MIOCENE VOLCANIC CENTERS IN THE SOUTHERN ALTIPLANO OF BOLIVIA. THE CERRO MOROKHO & CERRO BONETE AREA (SUR LIPEZ).

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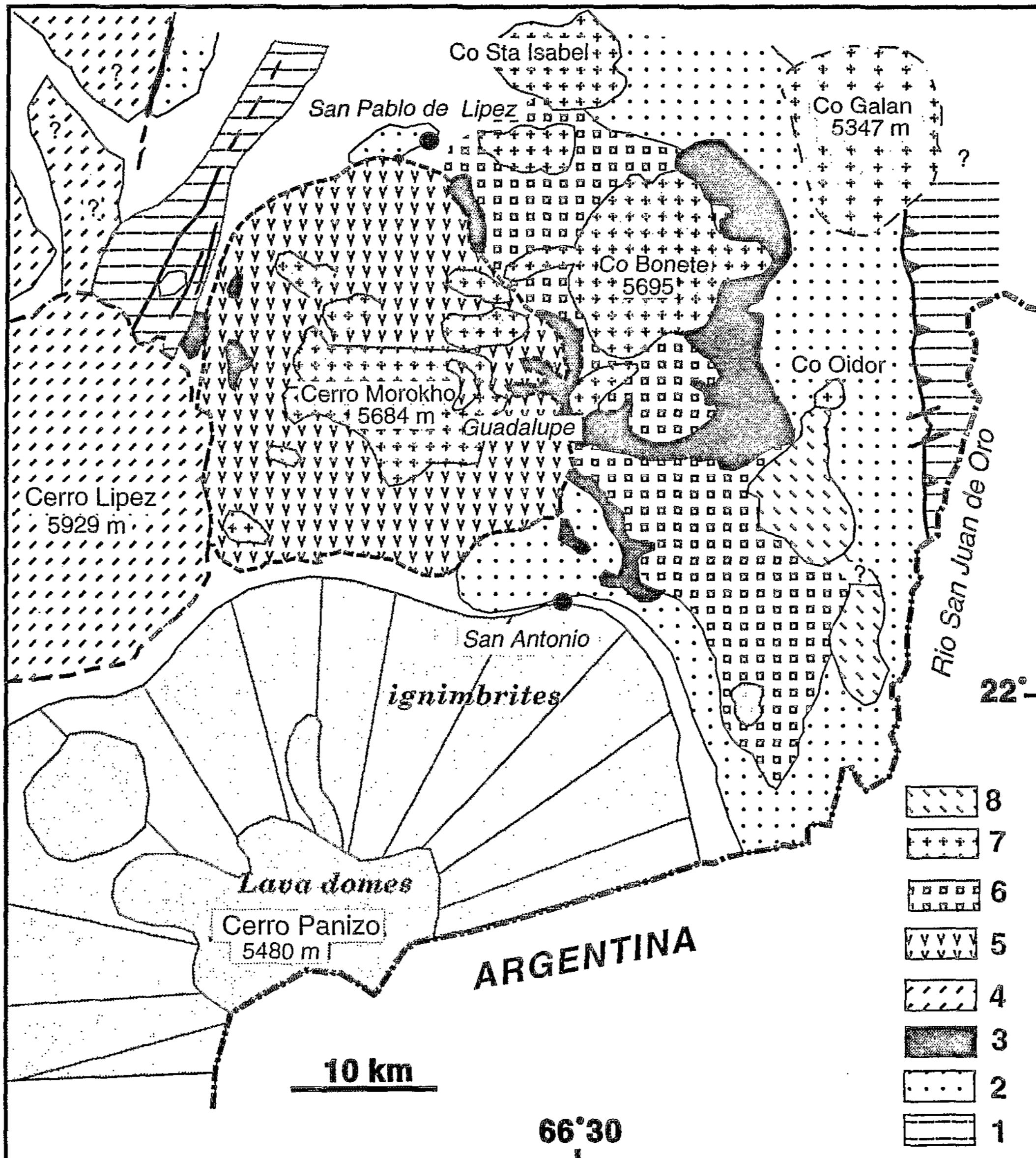
RESUMEN: En la terminación SE del Altiplano boliviano (22°S - 67°W), encima de las capas rojas del Oligoceno (Fm. San Vicente), la actividad magmática empieza por un magmatismo básico de afinidad alcalina (andesitas basalticas y micro-gabbros) de edad Oligoceno superior - Mioceno inferior (Fm Rondal). Está seguida por una etapa magmática que genera rocas de composición intermedia a ácida y de afinidad calco-alcalina; se han identificado varios centros volcánicos, entre los cuales los cerros Bonete, Morokho, Lípez (con actividad Mioceno inferior a Medio), y el cerro Panizo (con actividad Mioceno superior a Plioceno). La mayoría de los productos son de composición dacítica, de carácter potásico y peraluminoso (corindon normativo, presencia de granate). Por su posición tras-arco este magmatismo puede representar un equivalente más antiguo de los Frailes y Morococala.

