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Characterisation of the Cenozoic volcanism in northern Peru (7°45'-9°00's; 78°00'-78°45'w)

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INTRODUCTION

In northern Peru, along Andean Cordillera outcropping volcanic and volcanoclastics deposits of ~3000 m thick, emplaced during the subaerial volcanism occurred between 53 - 14,6 Ma. (Wilson, 1975; Farrar & Noble, 1976), it is in the Eocene-Miocene. Cossio (1964) named this volcanism as Calipuy Formation, later the term Calipuy Group was used by Cobbing (1973) to refer all the Cenozoic volcanic rocks in northern Peru.

Volcanic studies made in a sector of northern Peru (Figure 1), show the existence of eight eroded volcanoes, two collapse caldera, domes, as well as pyroclastics sequences, lava flows and lahars, emplaced during the intense volcanism occurred in Eocene-Miocene. Most of the volcanic centres had an evolution phase, characterized at the beginning by effusive eruptions that emplaced lava flows interbedded with pyroclastic flow deposits and lahars, and a final phase generally explosive characterized by emissions of important volumes of pyroclastics flows and lahars.

Generally the volcanic centres were built along NW-SE trending fractures and regional faults. The generation of the Cenozoic volcanism is possibly bounded to the mechanism of Nasca Plate subduction that generated the partial melting of the mantle wedge (Worner, 1991).

CENOZOIC PRE-VOLCANISM SEQUENCES

They correspond to sedimentary sequences, volcano-sedimentary and intrusive rocks that form the basement on which products of Cenozoic volcanism were unconformity emplaced. Marine sedimentary rocks belong to Mesozoic (Jurassic - Upper Cretaceous), and they are located mainly to E and NE of the study zone. Lithologically consists of shales, slates, quartzous sands, limestones and conglomerates (Cossio, 1964). Whereas the volcano-sedimentary sequences named Casma Group, deposited in marine environment (Titonian - Albian) consist of andesitic pillow lavas, hyaloclastites and tuff intruded by both andesitic and basaltic dikes and sills (Petford & Atherton, 1995). The intrusive rocks belong to the Coastal Batholith (Upper Cretaceous-Eocene) and crop out to the West of the area. Lithologically ranges from gabbros to granites (Pitcher, 1985).

CENOZOIC VOLCANISM (CALIPUY GROUP)

An initial Cenozoic volcanism phase was determinated in the area, it was named as Tablachaca Formation (Paleocene) Figure 2, made of pyroclastic flows, lava and volcanoclastic deposits, interbedded in the lower and upper part with sedimentary levels (siltstones, sandstones) with Charophytes, suggesting the emplacement in a lake environment. The total thickness of the sequence is ~1200 m this unit is folded and intruded by the Coastal

Batholith rocks. The Tablachaca Formation is unconformity covered by sub-horizontal pyroclastics and lavas sequences from volcanic centres emplaced during the Eocene-Miocene (Figure 2).

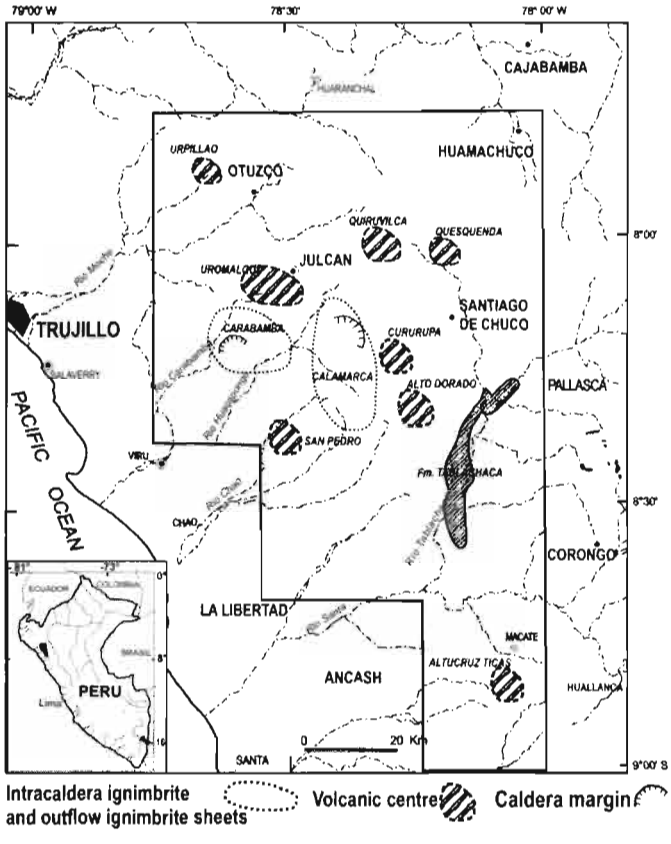

Figure 1. Location Map of the study area.

