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Analyses of upper-plate volcanic rocks at Picacho Peak, Pinal County, Arizona

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CONTENTS

ILLUSTRATIONS

TABLES

Introduction

Early Miocene, upper-plate volcanic rocks above the metamorphic core complex-related detachment fault at Picacho Peak, Pinal County, Arizona have K_2O content as high as 13 percent (Shafiqullah and others, 1976). Other volcanic rocks in Arizona with similarly high K_2O content have variously been called and compared to trachyandesites, ultrapotassic trachytes, and carbonatites (Shafiqullah and others, 1976), high-potassium trachytes (Scarborough and Wilt, 1979), and trachytes (Rehrig and Reynolds, 1980; Reynolds and Spencer, 1984). Whether or not the chemistry of these anomalously high K_2O volcanic rocks is magmatic (Shafiqullah and others, 1976) or metasomatic (Chapin and Glazner, 1983; Lindley and others, 1983; Brooks and Marvin, 1985) is controversial.

At Creede caldera, southwestern Colorado, Ratté and Steven (1967) showed that high potassium rocks containing as much as 11 percent K_2O and as little as 0.4 percent Na_2O had been metasomatised by younger intrusives; at Creede non-metasomatised rocks have K_2O:Na_2O ratios of approximately 1.4, and metasomatised rocks have ratios of 2.4 to 22.6.

Discussion and conclusions

An apparent decrease in K_2O content with distance from the core complex-related detachment fault (Shafiqullah and others, 1976) suggests that the detachment fault served as a conduit for hydrothermal fluids carrying excess K_2O and other elements. In order to test this spatial relationship a geochemical traverse was undertaken (fig. 1). Outcrop samples were taken at the surface trace of the detachment fault and the traverse was continued for approximately 7 km in the tilted rocks of the upper plate.

Picacho Peak andesites(?) are propylitically altered and have abundant secondary quartz and calcite in thin-section; therefore, SiO_2 and CaO analyses are unreliable. The K_2O content is as high as 11.3 percent (table 1), much higher than values given for high K_2O andesites; (1) >2.5 percent K_2O at 53-62 percent SiO_2 (Taylor, 1969), (2) 2.1-2.7 percent K_2O at 55-59 percent SiO_2 (Gill, 1981). Alteration-sensitive alkalies show a spatial relationship to the detachment with K_2O decreasing and Na_2O increasing away from the detachment fault; similarly, K_2O:Na_2O is 27.7 at the detachment and decreases to 1 approximately 7 km from the fault. Alteration is further indicated by LOI values of 2.5-9.1 percent, but they show no spatial relation to the detachment.

Alteration-insensitive TiO_2 (Gottfried and others, 1977) and Al_2O_3 seem little affected. Commonly considered to be an immobile element, Zr shows a similar spatial relationship to the detachment as K_2O. Zr is 350 ppm at the detachment and decreases to 186 ppm approximately 7 km from the fault (fig. 2). Other elements that show a spatial relationship to the detachment fault are Li (increasing with distance) and As (decreasing with distance). Rb and Ba content is anomalously high when compared to the Rb and Ba content of high K_2O andesites (Taylor, 1969; Gill, 1981); however, a well-defined spatial relationship to the detachment, such as is shown by analyses of the alkalies, is not present.

Quartz-calcite alteration, anomalous rock chemistry of upper plate volcanic rocks at Picacho Peak (K_2O, Na_2O, Zr, Li, As, Rb, and Ba), and the spatial relationship of K_2O, Na_2O, K_2O:Na_2O, and especially Zr, to the detachment support the premise that the rocks were altered by hydrothermal

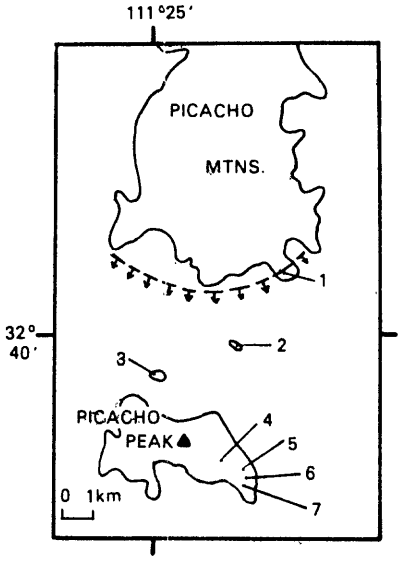

Figure 1.--Sample locations at Picacho Peak, Pinal County, Ariz. Analyses are given in table 1. Arrows indicate trace of detachment fault (Rehrig and Reynolds, 1980) and direction to upper plate.

