first variety.

The Jambil area is occupied by Precambrian- Cambrian Manglaur formation that is emplaced by the Swat granitic gneisses. Small bodies of carbonatite occur in the form of sills, dykes, and plugs up to several meters in breadth, especially in the area mapped as "intruded zone B" (DiPietro, 1990, 1991; DiPietro & Lawrence, 1991). In this zone (Fig.1), garnetiferous and psammitic schists of the Manglaur Formation are interlayered with leucogranites, leucogranite gneisses, amphibolite, and Swat granitic gneisses. The granitic gneisses along the road-cut south of Jambil contain available assemblage of quartz and plagioclase, \pm K-feldspar, \pm biotite, \pm tourmaline, \pm garnet. Formerly considered as Precambrian to Early Paleozoic, the Swat granitic gneisses have recently been dated Carboniferous (Anczkiewicz et al., 1998).

PETROGRAPHY AND MINERALOGY

Here we describe the two most accessible bodies of "carbonatite" along the road south of Jambil (location 1 & 2 in Fig.1).

Carbonatite 3 and 4 were not studied by us, but their description (Butt & Shah, 1985) is remarkably similar to the ones we are dealing with. Location 2 contains a meter-thick sheet (sill-form) of white carbonatite that intrudes garnetiferous schist. Some metasomatism (feintization) is discernible near the carbonatite bodies. Locations 1 contains a larger, isolated exposure of mottled brown carbonate rich rock that is associated with amphibolite. From its high albite content, it can be concluded that it may be a fenite or fenitized carbonatite. The amphibolite may be derived from a basaltic/doleritic or lamprophyric precursor.

The garnetiferous schists hosting the carbonatites are extensively fractured, highly sheared, strongly folded, and pervasively intruded by granitic gneisses. The nature of the exposures gives the appearance of a minor shear zone or a border zone to a forceful intrusion. Although much of the deformation can be attributed to the Eocene-Oligocene Himalayan orogeny, some is likely to be due to the Carboniferous intrusion of the Swat granitic gneisses (DiPietro, 1990).

The carbonatite

The Carbonatite sill at location 2 in Figure 1 is a sugary textured medium-grained rock. It

