NUEVOS ANALISIS DE LAVAS Y BOMBAS DEL VOLCAN RINCON DE LA VIEJA, COSTA RICA

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RESUMEN:

En diversas visitas a la cima del Volcán Rincón de la Vieja se recolectaron 5 muestras de productos eruptados recientemente y 7 muestras de productos de erupciones anteriores. Las 12 muestras andesitas porfiríticas pilostaxísticas con fenocristales de plagioclasa, augita y magnetita.

Aunque estas comprenden un rango limitado en sus contenidos de sílica (56-59 °/o por peso) y magnesio (3-4.5 °/o por peso), los análisis de las muestras sugieren cambios sistemáticos en el tiempo para algunos de los óxidos principales, elementos traza y en las razones de los elementos incompatibles, cuando se comparan las muestras entre sí, a contenidos similares de MnO, el FeO* ha disminuido y el Al_2O_3, K_2O y Ba han sumentado con el tiempo. Además la relación K_2O/Na_2O aumentó de .45 a .55 y la relación K/Ba aumentó de 15 a 17.

El cambio progresivo en la concentración de elementos incompatibles es el que debería esperarse si un sistema de cámara magmática abierta, grande y de larga vida, hubiera alimentado este centro volcánico.

Las pocas muestras presentadas aquí sugieren que este centro volcánico puede ser adecuado para examinar el desarrollo, en un tiempo largo, de un sistema magmático abierto.

NEW ANALYSES OF LAVAS AND BOMBS FROM RINCON DE LA VIEJA VOLCANO, COSTA RICA

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ABSTRACT

Visits to the summit area of Rincón de la Vieja provided five samples of recent eruptive products and samples from earlier eruptive periods. The 12 samples are porphyritic, pilotaxitic andesites with phenocrysts of plagioclase, augite and magnetite. Although they span a limited range of silica contents (56-59 wt °/o) and magnesia contents (3-4.5 wt °/o), the samples analysed suggest systematic changes over time for certain major oxides, trace elements and incompatible elemen ratios. When compared at similar MgO contents, FeO* has decreased and Al_2O_3, K_2O and Ba have increased

whith time. In addition, the K_2O/Na_2O ratio increased from .45 to .55 and the K/Ba ratio increased from 15 to 17. The progressive changes in concentrations of incompatible elements are what would be expected if a large, long-lived, open-system magma chamber was feeding this volcanic center. The few samples presented here suggest that this volcanic center may be suitable for examining the long term development of an open magmatic system.

INTRODUCTION

Rincón de la Vieja, the largest volcanic center in the Guanacaste range of northwestern Costa Rica, has a volume of about 250 km^3 (Carr, 1984). This center is comprised of 6 readily identifiable recent vents and three peaks that appear to be remnants of an earlier generation of cones (Healy, 1969). The major vents are identified in Figure 1. The coalescing cones form an elongate structure that trends about N60W, parallel to the volcanic front. The elevations of the 6 principal cones varies over a narrow range between 1670 and 1920 m. The divides between the cones vary between 1550 and 1700 m. Since the cones are spread over an 8 km long axis, the volcano appears from a distance as a long ridge.

Most historic eruptions of Rincón de la Vieja appear to have been vulcanian, strombolian or phreatic explosions from the Cráter Activo (Barquero y Segura, 1983). One of the larger eruptions in the last two decades occurred on December 19, 1966, when eruptions of bombs, blocks and ash destroyed vegetation up to two km from the crater (Barquero y Segura, 1983). Subsequent eruptions, including the recent eruption in February 1983, appear to have affected smaller areas (Barquero y Segura, 1983).

Very limited geochemical data exists for volcanoes in the cordillera de Guanacaste. Kussmaul et al. (1982) list only 9 analyses for the stratovolcanoes other than Arenal, which has been extensively studied (Malavassi, 1979). The available data include four analyses of Rincón de la Vieja, which are interpreted as normal andesites with FeO/MgO ratios consistent with a crustal thickness of 25-30 km (Kussmaul et al., 1982).

DATA

Twelve samples were analysed using a DCP-AES technique described by Feigenson and Carr (1985). Raw data are presented in Table 1. The variation diagrams were prepared after recalculating the analyses to 100 % on a water-free basis.