Table 1.--Analyses of upper-plate volcanic rocks at Picacho Peak, Pinal County, Arizona

Field No.	PP1	PP2	PP3	PP4	PP5	PP6	PP7
Major elements (weight percent, uncorrected) determined by x-ray spectroscopy, analyst, K. Stewart; $FeTO_3$ indicates total iron reported as Fe_2O_3							
SiO_2	47.0	56.6	50.8	50.4	51.6	46.1	49.2
Al_2O_3	13.4	14.5	14.9	13.5	14.8	15.1	16.8
$FeTO_3$	5.9	7.3	6.8	6.5	6.7	6.0	7.5
MgO	0.2	0.6	0.3	4.1	2.4	4.2	6.1
CaO	11.6	3.5	7.1	7.6	6.6	9.6	4.8
Na_2O	0.4	0.8	0.5	1.2	2.1	3.0	3.9
K_2O	11.1	11.0	11.3	6.9	7.3	4.9	3.8
TiO_2	0.9	1.1	1.1	0.8	0.8	0.8	1.0
P_2O_5	0.6	0.9	0.8	0.6	0.6	0.4	0.5
MnO	0.2	0.3	0.3	0.4	0.2	0.2	0.2
LOI 900°C	8.6	2.5	5.4	7.7	6.0	9.1	5.5
K_2O:Na_2O	27.7	13.7	22.6	5.7	3.5	1.6	1.0
Trace elements (ppm) determined by ICP method, analyst P. H. Briggs; --- not reported							
Mn	1300	2200	2000	2700	1800	1600	1200
Ag	<2	<2	3	<2	<2	2	<2
As	100	10	30	<10	<10	<10	<10
Au	<8	<8	<8	<8	<8	<8	<8
Be	1	2	3	2	2	1	2
Bi	<10	<10	<10	<10	<10	<10	<10
Cd	<2	<2	<2	<2	<2	<2	<2
Ce	120	110	130	150	130	91	84
Co	10	24	13	24	23	28	36
Cr	58	25	71	150	130	130	48
Cu	23	120	110	5	---	---	12
Eu	<2	<2	2	2	2	<2	<2
Ga	18	19	20	20	17	19	27
Ho	<4	<4	<4	<4	<4	<4	<4
La	75	63	76	89	74	49	53
Li	15	34	19	120	45	110	160
Mo	3	2	<2	<2	<2	<2	<2
Nd	50	45	56	69	62	48	43
Ni	20	28	28	96	65	81	50
Pb	130	120	470	14	16	13	16
Sc	10	10	11	13	14	18	15
Sn	<20	<20	<20	<20	<20	<20	<20
Ta	<40	<40	<40	<40	<40	<40	<40
Th	6	14	9	16	15	10	6
U	<100	<100	<100	<100	<100	<100	<100
V	110	120	130	170	170	150	140
Yb	2	3	3	2	2	1	1
Zn	25	1100	800	150	44	98	330
Trace elements (ppm) determined by an energy dispersive analyzer Cd^{109} source for Rb, Sr, Y, Zr, and Nb; Am^{95} source for Ba, analysts W. E. Brooks and R. A. Yeoman							
Rb	381	379	345	205	235	124	101
Sr	196	149	142	209	439	510	733
Y	26	22	25	28	16	27	9
Zr	357	323	347	320	271	247	186
Nb	14	27	12	16	13	11	0
Ba	1485	2144	2469	2122	2350	1881	1707
(increasing distance from surface trace of the Picacho Peak detachment fault--->)							

