An Overview to the High-K and Shoshonite Andesite Lava in Simara Island (Central Philippines)

Consideraciones acerca de la lavas andesíticas ricas en K, y shoshoníticas de la isla de Simara (Filipinas Central)

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ABSTRACT

The Simara island is an extinct Pliocene volcanic island geographically situated at the central portion of the Philippines. This island likewise represents the southernmost end volcanic center of the Luzon Arc, an arc produced by the eastward subduction of the South China Sea oceanic basin along the Manila Trench. Situated west-southwest of Simara is a fragment of micro-continental North Palawan-Mindoro Block, which collided with the western Philippine mobile belt during Miocene. The island comprises andesitic lava flow and pyroclastic products alongside with limestone deposit. Geochemical analyses indicates high-K and shoshonite andesite island arc signatures.

RESUMEN

La isla de Simara es una isla volcánica pliocénica extinguida situada en la zona central de las Filipinas. Esta isla representa el extremo sur del Arco de Luzón, un arco producido por la subducción en dirección este de la cuenca oceánica del Mar del Sur de China a lo largo de la Trinchera de Manila. Al oeste-suroeste de Simara hay un fragmento del Bloque micro-continental Norte de Palawan-Mindoro, que colisionó durante el Mioceno con el cinturón móvil de Filipinas occidental. La isla comprende flujos de lava andesítica y productos piroclásticos junto con depósitos calizos. Los análisis geoquímicos indican rasgos de andesitas de arco de isla shoshoníticas y con alto contenido en potasio.

***Key words**: High-K, Shoshonite, Andesite, Simara island, Luzon arc, Philippines*

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Introduction

The Philippines Islands are represented by island-arc volcanism and continental collision. Active and inactive subduction zones surround the entire archipelago which form chains of front and back-arc volcanism having geochemical signatures from tholeiitic, calc-alkaline and shoshonitic eruptive centers. Likewise, associated to the subduction is the emplacement of plutons, which became the backbone in most of the Philippine Cordilleras (highlands). Complex faulting transects the entire islands.

Simara (12°49'N-122°3'E) is one of the island of the Romblon Group of

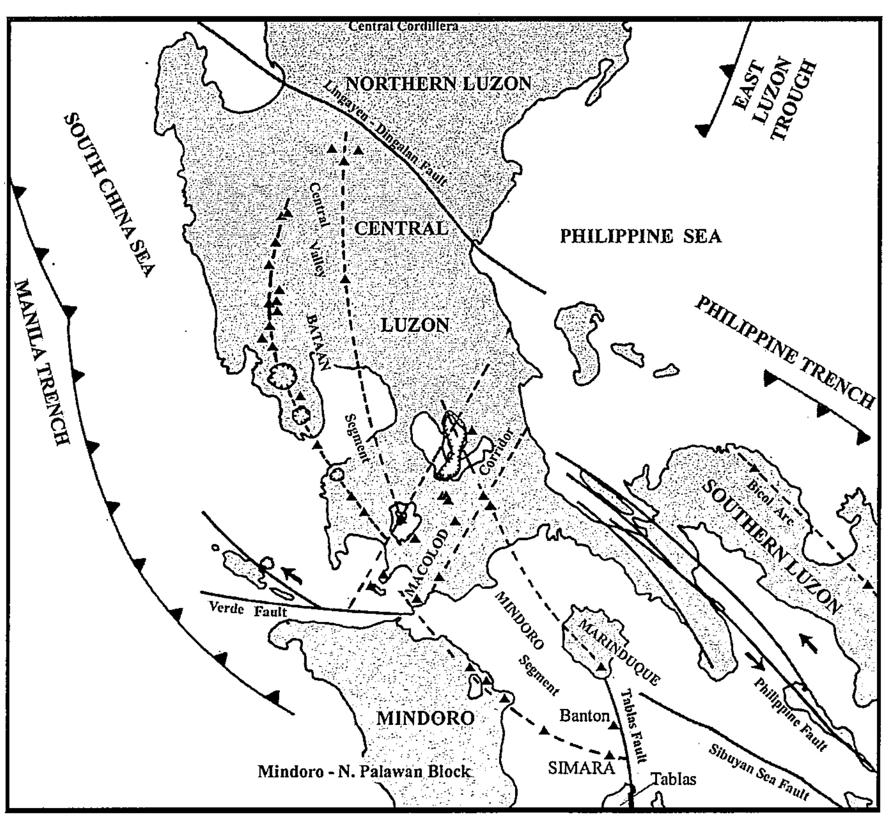

Fig. 1.- Location map of Simara island and simplified tectonic map of southern Luzon, Philippines. Triangles represent volcanic centers.

Fig. 1. - Mapa de situación de la isla de Simara y mapa tectónico simplificado de la parte meridional de Luzon (islas Filipinas). Los triángulos representan centros volcánicos.