The strctural and stratigraphic setting of the samples were defined by reference to Healy (1969), the 1:50.000 quadrangle maps. Curubande and Cacao, and the photomosaic of Rincón de la Vieja in Bergoeing (1978) and Weyl (1980).

PETROGRAPHY

The andesites sampled have phenocrysts of plagioclase, augite, hypersthene and magnetite, which occur separately or in glomeroporphyritic clusters. The textures of the samples from von Seebach are distinctively porphyritic-pilotaxitic. Samples from Santa María are porphyritic-intergranular and have distinctive pyroxenes comprised of orthopyroxene cores and augite overgrowths. Plagioclases are quite variable in all samples. Large clear, strongly zoned crystals coexist with highly resorbed and mottled crystals. As a group the samples are normal two-pyroxene andesites, like those typically found at other volcanoes from the Central American volcanic front.

STRUCTURE AND STRATIGRAPHY

No detailed geologic mapping has been done at Rincón de la Vieja, so the brief outline of its geologic history that follows is not well constrained and is only an extension of the photogeologic interpretation of Healy (1969). Our purpose is just to provide a simple stratigraphic framework for the samples we have analysed.

Healy (1969) recognized a series of scarps that extend around the southern and eastern flanks of the volcano (I and II in Fig. 1.). He suggested they are the remnantes of a caldera with a diameter of about 15 to 20 km. The present ridge-shaped volcanic center fits within this suggested caldera. Further evidence for the existence of a large caldera is

an extensive ignimbrite sheet which slopes gently to the south away from the volcano.

Healy proposed that the recent vents were controlled by two volcanic lineaments, an east-alignment including the Cráter Activo, The Rincón de la Vieja cone, the von Seebach cone and the deeply eroded crater drained toward the north by the Río Blanco. The second alignment runs southeast from the von Seebach cone, to Santa María, to the double vent whose northeastern flank is drained by the Río Aguas Verdes.

We suggest additional controls on vent alignment. Four of the cones, beginning with Santa María, and extending through Rincón de la Vieja, Cráter Activo and von Seebach, define an arc. Topographic offsets and stream cuts extend this structure into a horseshoe shape, open to the south. The prominent geothermal area (at in Figure 1) occurs where the eastern and western arms of this structure would intersect. We suggest that this elliptical pattern, (III in Fig. 1), is caused by a partially buried caldera much younger than the one suggested by Healy (1969).

The large caldera suggested by Healy (1969) is made up of subtle scarps on the southwest and south flanks (I in Fig. 1) and an obvious scarp (II in Fig. 1) on the east flank. We suggest that the much fresher and younger appearing scarp on the east flank represents a small, more recent caldera that has coincided in part with the larger caldera suggested by Healy.

The flanks of the volcano to the south of its main axis are deeply dissected. In contrast, the flanks to the north are smooth and appear to be newly constructed. Differential erosion should have produced the opposite effect, because rainfall is much greater on the northern, Caribbean side. The recently active vents appear to have formed just north of the remnants of a preexisting ridge and, therefore, most recent lavas have gone north. Only Santa María has produced a substantial quantity of lavas that have flowed to the south.

During our three brief visits to Rincón de la Vieja we have sampled deposits from three of the centers which can easily be assigned relative ages on the basis of extent of erosion of lava fields and the historic record. The oldest rocks sample are three lava flows on the heavily forested south flank of Santa María. Four lavas of intermediate age were collected near the summit of the historically inactive von Seebach cone. The youngest samples are five recent bombs which erupted from the Cráter Activo, most likely in the large eruption of 1966.

RESULTS

The twelve samples analysed define a narrow range in SiO_2 and MgO contents. In general, they are normal andesites, as was the case for previous samples from Rincón de la Vieja (Kussmaul et al., 1982). However, in Figure 2 there are slight variations between the three stratigraphic groups; the older Santa María lavas (stars), the intermediate aged lavas from von Seebach (triangles), and the recently erupted bombs (circles). When compared at similar MgO contents, FeO* has decreased with time and Al_2O_3, K_2O and Ba have increased. In addition the K_2O/Na_2O ratio increased from .45 to .55 and the K/Ba ratio increased from 15 to 17 over the stratigraphic interval sampled.