KEY WORDS: Altiplano, Bolivia, Magmatism, Miocene.

INTRODUCTION

In the Southeastern part of the Bolivian Altiplano (25°S-67°W), the deposition of the Oligocene continental red beds (San Vicente Fm.) has been followed by basic magmatic activity which in turn is followed by intermediate to acid magmatism. Several early to mid-Miocene volcanic centers were recognized, e.g. cerro Bonete, cerro Morokho, cerro Lipez (fig.1) whereas a younger center is formed by the cerro Panizo "caldera", a 40 km diameter ignimbritic plateau around a 10-15 km cluster of dacitic lava domes of upper Miocene age (7.87 Ma, $^{40}Ar/^{39}Ar$ date of pumice biotite, 6.1±0.2 Ma K/Ar whole rock date on dacitic lava of the central dome complex, Ort, 1991). Magmatic activity expands to Plio-Quaternary times. In this abstract we report some features of early to mid- Miocene magmatism.



1: Lower Paleozoic shales, 2: Oligocene San Vicente Fm (conglomerates)
3: Rondal Lavas, 4: Co Lipez tuffs and Lavas, 5: Co Morokho tuffs and lavas
6: Co Bonete tuffs and lavas, 7: tuffs and lavas from others volcanics centers
8: Tuffs from undetermined vent (above Bonete tuffs).

Fig. 1: map of the Guadalupe area showing the major volcanic centers.

TABLE 1: K/Ar analytical data and calculated ages, by M. G. Bonhomme, University of Grenoble.

sample #, type of rock	Location	material analysed	K2O (%)	^{40}Ar rad (%)	^{40}Ar rad (nl/g)	Age Ma ± 2 σ
S5, basalt (Rondal)	Qda Herreria	WR	3.72	38.3	2.66	22.1 ± 0.6
S8, ignimbrite	Coripampa	Biotite	8.89	56.7	4.43	15.4 ± 0.5
2210-3, ignimbrite	Coripampa	Biotite	8.89	69.8	4.40	15.3 ± 0.5
S17, ignimbrite	Co Pabellon	Biotite	9.13	71.1	4.39	14.8 ± 0.5

ALKALINE MAGMATISM.

The volcanic activity began with basic magmatic products (mainly basalt-andesitic and micro-gabbroic lava flows, sills, dykes), known as the Rondal Fm. They contains phenocrysts (1-3.5 mm) of forsterite (up to 14%) frequently altered to iddinngsite. Augite phenocrysts (up to 12%) form millimetric automorphic sections and groups of crystals; minor amounts (2.5%) of small corroded orthopyroxenes are present. The matrix contains mainly microlites of plagioclases (An 81-64). Sometimes the dykes contain biotite and amphibole phenocrysts.

The Rondal lavas display high K content (fig. 2) and an alkaline affinity.

A basaltic dyke (sample S5) of the Guadalupe area gave a whole rock K/Ar age of 22.1± 0.6 Ma. Kussmaull et al. (1975) report an age of 23.5 Ma in the same area. Similar lavas in the Tupiza basin (about 60 km ENE of Guadalupe) have been dated at 22.7 ± 0.6 Ma (Hérail et al., this volume).

This magmatism is correlated with the Julaca and Tambillo lavas that form a nearly NS belt of outcrops in the western part of the Altiplano and in the Cordillera Occidental. This magmatism would be related to trans-tensional crustal fractures (see Soler and Jimenez, this volume).

ACID PERALUMINOUS VOLCANISM.

This alkaline episode is followed by a stage of erosion, with a rough paleo-topography which is partially buried by the products of high-K calc- alkaline magmatism. In the studied area, two volcanic centers were investigated (cerros Morokho and Bonete).

The volcanic activity began with an explosive stage represented by voluminous pyroclastics flows and minor ash-fall deposits, sometimes accompanied with their "co-ignimbrite" breccias deposits near the vent. The total thickness of these deposits is about 700 m. The different pyroclastic units defined in the field show variations in thickness, color, abundance and size of pumices and lithoclasts at the scale of the outcrop and in thin section; generally they show low welding grade and the pumices are uncollapsed. They are generally crystal rich (up to 40%), with fragmented and automorphic plagioclases (An40-55), biotite and quartz with minor zircon, apatite, sphene, opaque minerals. Generally they have a dacitic composition (fig 2). Biotite from pumices from the dacitic ignimbritic units from the cerro Bonete gave K-Ar ages around 15 Ma. (table 1).