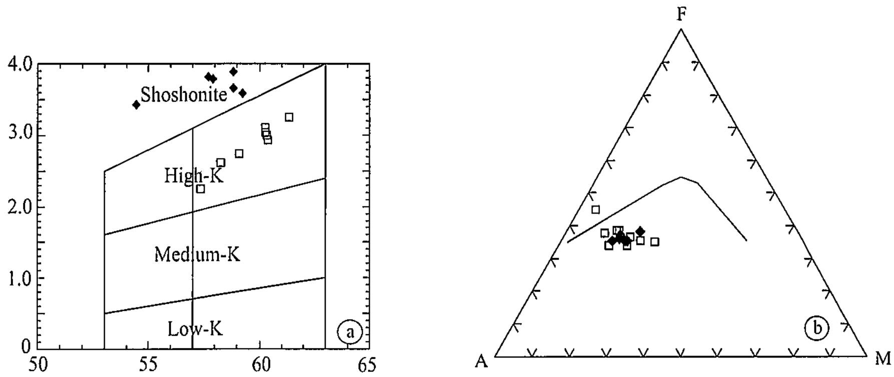

Fig. 2.- (a) The K_2O-SiO_2 diagram which classified the Simara lavas as high-K and shoshonite andesite. (b) The AFM diagram showing calc-alkaline affinity and absence of Fe-enrichment.

Fig. 2.- (a) Diagrama K_2O-SiO_2 que permite clasificar las lavas de Simara como andesitas ricas en K y shoshonitas. (b) Diagrama AFM que muestra la afinidad calco-alcalina y la ausencia de enriquecimento en Fe.

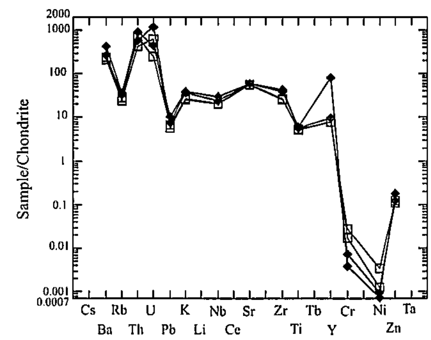

Fig. 3.- The spider diagram of Simara trace element normalized to chondrite. Symbols the same as in Fig. 2a.

Fig. 3.- Diagrama de elementos traza de la isla de Simara normalizados a condrita. Simbolos idénticos a los de la Fig. 2a.

Islands, situated in the central portion of the Philippine Archipelago (Fig.-1). This 23.4 km^2 island lies between Tablas and Banton islands and bounded on the east and on the west by Romblon Pass and Tablas Strait, respectively. Topographically, the northern section of Simara is characterized by relatively flat while the southern half is rolling with northeast trending ridges, which can attain a height of 189 m.

This extinct volcanic island is the southernmost volcanic center of the Luzon Arc, an arc which traverse 1,200 km long in an almost north-south trend and 200-300 km wide extending eastward (Fig.-1). It comprises of chains of stratovolcanoes and volcanic plugs extending from the segment of Mindoro (13ºN) to the Coastal Range of Taiwan (21ºN) (Richard *et al.*, 1986; Defant *et al.*, 1990). Additional segments which comprise the entire stretch of the arc from south to north such are Bataan, Northern Luzon and Babuyan-Batanes (Bashi). Separating between the Mindoro and Bataan segments is the northeast-southwest Macolod Corridor. Volcanism throughout the Luzon arc is associated to the eastward trend subduction of South China Sea basin beneath the western margin of the Philippine Sea plate along the Manila Trench. Situated west-southwest of Mindoro segment is the Mindoro-North Palawan Block, a detached micro-continental block, which collided with the exotic western Philippine terrain during Miocene (Taylor and Hayes, 1983).

Geology

In regional geology and stratigraphy the volcanic rocks in Simara classified and corresponds to Banton volcanics with short eruption period of early Pliocene (JICA-MMAJ, 1990). Whereas, the sedimentary rocks are under the Pliocene and Pleistocene Peli Formation (BMG, 1981; JICA-MMAJ, 1990). Malapitan and Pastor (1996) roughly mapped two main rock types in the island: 1) andesite volcanic flows and pyroclastics and 2) sedimentary rocks (clastic and limestone).