DISCUSSION

The limited number of analyses available, especially in comparison with the complexity of this volcanic center, prevent us from making any general conclusions about the petrogenetic evolution of Rincón de la Vieja. Instead, we suggest that the elongate, coalescing structure of this volcano may provide a fairly complete stratigraphic sequnce of a developing composite volcano. The available samples indicate that the incompatible element contents of lavas at a similar stage of fractionation have been increasing with time. Carr (1984) has shown that larger Central American volcanoes generally have higher incompatible element contents than smaller ones. However, it is no clear whether this is caused by differences in the parental magmas, or by progressive enrichment in incompatible elements during the growth of the volcano. Available data from Rincón de la Vieja suggest that the latter hypothesis is correct and that the magma chamber feeding the volcano has become progressively more enriched in incompatible elements, probably by

open system processes described by O' Hara and Mathews (1981).

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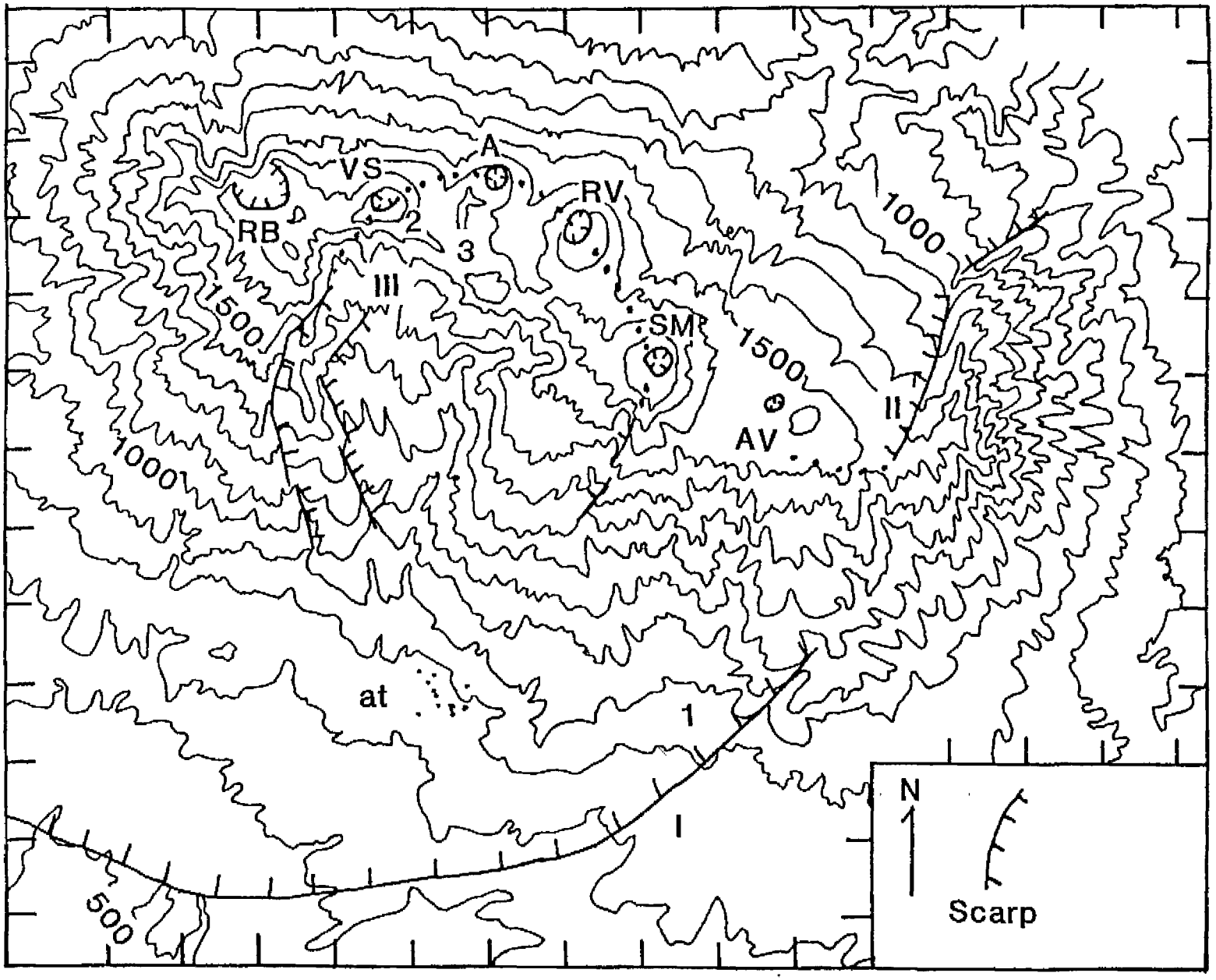
TABLE AND FIGURE CAPTIONS

