EVIDENCE FOR THE ORIGIN OF A SHOSHONITIC SUITE BY MIXING OF PERALUMINOUS AND ULTRAPOTASSIC MAGMAS: THE OROSCOCHA AND QUIMSACHATA QUATERNARY VOLCANOES, SICUANI PROVINCE, SOUTHERN PERU.

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Resumen

Rocas peraluminosas, ultrapotasicas y shoshoniticas fueron emitidas por los volcanos cuaternarios de Oroscocha y Quimsachata, Provincia de Sicuani, Sur Peru. Todas muestran evidencias texturales, mineralógicas y químicas de mezcla magmatica. Un origen de las rocas shoshoníticas por mezcla de magmas peraluminosos y ultrapotasicos esta propuesto.

Key Words: mixing, peraluminous, ultrapotassic, shoshonite, Peru,

The origin of shoshonitic rocks is subject to debate. We present petrological and chemical data on two volcanic centers of the Sicuani Province (southern Peru) that strongly suggest a genesis by mixing of peraluminous and ultrapotassic magmas for these rocks.

The Oroscocha (71° 09' 30'' W, 14° 05' 48'' S) and Quimsachata (71° 21' 17'' W, 14° 09' 30'' S) quaternary (< 0.3 M.y.) volcanoes are the latest volcanic manifestations related to the active fault belt separating the Eastern Cordillera from the High Plateaus in southern Peru.

The two volcanoes can be interpreted as representing different stages of shoshonite production by mixing processes.

DIRECT MIXING EVIDENCES OF PERALUMINOUS AND ULTRAPOTASSIC MAGMAS

The Oroscocha centre emitted a peraluminous rhyolite block-lava flow containing millimetric to decimetric inclusions of ultrapotassic minette

The minette displays olivine, clinopyroxene and phlogopite phenocrysts (1 mm), clinopyroxene microphenocrysts (0.2 mm) in a fine-grained groundmass (0.05 mm) made up of clinopyroxene, phlogopite, plagioclase, orthoclase, anorthoclase and magnetite. Olivine is zoned (core= Fo 90-86, rim= Fo 79), NiO decreases whereas CaO and MnO increase from core to rim. The core of the clinopyroxene phenocryst cores consist of endiopside whereas microphenocryst core is a salite. The rims of the phenocrysts and microphenocrysts and the clinopyroxenes from the groundmass are fassaite. Al IV and Ti contents increase from phenocryst cores to fassaites matrix. The micas are Ba-Ti-phlogopites (100 Mg/(Mg+Fe)= 80.5-56.7, TiO2= 5.4-4.5%, BaO= 4.2-1.3%). From phenocryst core to matrix mica, Mg/(Fe+Mg) ratio and Ba content decrease whereas Ti content increases. Sr-rich andesine (An=33-35, SrO= 0.4-1.3%) only appears in the groundmass which also contains Orthoclase (Or65 Ab32 An3), Sr-rich anorthoclase (Or22 Ab55 An23, SrO=1%) and Ti-rich magnetite microlites.

The rhyolite contains quartz, plagioclase, orthoclase and biotite phenocrysts in a colourless glass. Biotite (100 Mg/(Mg+Fe)=35, TiO2= 3.00-3.50%, BaO= 0.04-0.13%), plagioclase(An16 Ab79 Or5), orthoclase (Or50 Ab47 An3), sillimanite, apatite and zircon are common microlitic phases. Quartz phenocrysts are anhedral, fractured and corroded. Plagioclase and orthoclase phenocrysts are either euhedral or anhedral. The phenocrysts are zoned (core: An 21-26, Or= 5-3, SrO= 0-0.4%; rim: An= 14-18, Or= 6.4, SrO=0). The composition of the orthoclase phenocrysts are Or68 Ab31 An1. The biotite phenocrysts are annite-rich (100Mg/(Mg+Fe)= 32.56-35.16). Their Ti content varies from 2.86 to 4.19% and their BaO is low (0.04-0.20 %).