In detail, Simara island can be subdivided into three zones: the northern, the central and southern. The northern district is generally composed of coralline limestone and boulder-sized volcanic rocks, which overlying the volcanic pyroclastic and lava flow. Limestone outcrop varies in thickness from more than 1 m in the southern section and increases approximately to more massive 5 m in northern portion. The clastic deposits are composed mainly of conglomerate bed with interbedded sandy shale. Sporadic outcrops of relatively thin (~2 m) volcanic materials are limited to the southern section. The central and southern zones are northeasterly trend volcanic ridges. However, in the central part is characterized by massive boulder sized volcanic materials. No in-situ outcrops mapped in this area. Separating the central and southern zones is an inward extension deposit of limestone. The southern part is constituted of chaotic deposits of volcanic lava and pyroclastic material. In southern tip of the island the volcanic assemblages were affected by bleached color hydrothermal alteration. There is no defined demarcation mark between high-K and shoshonite andesites.

Petrology and Mineral Chemistry

Whole rock and mineral chemistry were analyzed at the *Laboratorio de Geología y Geoquímica de los Servicios Comunes de Investigación* in the University of Oviedo, using XRF Philips 1424 and Cameca SX 50 electron microprobe.

The entire bulk of Simara volcanic is constructed of light to middle-gray and whitish andesite. It is generally porphyritic in texture but shoshonite andesite is relatively less porphyritic containing <35% of phenocrysts. High-K andesite has minor variational textures such as glomeroporphyritic and diabasic.

Plagioclase is the dominant crystal for both andesite types. It is twinned and normaly or reversey zoned. It is typically resorbed. The mineral compositions are relatively within the same ranges of An_{70-45} and An_{64-39} for shoshonite and high-K, respectively.

Both calcic rich and poor pyroxenes precipitated in the two andesite lavas, having modal analyses typically <10%. Pyroxenes are magnesium rich, typical in an island-arc setting (Gill, 1981). Calcic high augite and diopside pyroxenes and calcic low enstatite pyroxene both crystallized in a single sample.

Calcic amphibole crystallized in Simara lavas. It is infrequent in shoshonite. It features by dark Fe-oxide rim which also traverse the inner section of the grains and also by formation of oxyhornblende. It is variational into hornblende, pargasite, edenite and magnesio-hastingsite.

Biotite likewise precipitated in both Simara rocks. Normally occurred with thin red opacite enclosing rim. The Al^{IV} and Fe^{+2} (Fe^{+2}+Mg) ranges from 1.8-2.5 and 0.19-0.53, respectively for high-K andesites whereas for shoshonite lavas

Sample	ROM-20	ROM-21	ROM-22	ROM-23	SMR-01	SMR-03	SMR-05	SMR-06A	SMR-09	SMR-12A	SMR-14	SMR-16	SMR-22
SiO2	54,45	58,83	57,72	57,92	58,82	57,26	61,04	58,28	59,27	60,36	59,13	60,32	60,25
TiO2	0,73	0,65	0,62	0,65	0,68	0,59	0,54	0,6	0,63	0,6	0,57	0,59	0,6
Al2O3	18,22	17,94	17,11	16,99	16,67	17,95	16,42	16,31	16,77	16,66	16,48	17,08	16,92
Fe2O3T	7,01	5,66	6,25	6,14	5,96	6,05	5,23	6,06	5,78	5,93	5,66	5,69	6,03
MnO	0,12	0,07	0,1	0,09	0,08	0,11	0,1	0,11	0,09	0,1	0,11	0,07	0,11
MgO	3,35	2,03	2,33	2,84	2,63	0,61	1,9	4,01	2,26	2,65	3,03	1,48	2,18
CaO	6,23	3,65	5,21	5,48	6,12	2,95	5,03	6,76	5,33	5,93	6,74	5,68	5,36
Na2O	3,46	3,37	3,42	3,47	3,54	3,87	3,72	3,44	3,42	3,68	3,37	3,65	3,63
K2O	3,42	3,89	3,81	3,79	3,65	2,26	3,32	2,63	3,58	2,96	2,72	3,08	3,02
P2O5	0,27	0,25	0,24	0,25	0,27	0,2	0,21	0,21	0,27	0,24	0,21	0,24	0,23
LOI	2,38	3,02	2,52	1,65	1,16	6,63	1,76	1,37	2,03	0,52	1,38	1,8	0,95
Total	99,65	99,36	99,33	99,3	99,57	99,47	99,27	99,78	99,44	99,61	99,38	99,67	99,28
Ba	1135,5	1421	917,3	945,1	884,7	957,1	884,4	714,1	973,5	784,9	796,9	1231,8	925,2
Rb	67,4	126,1	116,4	131,1	127,6	107,8	108,7	84,2	119,3	96,8	96,6	104,5	99,8
Sr	740,2	706,7	703,2	681,7	700,7	576,4	694,4	659,4	695,3	707,5	662,1	734,1	700,4
Y	22,5	186,5	21,7	19	23,1	13,1	17,5	17,2	21	18,5	17,5	23	19
Zr	240,3	233,6	216,8	224,1	220,1	171,5	176,7	138,3	218,8	155,8	146,9	160,5	160,5
Nb	16,4	10,9	9,2	9,9	9,7	8,3	8,5	7,7	9,4	8,1	7,8	8,3	8,4
Th	28,2	37,6	24,3	36,1	32	34,3	34,3	18,2	34,5	23,2	29,2	29,4	30,2
Pb	28,3	37,1	26,5	24,2	21,2	25,9	26,5	20,8	23,7	19,5	24	23,9	24,5
Zn	63,6	82,3	56,5	54	53,1	52,6	50,3	56,5	52,6	51,5	50,9	54,5	54,4
Cu	80,5	82,8	90,4	97,9	114,9	68,6	82,8	58,3	75,6	72,6	89,9	68,1	82,6
Ni	15,4	12,6	16,1	13,4	9,7	5,6	5,1	58,2	5,5	5	21	5,5	5,1
V	176,4	154,3	147,1	168,9	154,7	118,2	122,2	133,6	134	157,9	129,5	157	136,6
Cr	25,7	15,4	28,5	30,5	30,3	28,3	15,1	113	16,7	22,1	67,6	21,4	22,3
Co	47,8	51,3	59,6	49,5	43,1	39,4	48,8	32,5	36,1	41,5	39,3	33,3	36,2
U	16,4	5,6	14,2	5,4	5,8	5,3	3,7	7,4	6	8,9	3,1	3,9	5,2

