Vogesite from carbonatite complex of Tiruppattur, Tamil Nadu, India

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Abstract

Vogesite occurs as a melanocratic dyke rock in close proximity to carbonatite outcrops of Sevvattur. Vogesite was formed as a late magmatic differentiate of a monzonitic magma under CO_2-rich wet subvolcanic conditions. Postmagmatic fluids enriched in acidic components permeated through the rock causing development of lamprophyric character.

Introduction

Carbonatite complexes generally include rare alkaline rocks, shonkinites and lamprophyres. The carbonatite complex of Tiruppattur (N 12°15′ - 12°30′; E 78°25′ - 78°35′) is no exception. Amidst this complex, in the vicinity of carbonatitic outcrops of Sevvattur (N 12°25′; E 78°32′) described by Deans and Powell (1968), Borodin *et al* (1971), a melanocratic dyke rock of lamprophyric character occurs within granite gneiss. This rock was designated as vogesite on the basis of presence of two generations of black needles and rhombs of katophorite set in a matrix of potash feldspar. The rock is seen as an arcuate exposure for a length of 70 m and a width of 10 m. The emplacement of vogesite is localized by adjacent NE-SW trending shear planes. It is seen to occur within granite gneiss adjacent to the southern periphery of a plug of speckled syenite composed essentially of oligoclase and hornblende. Small plugs of biotite-oligoclasite, a heteromorphic variant of vogesite occur as minor intrusives in pyroxenites and in speckled syenites. Younger intrusives of anastomosing veins of pink alkali pegmatites are seen amidst vogesites.

Petrography

In thin section, the rock exhibits porphyritic to subophitic panidiomorphic texture. The presence of mafic minerals in matrix and as phenocrysts, and felsic minerals only in the matrix, are typical of this lamprophyre. Modal composition of the rock is as follows: orthoclase 26.74%, microcline 12.27%, oligoclase 20.86%, augite 3.62%, katophorite 28.31%, biotite 5.60%, chlorite 0.32%, calcite 0.16%, sphene 0.96%, apatite 0.21% and other accessories 0.37%. Bluish-green katophorite occurs in two generations as phenocrysts of euhedral rhombs and slender prisms, as well as poikilitic inclusions, in a matrix composed of orthoclase, oligoclase and microcline. Katophorite has the following optical properties: $2V_X$ small, $Z \wedge c$ 28°, $(\gamma - \alpha)$ 0 013, N_m 1.645, X-pale yellowish green, Y-bluish green, Z-bluish green. Katophorite is the only abundant mafic mineral present in the rock. Often, it shows colour zoning and less commonly twinning on (100). Orthoclase laths constitute the chief feldspar of the groundmass and oligoclase is subordinate to orthoclase. The optical properties of orthoclase are: $2V_X$ 74°, $X \wedge (100)$ 13°, $(\gamma - \alpha)$ 0.007. Orthoclase exhibits polysynthetic twinning of original plagioclase relics. 2θ values of 060 Cu Kα 42.20 and 2θ values for $\bar{2}04$ Cu Kα 51.00, indicate microcline state, in between orthoclase series and low albite series for the potassic