Minette and rhyolite display textural, mineralogical and chemical evidences of mixing. Minette inclusions show crenulated margins and are highly vesicular. Acicular fassaite and skeletal phlogopite in groundmass evidence a crystallization in an undercooled state and is a strong evidence for molten condition of the inclusions at the time of entrapment. This is confirmed by the presence of quartz, plagioclase, orthoclase, biotite xenocrysts in minette. Rhyolite contains clinopyroxene and phlogopite xenocrysts. All xenocrysts show disequilibrium evidences. Quartz megacrysts are surrounded by clinopyroxene corona. Plagioclase xenocrysts display sieve-like textures. Clinopyroxene xenocrysts are rimmed by biotite and orthopyroxene. Disequilibrium, furthermore, is clearly illustrated by variations of trace element contents in biotite and plagioclase. In minette, Fe-rich biotite xenocrysts are surrounded by Ba-phlogopite margins similar to minette matrix biotite (Figure 1). Sr-poor oligoclase xenocrysts are rimmed by Sr-rich andesine (Figure 2). In rhyolite, some biotite phenocrysts contain Al-spinel indicating disequilibrium melting of the mica.

Fe-rich biotite, oligoclase and quartz xenocrysts are interpreted as rhyolite phenocrysts incorporated in the ultrapotassic magma. Clinopyroxene and biotite xenocrysts in rhyolite are minette phases entrapped in the peraluminous magma. This textural, mineralogical and chemical features are interpreted as the initial stage of a two magmas mixing.

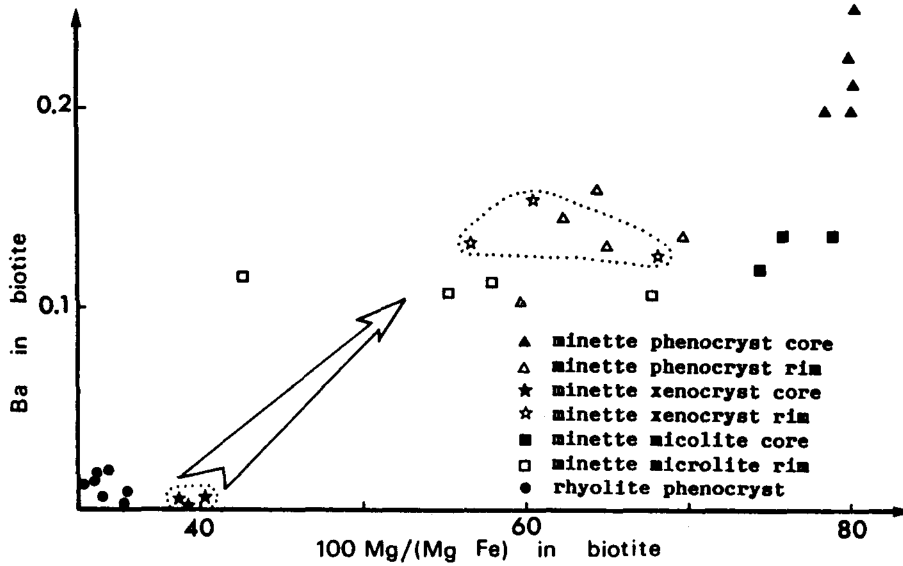

Figure 1: Ba vs. Mg/(Mg+Fe) plot for rhyolite and minette biotites (cations per formula unit).