Table I.- Major and trace elements samples of Simara shoshonite and high-K andesite lavas.

Tabla I.- Elementos mayores y trazas de lavas de andesitas de alto K y shoshoniticas de Simara.

it vary typically from 2.01 to 2.4 and 0.18-0.42, respectively.

Traces of quartz and iddingsite were detected in shoshonite but lacking in high-K lavas. Magnetite typically in microcrystals form ~3% for both lava types.

Geochemistry

The representative major and trace elements of Simara high-K and shoshonite andesite lavas are listed in Table 1.

The most noted difference between the two lavas is the K_2O content which is relatively much higher in shoshonite lavas; however both exhibiting restricted values of SiO_2, which classified both as acid andesites (Fig.-2a; Gill, 1981). The Fe_2O_3 values are relatively enriched in shoshonitic lavas 5.7-7.0%, while the high-K andesites have values ranging (5.2-6.0%), but the two lavas are not marked by Fe-enrichment and further identified as calc-alkaline signatures (Fig.-2b). MgO values are relatively the same. TiO_2 contents are typical of island-arc affinity, shoshonite signatures are higher (0.6-0.73%) than high-K (0.54-0.6%). Al_2O_3 values are much lower in high-K (16.3-17.9%) than shoshonite (16.7-18.2%). CaO and Na_2O concentrations for both rock types are relatively equal, but CaO values are relatively much higher in high-K andesites. The Na_2O+K_2O is more elevated in shoshonite than high-K andesites. The lavas in Simara exhibit relatively moderate freshness to altered samples in terms of LOI.

The trace elements are characterized by overlapping values between the two lavas. The large-ion lithophile elements (LILE's), K and Rb are more abundant in shoshonite lavas whereas Sr and Ba are likewise elevated in shoshonite but with an overlapping data. Cr and Ni are higher in high-K lavas but also there are values that overlap, which further suggest that it was not derived from primitive magma. V, Zn and Cu are more abundant in shoshonite lavas. Nb is relatively lower in high-K andesite. U and Th are much higher in shoshonite. The contents of these trace elements are typical of orogenic lavas (Gill, 1981).

The chondrite-normalized trace elements abundance in Simara lavas shows enrichment of LILE and HFSE (U and Th), which is very slightly higher in shoshonite lavas (Fig.-3). Compatible Cr and Ni elements are depleted to be primary magmas for both lava with slight enrichement in high-K lava but there is overlap in values if all the data points are plotted.

The Mindoro and Macolod segments generally possessed high LILE, La/Sm ratio, radiogenic Sr and $d^{18}O$, which have been attributed to continental crustal contamination from the North Palawan-Mindoro block (Defant *et al.*, 1991).

Conclusions

The Simara island is the southernmost end volcanic center of the Luzon Arc, an arc formed by the subduction of South China Sea oceanic basin along the Manila Trench. The island comprises of volcanic lava flows-pyroclastic (early Pliocene) and sedimentary rocks mostly limestone and clastic materials (Pliocene-Pleistocene). Mineral components consist of plagioclase, clinopyroxene and orthopyroxene, hornblende, biotite and magnetite. Texture is usually porphyritic but in a lesser degree in shoshonite lavas. Shoshonite lava is characterized by an elevated K_2O concentration in comparison to high-K lava. Absence of Fe-enrichment has been recognized in both lavas. The abundance of LILE's, Th and U elements, are slightly higher in shoshonite lavas. Cr and Ni concentrations are depleted for both types of lavas.

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