American Mineralogist, Volume 62, pages 333–335, 1977

Post-emplacement alkali modifications in rapidly cooled acid volcanic rocks

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Abstract

The present work indicates that rapidly cooled calc-alkaline acid volcanic rocks do undergo post-emplacement devitrification modifications in their alkali content. They may not represent true magmatic compositions. This conclusion is contrary to that of Lipman *et al.* (1969).

Introduction

Significant changes in the composition of rhyolitic volcanic rocks can take place subsequent to extrusion, and silicic volcanic rocks that have devitrified or crystallized may not provide good approximations of magmatic compositions (Lipman, 1965). Appreciable loss of sodium during primary devitrifications has been demonstrated for certain peralkaline volcancic rocks, in which molecular alkalies exceed alumina (Noble, 1965a). But Lipman *et al.* (1969) have suggested that the initially devitrified calc-alkaline Cenozoic rhyolites do not tend to undergo measurable post-emplacement modifications of alkali contents by groundwater leaching or ion exchange as hydrated glasses do.

Material studied

This paper discusses the post-emplacement alkali modifications of acid volcanic rocks from the Tusham area (28° 53′N: 75° 55′E), 160 km WNW of Delhi in the northwest part of the Indian shield. The rocks, a comagmatic suite of felsite, quartz porphyry, ash beds, and muscovite granite, form the various members of the Tusham ring complex. These rocks belong to the calc-alkaline suite (Kochhar, in preparation) and have molecular proportion of alumina in excess of alkali and calcium. The suite is 940 ± 20 m.y. old (Kochhar, 1974), and it is possible that the felsite was affected by ground-water leaching while in the glassy state. Because of the antiquity no perlitic cracks are found in felsite.

Results

The felsite, ash beds, and muscovite-biotite granite are quite poor in sodium but rich in silica as compared to the quartz porphyry (Table 1). The low sodium content of these rocks is probably the result of devitrification and hydration (Friedman and Smith, 1958) and hydrothermal alterations. It is now well known that quickly cooled silicic volcanic rocks (which undergo devitrification with time) are highly susceptible to ground-water leaching.

Rapidly cooled acid volcanic rocks such as felsite have cristobalite in the groundmass and are more prone to alkali modifications, whereas more slowly cooled rocks such as quartz porphyry have primary quartz in their groundmass and are not susceptible to the leaching of sodium (*cf.* Noble, 1965b). The latter may represent true magmatic compositions. Ash beds that are porous and have a vitric groundmass are equally susceptible to sodium leaching. According to Noble (1965b) and Lipman (1965), rocks with vitric groundmass, particularly highly porous tuffs, may lose as much as 3 percent Na_2O. This explains the low soda contents of felsite and ash beds. Lofgren (1970) also indicates that alkali ratios of devitrified products differ from those of unaltered glass and are functions of the aqueous-phase composition.

The high content of potash in felsite and ash beds can also be explained by hydrothermal alterations, because during hydrothermal alteration and weathering, potash may be added to normal igneous rocks, and if leaching occurs, soda and lime may be removed to a larger extent than is potash (Terzaghi, 1935, 1948; Fenner, 1936). The presence of druses and numerous quartz veins with schorl and mica in

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Table 1. Chemical analyses

Sample	T35	3F1	3F3	3F5	1F1	4F2	1F15	TG2	AB
SiO_2	71.20	76.43	73.60	75.55	75.29	74.50	73.60	74.20	74.82
TiO_2	0.35	0.08	0.01	0.12	0.02	0.01	0.01	0.04	0.35
Al_2O_3	14.42	15.86	14.90	15.16	14.20	14.30	15.80	14.62	14.83
Fe_2O_3	1.51	1.71	4.30	0.48	4.18	5.10	5.84	5.63	2.86
FeO	2.00	0.50	0.60	1.90	0.45	0.65	0.20	0.86	1.55
MnO	0.01	tr	tr	0.01	0.01	tr	0.20	0.01	0.01
MgO	0.37	0.24	0.15	0.16	0.31	0.21	0.12	0.21	0.40
CaO	1.50	0.32	0.28	0.25	0.41	0.17	0.34	0.30	0.80
Na_2O	2.50	0.30	0.30	0.30	0.30	0.30	0.30	0.50	0.35
K_2O	6.50	3.85	4.50	5.20	3.10	3.10	4.10	3.00	3.29
P_2O_5	0.03	tr	tr	0.01	tr	tr	0.01	0.20	0.21
H_2O	0.43	0.62	0.40	0.66	0.61	0.40	0.43	0.56	0.42

Sample Descriptions: (all samples are from Tusham Hill)

T35 = quartz porphyry; TG2 = muscovite-biotite granite; AB = ash bed; 3F1, 1F1, 3F3, 4F2, 3F5, 1F15 = felsite

Nine samples were analyzed using rapid methods of Shapiro and Brannock (1962) and the alkalies were determined by the flame photometer method.

the felsite and ash beds indicates that the extrusion of these rocks was followed by a period in which hot aqueous solutions and gases were abundant, and which were responsible for the hydrothermal changes. The evidence of hydrothermal alterations in felsite and ash beds includes the following: the alteration of potash feldspar to sericite and magnetite to hematite, and the intersection of quartz phenocrysts by veinlets of sericite of the groundmass. The quartz porphyry, on the other hand, has not suffered hydrothermal alterations to that extent and is therefore not depleted in potash.

The muscovite–biotite granite, which is actually a microgranite, is also poor in sodium possibly because of hydrothermal alterations (*cf.* Terzaghi, 1948) coupled with alkali-ion exchange (*cf.* Scott, 1971; Orville, 1967).

The present study indicates that the rapidly cooled acid volcanic rocks do undergo post-emplacement modification in their alkali contents by devitrification and hydrothermal alterations. The conclusions arrived in this paper are contrary to that of Lipman *et al.* (1969).

Acknowledgments

Financial assistance from the Indian National Science Academy, New Delhi, is gratefully acknowledged.

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Manuscript received, April 28, 1976; accepted for publication, September 24, 1976.