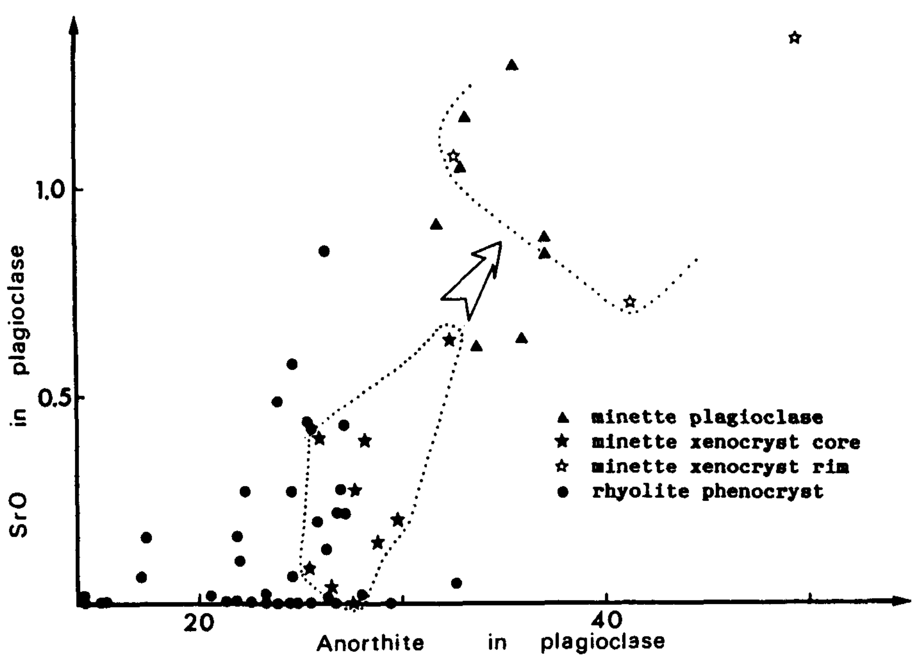

Figure 2: Weight percent SrO vs. anorthite percent plot for rhyolite and minette plagioclases.

ORIGIN AND EVOLUTION OF THE QUIMSACHATA SHOSHONITES

Banakite aa-lava flows were erupted from the Quimsachata centre. These rocks are porphyritic and consist of orthopyroxene, clinopyroxene, olivine and biotite phenocrysts in a groundmass made of orthopyroxene, biotite, plagioclase, ilmenite, Ti-magnetite microlites and brown glass. Olivine and hypersthene are zoned (core= Fo 76, rim= Fo 68 and core= En 80-85, rim= En 65-80). In orthopyroxene, Al_2O_3 content increases from core to rim (core= 1.25-1.75%, rim= 1.70-2.90%).Clinopyroxene shows an endiopside core and an augite rim. TiO_2, Al_2O_3, FeO and CaO contents increase from core to rim whereas MgO content decreases. Mica is Ba-Ti-rich phlogopite (100Mg/(Mg+Fe)= 77-87, TiO_2= 3.36-4.00%, BaO= 0.61-0.86%).

The banakites also contain Ba-poor phlogopite, Sr-poor oligoclase and quartz xenocrysts. Biotite contains inclusions of aluminous spinel, ilmenite and plagioclase indicating disequilibrium melting of the mica. Plagioclase shows well developed sieve-like texture rimmed by Sr-rich andesine. Clinopyroxene and brown glass corona occurs around quartz megacrysts. These quartz, plagioclase and phlogopite xenocrysts show textural and chemical similarity with the xenocrysts of the Oroscocha minette. They would represent rhyolite phenocrysts preserved in banakites.

Moreover, both Oroscocha minette and Quimsachata banakites display the same unusual chemical features: high MgO/CaO ratios (0.91 to 1.14), high Ba (1754 to 5117 ppm) and Sr (982 to 2209 ppm) contents, suggesting parental relations.

However, banakites also contain numerous aggregates (1-3 mm) made up of bronzite, augite and minor phlogopite, olivine and plagioclase. These are cumulative phases that indicate a magma evolution dominated by the crystallization of pyroxene.

CONCLUSIONS

The petrological and chemical features of the Quimsachata banakites strongly suggest that Quimsachata shoshonitic rocks originate from mixing of ultrapotassic and peraluminous magmas. Direct evidences of mixing are observed in the nearby Oroscocha volcano. After the mixing has occurred, the banakites of Quimsachata evolved through fractional crystallization dominated by pyroxene.