TABLE 1. New analyses of samples from Rincón de la Vieja. Key refers to the cone that produced the sample: SM-Santa María. VS-von Seebach. AC-Crater Activo.

FIGURE 1. Location map of Rincón de la Vieja. Ticks have 1 km spacing. Contour interval 100 m. Roman numerals are scarps: I-large caldera of Healy (1969). II-young caldera on east flank, III-elliptical caldera proposed here. Capital letters are cones: RB-deeply eroded cone drained by Río Blanco, VS-von Seebach, A-Cráter Activo, RV-Rincón de la Vieja. SM-Santa María. AV-double cone drained by the Río Aguas Verdes. Numbers are sample sites: 1—Santa María samples, 2-von Seebach samples, 3-Cráter Activo samples. The prominent hot spring area ia marked by the at.

FIGURE 2. Variation diagrams for samples from Rincón de la Vieja. Stars are older lavas from Santa María. Triangles are intermediate aged samples from von Seebach. Circles are recent bombs from the Cráter Activo.

Sample	RU1	RU15	RU16	RU27	RU28	RU29	RU30	RU3	RU4	RU4A	RU5	RU26
Key	SM	SM	SM	VS	VS	VS	VS	AC	AC	AC	AC	AC
SiO2	56.59	57.32	57.53	56.89	57.46	58.91	56.99	57.09	56.99	58.91	57.27	57.71
TiO2	0.69	0.65	0.71	0.70	0.73	0.61	0.70	0.75	0.79	0.71	0.74	0.73
Al2O3	16.90	17.89	17.25	16.99	17.26	17.36	16.88	16.48	16.67	16.50	16.63	15.78
FeO	7.13	7.00	7.30	7.65	7.61	6.51	7.58	8.36	8.10	7.38	8.19	7.84
MnO	0.16	0.15	0.15	0.16	0.16	0.15	0.16	0.17	0.18	0.15	0.16	0.16
MgO	4.46	4.01	3.79	4.37	4.02	2.97	4.37	4.21	4.30	3.55	4.41	4.26
CaO	8.29	7.70	7.33	8.25	7.91	6.63	7.83	7.69	7.80	6.98	7.79	7.13
Na2O	3.01	3.22	3.09	3.02	3.14	3.10	3.10	3.01	3.04	3.16	3.04	3.03
K2O	1.37	1.40	1.46	1.55	1.60	1.61	1.65	1.60	1.63	1.98	1.65	1.69
P2O5	0.18	0.17	0.21	0.20	0.20	0.22	0.19	0.22	0.19	0.20	0.20	0.22
H2O+	0.31	0.37	0.42	0.46	0.25	1.05	0.21	0.42	0.57	0.46	0.27	0.37
Total	99.09	99.88	99.24	100.24	100.34	99.12	99.66	100.00	100.26	99.98	100.35	98.92
Rb	21.8	21.6	31.6	33.3	27.9	39.1	43.2	40.7	31.5	39.4	37.4	36.4
Ba	749	758	862	792	792	866	787	818	809	951	825	814
Sr	557	659	530	521	511	531	494	516	495	468	507	455
V	215	210	216	228	215	180	207	248	215	210	230	230
Cr	58	28	35	25	19	20	25	36	176	27	60	24
Ni	17	15	19	16	11	13	16	20	17	13	25	16
Zr	118	115	120	122	126	125	118	147	136	151	128	118
Sc	25.8	22.0	23.9	25.8	23.1	20.0	25.0	25.8	25.5	22.9	26.4	26.3
Cu	111	79	102	113	102	78	107	158	138	90	124	111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