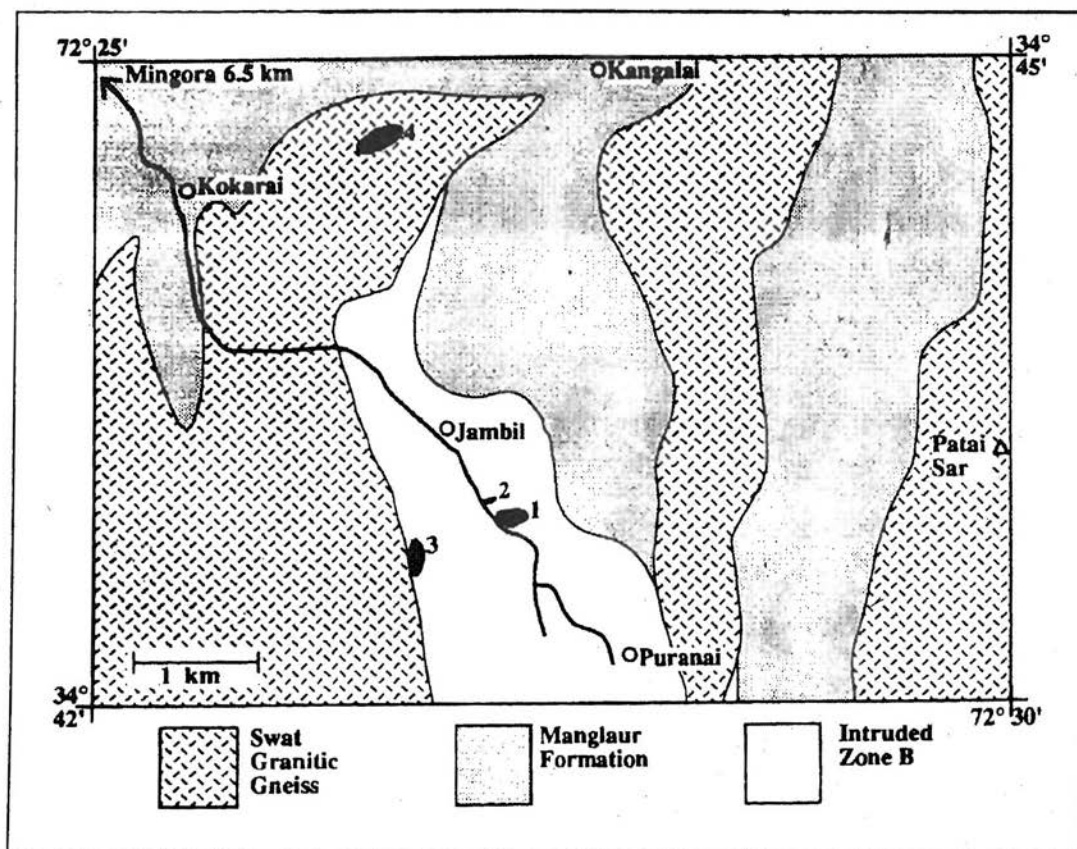


Fig. 1. Generalized geologic map of the northeast corner of the 43 B/6 15' quadrangle, Swat, Pakistan (after DiPietro, 1990). The heavy line represents the road from Mingora to Puranai. Four carbonate bodies indicated by number are as follows: 1 - mottled brown carbonatite associated with amphibolite; 2 - a one meter thick sill of white carbonatite; 3 and 4 - carbonatite bodies mapped by Butt and Shah (1985).

shows somewhat uneven distribution of mafic minerals that tend to define, at least locally, crude banding. The rock consists of carbonate (~80 modal%) and clinopyroxene, with small amount of epidote and minor to trace amounts of (?) cancrinite- vishevite, apatite, sphene, opaques, zircon, and (?) quartz and can be termed sovite according to the classification of (Brogger, 1921; Eckermann, 1948a). The carbonate effervesces readily in diluted HCl and has refractive indices typical of pure calcite. The clinopyroxene is weakly pleochroic green (? sodic) diopside with $\gamma:Z=40^\circ$ and $2V\gamma=55-60^\circ$.

Most of the epidote (clinozoisite) and vishevite display reaction relationship, with vishevite occurring as relics of intergrown calcite. The epidote grains show compositional zoning, as reflected by higher interference color towards matrix calcite. But epidote and vishevite also occur independently in well-formed, tiny granins adjacent to calcite, diopside, and apatite. Some of the independent epidote grains are perfectly euhedral, raising the possibility that the mineral may be of igneous origin. There are rare-tiny inclusions of vishenite in clinopyroxene and quartz in calcite.

Fenite

Thin zones of fine- to medium-grained fenites are discernable adjacent to the carbonatites. But there also are apparently independent masses of fenitic rocks many meters across. These may be related to larger carbonatite bodies, either removed by erosion or occurring at depth. In the following, we present details of one of such bodies (Location 1 in Fig.1) hosted by country rock amphibolite. This fine to medium-grained, subequigranular rock is mottled brown. It essentially consists of sodic plagioclase (abundant), carbonate, and biotite, minor amounts of opaque minerals and traces of

sericitic mica along fractures and grain boundaries.

Making about a third of the rock specimen that we studied, the carbonatite is unevenly distributed in irregular patches and as matrix to plagioclase, giving the rock a mottled look. The carbonate is commonly stained brownish red by hematite but many microfractures are filled by clear calcite. The plagioclase forms subrounded to subhedral, equant grains, commonly fresh and devoid of zoning. Biotite is pleochroic from yellow to orangy brown. Some biotite grains are strained and show non-uniform extinction; other than this, no deformation is observed in the rock. The opaque grains are commonly euhedral to subhedral, and consist of magnetite and oxidized/hydroxidized pyrite.

Selected microprobe analyses of the minerals in the fenite are presented in Table 1. The plagioclase (analyses 1 & 2) is nearly pure albite ($Ab > 98$ mole%), with very small amounts of anorthite and orthoclase components. But one analysis contains 4.4 mole% anorthite. The analyses are devoid of Ba, but contain about 0.3 wt% SrO and variable amounts (0.0 to 0.4 wt%) of FeO. The carbonate (analyses 9 & 10), as in the nearby carbonatite, is essentially calcite with small amounts of MgO, FeO, MnO, SrO, and traces of BaO. There is a minor variation in a zoned grain (with increase of Fe and MgO, and decrease of CaO and SrO from core to margin. A clear calcite filling a fracture (analysis 8) is devoid of FeO and MnO, and contains lower SrO and higher MgO than those of the main phases carbonate.

The magnetite analysis (No. 6) is not unusual in any way except for its low total. The reddish brown secondary material in the carbonatite (analysis 7) is, apparently, hematite.