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phase. The orthoclase content estimated based on d 201 is Or 40% (mol). 2θ 131 peak at 30.84 indicates, that the potash feldspar is mainly anorthoclase. Again, the peak of 131 reflection is split into two sharp peaks at 2θ 30.60 and at 2θ 30.84 and it is indexed as 131 and $1\bar{3}1$ (Hutchison, 1974). Low triclinicity indicates (Δ0.25) a highly disordered state of the potash feldspar pointing high temperature condition with rapid cooling. This supports the petrographic observation of poikilitic texture of the rock fabric. Oligoclases are slightly richer in anorthite content (An_{24-28}). Twin laws of oligoclases are albite 11%, baveno 22%, manebach-ala 22%, albite-ala 45% and albite-carlsbad 22%. Of these, albite-carlsbad, baveno and manebach-ala twins may be postulated as primary. Saussuritization of plagioclases and occurrence of quartz are attributed to late stage alteration. Xenocrysts of quartz occur in the groundmass as deuteric minerals replacing oligoclase. Bluish-green biotite shows pleochroism from yellow to dark green and is often seen shooting out from mafic clusters. The low birefringence of biotite ($\gamma - \alpha$) 0.040 shows that the biotite is rich in magnesia. Granules of epidote show ($\gamma - \alpha$) 0.003, X- pale yellow, Y- greenish yellow and Z- lemon yellow. Calcite is interstitial to feldspar and amphibole. Lumps of sphene are found adjacent to amphibole sheaths. Calcite, biotite, epidote and bluish-green fibrous chlorite are developed at the expense of amphibole. Granules of magnesite and needles of apatite are quite numerous in the groundmass. Specimen collected at the marginal facies of vogesite shows flow orientation parallel to the walls of the dyke, evidenced by crude alignment of needles and elongate prisms of phenocrysts in the groundmass along the direction of flow.

Petrochemistry

Katophorite separated from vogesite was chemically analysed (Table I). Numbers of ions calculated on the basis of 24 (O, OH) is $(Si_{6\ 695}Al_{1.301}Ti_{0.004})_{8.00}$ $Ti_{0.137}$ $Fe'''_{1.019}Mg_{1.405}Fe''_{2.112}Mn_{0.038})_{4.71}$ $(Na_{1.508}Ca_{0.943}K_{0.830})_{3.28}$ $OH_{2.36}$. The composition of the amphibole falls near the field of katophorite (Sundius, 1946). A low ratio of 100 Mg : Mg + Fe'' + Fe''' + Mn (30.72) indicates that the mineral belongs to iron-rich katophorite (Miyashiro, 1957; Leake, 1978). Plots of Fe''/R'' and Fe'' + $(Al)^6$ of the mineral fall in igneous field. Tetrahedral site shows a substantial amount of replacement of Si by Al. Since the mineral is crystallized from an agpaitic environment, Al is typically absent in Y group. The Y and X groups fall within normal limits. The OH molecule is slightly in excess by 0.36 and this indicates that the mineral was formed under high water pressure condition.

Silicate analyses were carried out by ordinary gravimetric methods within an accuracy limit of ±0.01%. Trace analyses were carried out by using quartz grating spectrograph at the Geochemical Laboratory, Faculty of Geology, Moscow State University, USSR, with a precision of 0.8 ppm detection limit. Chemical analyses of vogesite and associated rocks are presented in Table I. All the rocks have 'k' values more than 0.37 and are, therefore, considered to be potassic. Even though, they are nepheline normative, the absence of nepheline and other foidal minerals indicates that the magma from which these rocks were formed, was crystallized under wet sub-volcanic conditions. Under such conditions, owing to high water pressure, the field of leucite was restricted to a narrow range of time and crystallization of feldspathoids was prevented (Naidu, 1963). The distribution of trace elements Cu 300 ppm, Cr 200 ppm, Co 30 ppm, Ni 60 ppm, Zn 1000 ppm, Mn 10000 ppm, Li 18 ppm, Rb 165 ppm, Ba 10000 ppm, Sr 10000 ppm, Zr 400 ppm, Ga 20 ppm, V 1000 ppm and

TABLE I. Chemical analyses of vogesite, associated rocks, and a katophorite separated from vogesite. Tiruppattur.