The main stage of pyroclastic emission is followed by lava domes, flow breccias, and lava flows. This general sketch shows local variations in each centers and in particular pyroclastic flows deposit can be present in the late stages. The rocks are generally similar withstanding they crop out in several stocks and domes; they show a porphyritic texture with plagioclase, biotite and quartz phenocrysts up to 5 mm in length, and in some cases microphenocryst of amphibole. The quartz crystals show rounded and engulfed shapes, plagioclases are zoned (inner part An50-border An30-45) and with thin reaction rims. Minor minerals are apatite, zircon, garnet, rutile and titano-magnetite. The matrix forms about 65% of the rocks; it contains small and generally xenomorphic quartz (50-60%), microlites of automorphic plagioclases, more calcic than the phenocrysts, and very small K feldspar. In spite that they are broadly similar, these rocks present small geochemical differences and represent different magma batches. K/Ar age determinations of these events are in progress.

One characteristic feature of these rocks is their peraluminous nature (presence of garnet, normative corindon (1-3%), high A/KCN ratios - fig 3). Another one is the relatively restricted range of composition (dacitic) of the more voluminous outcrops.

This back arc magmatic activity belongs to a mid-Miocene belt which extends all along the Bolivian Orocline (Soler and Jimenez, this volume) and would represent an older equivalent of the voluminous volcanism of Los Frailes and Morococala.

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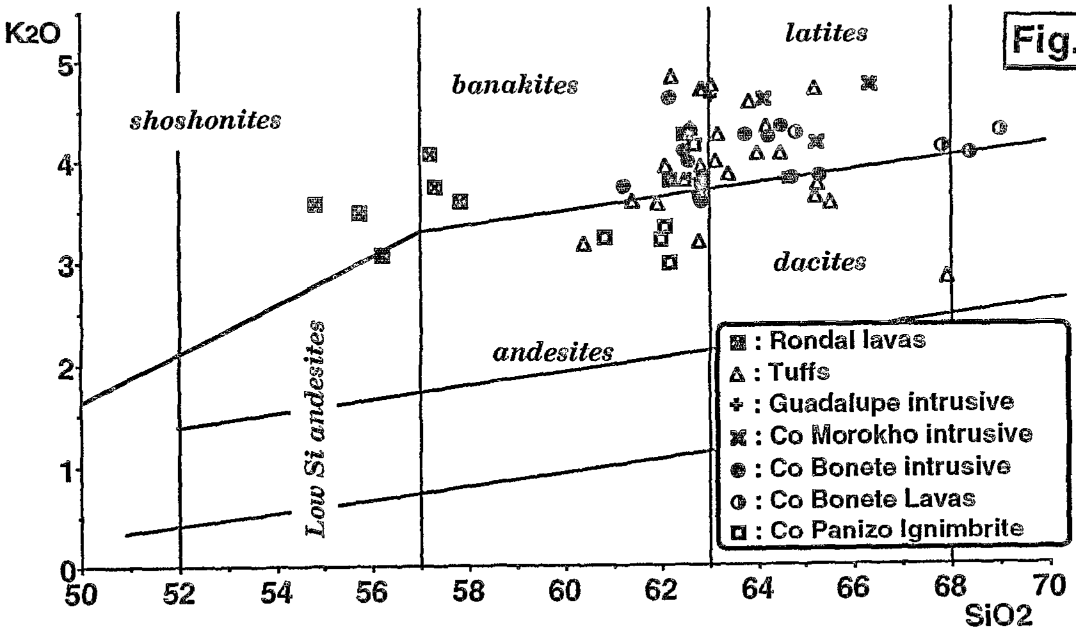

Fig. 2.

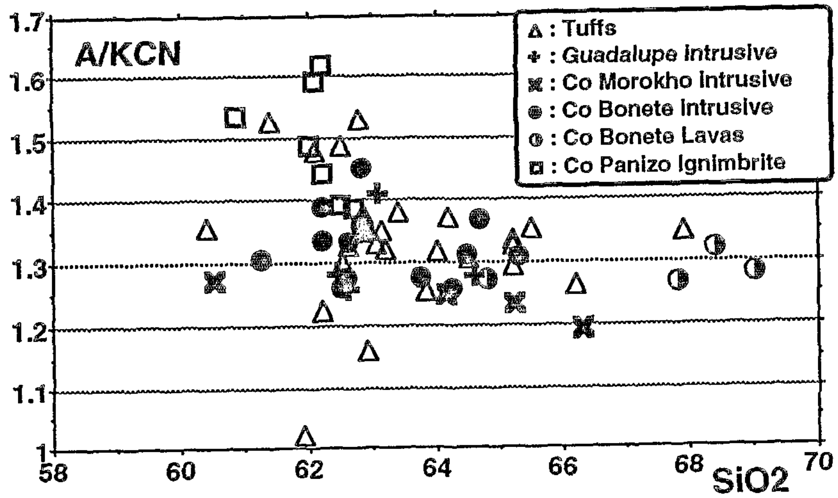

Fig. 3.