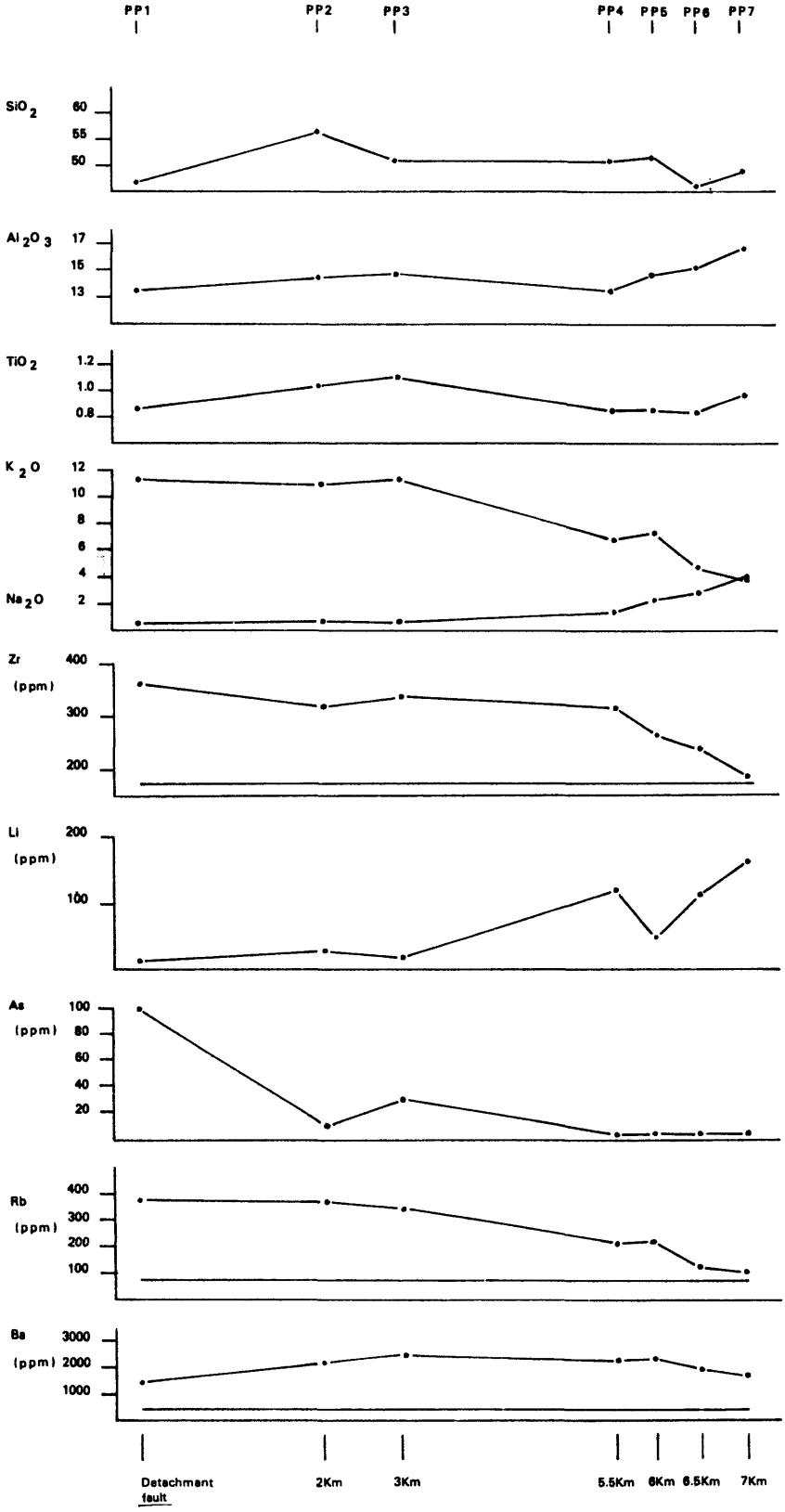

Figure 2.--Variation of selected oxides and elements with distance from Picacho Peak detachment fault. Solid line indicates Zr, Rb, and Ba averages of high K_2O andesites from Taylor, 1969; Li and As averages are not available.

fluids moving along the detachment conduit. Therefore, analyses of these altered, K_2O-metasomatised lavas should not be considered representative of magmatic chemistry.

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