	723	733	18	7	Katophorite from vogesite	24 (O, OH)		
SiO_2	48.35	53.07	58.18	61.26	42.60	Si	6.695	8.00
						Al	1.301	
Al_2O_3	12.97	13.03	17.19	20.91	7.04	Ti	0.004	
Fe_2O_3	3.78	4.28	2.64	0.89	8.62	Ti	0.137	4.71
FeO	3.26	5.09	3.19	Tr	16.13	Fe'''	1.019	
						Mg	1.405	
MgO	2.68	3.75	1.36	Tr	6.95	Mn	0.038	
						Fe	2.112	
CaO	12.91	11.75	6.36	1.10	5.61			
						Na	1.508	3.28
Na_2O	3.54	4.00	5.40	4.67	4.94	Ca	0.943	
						K	0.830	
K_2O	5.00	3.93	4.08	8.84	4.13			
MnO	Nd.	Nd.	0.17	Nd.	0.25	OH	2.358	2.36
TiO_2	0.75	0.69	0.69	Nd.	1.20			
P_2O_5	1.06	0.48	0.29	Nd.	Nd.			
CO_2	2.76	Nd.	Nd.	Nd.	Nd.			
H_2O	3.15	0.38	0.20	0.35	2.25			
Total	100.21	100.43	99.75	98.02	99.72			

723 - Biotite oligoclasite, 733 - Vogesite, 18 - Hornblende syenite, 7 - Alkali pegmatite.
Analysts: R. Ramasamy and M. P. Ukina.

Pb 100 ppm are all well above the average crustal abundance of respective elements (Goldschmidt, 1954). High K/Rb ratio as well as high concentration of Rb indicate that the rock is highly fractionated by differentiation. High Ba, Sr values with enrichment of Nb 50 ppm, La 60 ppm, Yb 30 ppm, Y 100 ppm, points to their affinity to carbonatites. The low La/Yb ratio of 2 indicates that the rock has undergone subsequent metasomatic changes. Mineralogy and chemistry of various co-magmatic members of the alkaline complex ranges from monzonite to ultrapotassic syenites. From the structural and textural features of the anastomosing pegmatite intruding vogesite, it is inferred that the vogesite was formed by permeation of feldspathic material into a more melanocratic rock.

Discussion

Except vogesite and its anastomosing thin veins of alkali pegmatites, the other rocks in Sevvattur structural basin (Ramasamy, 1982) are all essentially composed of oligoclase than potash feldspar. It looks as though originally oligoclase-rich melanocratic monzonite got modified to vogesite by enrichment of potash feldspar through potash metasomatism by way of intrusion of alkali pegmatite. Similar modification also caused the formation of biotite-oligoclasite from hornblende-bearing monzonite through differing intensity of post-magmatic metasomatic processes. It is common that during a sequence of emplacement of co-magmatic rocks, plugs of earlier intrusions are subsequently modified by younger intrusives through metasomatism and permeation of post-magmatic fluids. Since all the magmatic rocks were fractionated and derived from the same parent magma, a crude trend of original magmatic differentiation is still existing among these group of rocks without much variation. Enrichment of primary calcite in speckled syenite, vogesite, biotite-oligoclasite, oligoclasite and silico-carbonatite indicates that all these rocks were formed under high CO_2 pressure. Enrichment of CO_2 in presence of water should be capable of adding or removing magnesia (Turner and Verhoogen, 1962). The wave of acidic components in the flow of transmagmatic and postmagmatic solutions formed under CO_2 and H_2O-rich environment percolated through rocks faster than basic components of the fluids (Korzhinsky, 1964). The acidity conditions of post-magmatic solution is directly opposite to the behaviour of fenitizing fluids which are normally associated with alkali-carbonatitic crystallization. The enrichment of acidic components in the flow of transmagmatic and postmagmatic solutions of carbonatite complex of Tiruppattur, caused a second generation of feldspathic and mafic constituents, an essential lamprophyric characteristic feature. This proves the absence of fenitization which normally causes desilicification and alkali enrichment. From the mineralogical and chemical composition of closely related rocks of vogesite, it is inferred that vogesite belongs to wall-rocks along with biotite oligoclasite and syenite (Table I). Biotite-oligoclasite is one of the co-magmatic members of carbonatitic complex of Tiruppattur and all varieties descended from a common monzonitic garnet magma with immiscible separation of carbonatitic magma at a later stage of differentiation. All the postmagmatic and transmagmatic rocks indicate enrichment of acidic and alkali components without any desilicification characteristic of fenitization.

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