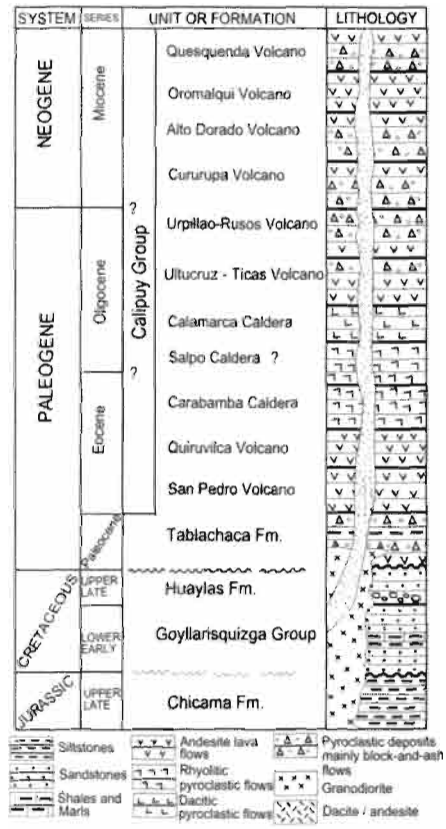

Figure 2. Calipuy Group litho-stratigraphic

Volcanoes

(1) **San Pedro Volcano** (78° 30'W, 8° 20'S), the base is constituted by andesite lava flows. In the middle part presents block-and-ash flows. The upper part of the volcanic centre is constituted of andesitic lava flows. (2) **Quiruvilca Volcano** (78° 18'W, 8° 00'S), eroded poligenetic volcanic centre constituted of altered and hydrothermalized lava of andesitic and basaltic andesites composition. The centre of the structure presents lavas with argillaceous and propilitic alteration, cut by veins with metallic minerals and andesitic dikes. (3) **Volcano Ultucruz - Ticas** (78° 07'W, 8° 51'S). The base is composed by andesitic lavas of ~400 m thick, covered by pyroclastic flows of ~200 m thick. (4) **Urpillao- Rusos Volcanic Complex** (78° 39'W, 7° 50'S). the base presents a sequence of lava flow of about 450 m thick overlying the base are block-and-ash flows, ash and pumice flows, and lahars, toward SW the lava sequences are intruded by subvolcanic andesites (stocks). (5) **Cururupa Volcano** (78° 16'W, 8° 13'S). The base is composed of lava flows of more than 300 m thick, and up to the top present block-and-ash flows, ash flows, and lahars. (6) **Alto Dorado Volcano** (78° 15'W, 8° 17'S), poligenetic volcano whose base is constituted by block-and-ash flows deposits. The middle part is constituted of andesitic lava flows, while to the top present of block-and-ash flows deposits of ~300 m thick linked the growing and destruction of the lava domes. The western sector is intruded by an andesite subvolcanic body. (7) **Paccha Uromalqui Volcanic Complex** (78° 32'W, 8° 04'S). is constituted by three strato-cone aligned from SE to NW,

intruded by an andesitic subvolcanic body in the NW (C° Quinga). The volcanic cones are constituted by andesitic lava flows basaltic andesites that reached distances of 10 km respect to the emission centres. **(8) Quespenda Volcano** (78° 12'W, 7° 59'S). Strato-volcano partially eroded. In central part of the structure presents andesitic lava domes that show *flow banding* type structures. To the N, NE and SE of volcanic centre of block-and-ash flows deposits, pyroclastic surges and lahars out crop, linked to the lava domes growing and destruction.

Calderas

(1) Carabamba Caldera (78° 18'W, 8° 10'S). To the SW of the Carabamba village (proximal facies) welded rhyolitics crystal flows are distinguished including mega-blocks of sedimentary rocks (basement) up to 20 m of diameter, lava blocks, and subvolcanic rocks intrusions. Their distal products are recognized to S and SE, they correspond to welded crystal flows of rhyioltic composition with little lithic fragments content (< 5%) These flows contain coarse phenocrysts of quartz (40 - 60%), plagioclase, biotite, amphibole and Fe-Ti oxides. **(2) Calamarca Caldera** (78° 18'W; 8° 11'S). Located to the NE of the Calamarca village. Their deposits related to the formation of a collapse caldera consist of dacitic cohesive pyroclastics flows of 1 to 8 m thick. The total of measures thickness is ~300 m, and has more than 8 km long to the SW of its source. The edges of the caldera is constituted by sequences of basaltic andesitic and andesitic lava flows.