TABLE 1. SELECTED MICROPROBE ANALYTICAL DATA ON FENITE

	1	2	3	4	5	6	7	8	9	10
SiO ₂	38.58	39.06	37.76	68.13	67.73	0.44	0.13	ND	ND	ND
TiO ₂	3.18	2.83	3.07	0.00	0.00	0.04	0.02	ND	ND	ND
Al ₂ O ₃	11.70	11.43	11.61	20.59	21.01	0.21	0.03	ND	ND	ND
FeO	20.30	19.45	19.27	0.18	0.41	84.67	100.34	0.00	0.75	3.05
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	1.02
MgO	13.91	14.45	13.70	0.00	0.01	0.04	0.05	1.52	0.72	1.22
CaO	0.33	0.39	0.63	0.77	0.01	0.01	0.02	57.38	57.11	52.01
SrO	ND	ND	0.23	ND	0.32	0.01	ND	0.20	0.83	0.42
BaO	ND	ND	0.31	ND	0.01	0.00	ND	0.06	0.00	0.01
Na ₂ O	0.19	0.11	0.18	9.21	9.68	0.01	0.00	ND	ND	ND
K ₂ O	10.00+	10.00	10.00	0.04	0.21	0.00	0.00	ND	ND	ND
Total	98.19	97.72	96.76	98.92	99.39	85.43	100.59	59.16	69.50	57.73

	Number of Cations						Mole Percentages			
Si	5.76	5.83	5.74	11.95	11.89	0.08	-	-	-	-
Al	2.06	2.01	2.08	4.26	4.34	0.01	-	-	-	-
Ti	0.36	0.32	0.35	0.00	0.00	15.88	-	-	-	-
Fe ³⁺	-	-	-	-	-	8.01	-	-	-	-
Fe ²⁺	2.54	2.43	2.45	0.03	0.06	0.00	0.00	1.0	4.2	
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.4	1.4	
Mg	3.10	3.22	3.11	0.00	00.00	0.00	3.51.7	1.7	3.0	
Ca	0.05	0.06	0.10	0.14	0.00	0.00	96.29	95.2	91.0	
Sr	-	-	0.02	-	0.03	0.00	0.2	0.7	0.4	
Ba	-	-	0.02	-	0.000	0.00	0.0	0.0	0.0	
Na	0.03	0.03	0.05	3.13	3.29	0.00				
K	1.91	1.91	1.94	0.01	0.05	0.00				

ND= Not determined; 1,2,3: biotite; 4,5: albite; 6: magnetite; 7: hematite; 8,9,10 carbonate 8 is clear vein carbonate; 9 is core and 10 is margin of the main carbonate phase. Cations based on 22 (O) in 1,2,3, and 32(O) in 4,5,6. K2) in all micas was underestimated by 3-4%; so a value of 10.0 wt% was assumed. In majority of carbonate analyses, CaO appears to be overestimated.

The biotite analyses (Table 1.1-3) are fairly uniform in composition. All are rather poor in Al₂O₃, resulting in a slight deficiency in Z site. They contain moderate amount of TiO₂ (2.7 to 3.2 wt%), and rather high MgO, but not sufficiently high to classify as phlogopite (Deer et al., 1962). The analyses also contain a constant amount of BaO and SrO (0.3 & 0.2 wt%, respectively). The consistent presence of Sr in the plagioclase, carbonate, and biotite is suggestion of a genetic link of the fenite with carbonatite.

DISCUSSION

Several occurrences of carbonatite have been reported in northern Pakistan. They can be grouped broadly into two types: 1) those associated closely in space and time with granitic to alkaline rocks i.e., Koga and Tarbela, and 2) those apparently occurring as independent intrusions, i.e., Sillai Patti and Loe Shilman. Radiometric data (Le Bas et al., 1987; Qureshi et al., 1991) suggest that the group 1 carbonatites were emplaced

during the Late Paleozoic (~ 300 Ma) and the group 2 carbonatites during the Oligocene (~30 Ma). Pb- Sr-Nd isotope data (Tilton et al., 1998) clearly supports this division as the two groups have distinct isotopic systematics.

Radiometric age dating has not been performed on the Jambil carbonatites, but two lines of evidence suggest that they are of Late Paleozoic age. Firstly, their close association with Late Paleozoic granitic rocks is very similar to that of the Koga area. Secondly, their isotopic composition is similar to the Koga carbonatite (Tilton et al., 1998). Since, there are many more granitic bodies of Late Paleozoic age in the Himalaya of Pakistan, there is a likelihood that additional bodies of carbonatite and related alkaline rocks would be discovered.

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