PETROLOGY

The lavic and pyroclastics products emitted by the volcanic centres varying from basaltic andesites to rhyolites, predominating andesites (Figure 3). The andesites mineralogy consists of phenocrysts of feldspar plagioclase, ±clinopyroxene, ±orthopyroxene, amphibole, Fe-Ti oxides, ±biotite, whereas quartz and ± alkaline feldspar appear in the rhyolites, and the absence of pyroxene and amphibole are distinguished.

The evolution of magmas emitted by Cenozoic volcanoes can not be explained by a simple processes of fractional crystallization. Additional processes such as magma mixing are also possible. The role of the fractional crystallization is however, fundamental that would explain a progressive evolution of basaltic andesites to rhyolites, from magmas derived from same mantle source. The processes of magma mixing are suggested by the existence of mineralogic phases in desequilibrium: zoning in plagioclases, presence of xenocrystals, and destabilization of certain minerals (amphibole, pyroxene), probably bound to successive feedbacks of basic and hot magmas in superficial magmatic chambers.

The rocks belong to the calc-alkaline series, moderately potassic (Figure 3). The trace elements study shows that the emitted magmas come from the mantle, bounded to subduction dynamic processes. The products display similar geochemical characteristics with Coastal Batholith rocks and with Plio-Quaternary volcanic rocks of the Central Volcanic Zone of the Andes (CVZ) coming from the partial melting of the mantle wedge (Figure 4). The later rocks show almost similar spectrum with the Calipuy volcanism rocks, with negative anomalies in Nd and Ti. However the rocks of the CVZ show a depletion HREE, while the rocks of the Calipuy Group are enriched, suggesting there is little or no garnet and amphibole in the source that retain the HREE.

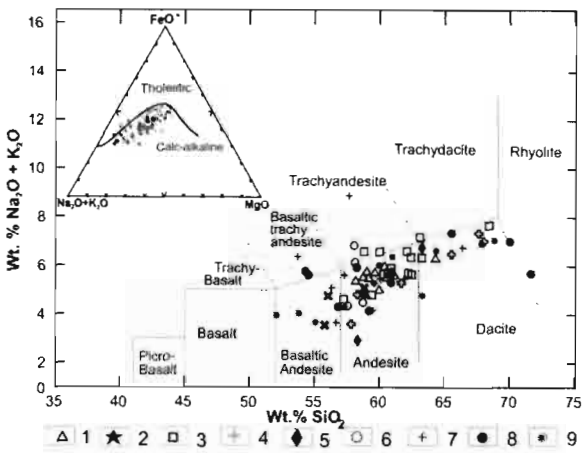

Figure 3. Rock classification of the Calipuy Group in TAS diagram (Irvine & Baragar, 1971), and AFM diagram showing typical calc-alkaline differentiation trend of the Calipuy Group. Volcanoes: 1 Totora, 2 Cururupa, 3 Stocks, 4 San Pedro, 5 Quesquenda, 6 Quiruvilca, 7 Alto Dorado, 8 Calamarca Caldera, 9 Paccha-Oromalqui.

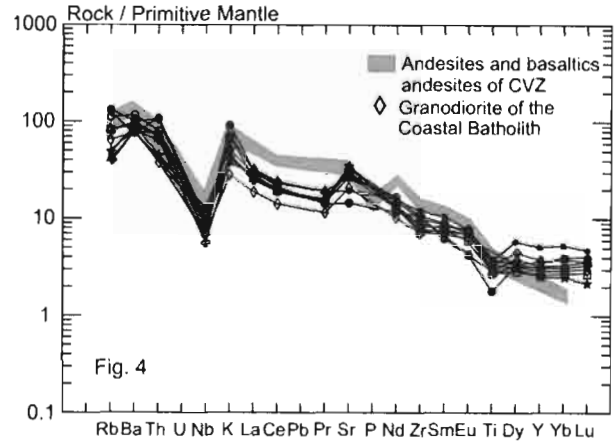

Figure 4 Multielement spiderdiagram pattern of the Calipuy Group, normalized to the primitive mantle (normalization constants of Sun & McDonough, 1989). The shaded zone corresponds to Payachata volcanoes, Tata Sabaya (De Silva et al., 1993), Ollague (Feeley & Davidson, 1994), Ubinas.

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