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# Geological and Structural Evolution of Apacheta-Aguilucho Volcanic Complex (AAVC), Northern Chile

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## Introduction

The Apacheta-Aguilucho Volcanic Complex (AAVC) is located in the Central Andean Volcanic Zone (CAVZ), at the 21º50' Lat S and 68º10' Long W, 105 km NE from city of Calama and 55 km NW from El Tatio geothermal Field, in the northwestern most part of Pabelloncito Graben, a prominent structural featured associated to Palpana-Azufre-Inacaliri NW-SE trend lineament. The AAVC is part of the Altiplano Puna Volcanic Complex (APVC) which is a large zone of silicic volcanism occupying the 21-24°S segment of the Central Andean Volcanic Zone (ACVZ; [1,2]) an area characterized by continental crust >70 km thick [3]. The APVC is dominated by 1-10 Ma ignimbrite flare up [4] and, although no major ignimbrite-caldera forming eruptions of < 1 Ma are known, relatively young dacite to rhyolite lavas (e.g. Chao) and domes (e.g. La Torta de Tocorpuri dome) erupted in the past 100 ka and the presence of famous active geothermal fields (i.e El Tatio and Sol de la Mañana) seem to indicate that the magmatic system of the APVC is currently active [1]. A geothermal system was recently discovered by CODELCO while drilling a shallow water well, in the area of the AAVC [5]. MT and TDEM survey detected a low resistivity boundary (< 10 Ohm.m) extending over an area of 25 $km^2$ [6] whereas a temperature >200°C was measured at depths >500 m in a 550 m-deep core-hole recently carried out) by the Empresa Nacional de Geotermia (Enel-Enap joint venture, October 2007).

Evidences from gas geochemistry of fumaroles and bubbling pools located in the eastern flank of Apacheta volcano suggest the presence of active magmatic system at depth [7,8]. The regional basement is constituted by Miocene andesitic-to-dacitic eroded volcanoes and dacitic-to-rhyolitic pyroclastic flows [9]. In this work, we present the geological and

structural data of AAVC collected during four field works carried out in August, October, December 2007 and July 2008. The main aim is to determine the geological and structural evolution of AAVC and their relations with tectonic framework of CAVZ.

Geological Evolution

1) ***Basement***: a) Named as Aguilucho Ignimbrite, correspond mostly to explosive events, constituted by nearly 50 m of white to pale pink pumice and lithic-rich moderate welded dacitic pyroclastic flows, and subordinately by surge flows. Degasification pipes are present in the uppermost part of flows, and occasionally, pumice-scoria fragments show evidences of mingling (7.5±0.6 Ma K-Ar). b) Porphyry and vesicular two pyroxene andesitic lava flows, with oriented vesicles and flow textures (6.7 ± 0.3 Ma K-Ar).
2) ***Stage I***: Effusive episode formed by two lava flows units: a) blocky hornblende dacitic lava flows, and b) blocky porphyry dacitic lava flows.
3) ***Stage II***: Correspond to building of Apacheta volcano, and is constituted mostly by a) interbedding of highly vesicular scoria-rich andesitic pyroclastic flows, block-and-ash flows and dark grey andesitic lava flows. This unit constitutes the original edifice of the volcano, actually moderate eroded, and hosts the fumarolic activity (east flank). The crater is covered by a succession of b) welded to moderate welded pumice pyroclastic flows, and is sealed by a c) single porphyry rhyolitic lava flow, that extend by 2.5 km and present ridge flow structures (ojives).
4) ***Stage III***: Correspond to building of Aguilucho volcano and is constituted by two lava flows units, a) highly vesicular and glassy blocky dacitic lava flows, and b) moderate vesicular blocky biotite dacitic lava flows.
5) ***Stage IV***: Effusive episode represented by two lava fields, located in the northeastern and southeastern flanks of Aguilucho and Apacheta volcanoes, respectively, a single lava flow and two lava domes, Chac-Inca and Pabellón domes, located at north and east of Aguilucho volcano, respectively. The lava fields are constituted by porphyry and vesicular biotite dacitic lava flows, which present ridge flow structures (1.1±0.2 Ma Ar-Ar). Highly vesicular biotite dacitic lava flow with flow structure (0.7±0.2 Ma K-Ar).The lava domes correspond to porphyry and glassy dacitic lavas and represents the last magmatic event of AAVC. Mafic inclusions are commonly found. Pabellón lava dome has been dated in 0.05±0.01 Ma, K-Ar [6] and 80-130 Ka, Ar-Ar [10], while Chac-Inca dome has been dated in 0.14±0.08 Ma, Ar-Ar.
6) ***Other Units***: a) A prominent hydrothermal alteration is present in the north, west, southwest and eastern flanks of AAVC, and is partially related to past and present fumarolic activity. b) In association to the weakening of the volcano structure resulting from hydrothermal alteration, a debris avalanche deposit (DAD) has been developed in the eastern flank of AAVC, formed by hummocks morphology and constituted by andesitic lava and hydrothermally altered fragments [11]. Apparently, the DAD has been formed before of Stage III moderate vesicular blocky biotite dacitic lava flows, located

around the Aguilucho volcano crater. c) Extensive moraines deposits are present at northeast of Chac-Inca dome and west flank of Apacheta volcano, and is related to last maximum glacial age (11,000 yr BP).

Structural Evolution

The AAVC is emplaced in the downward block of NW-SE trend Pabelloncito Graben, structural feature associated to Palpana-Azufre-Inacaliri NW-SE trend lineament, running parallel to Pastos Grandes-Lipez-Coranzulli lineament, the northernmost giant NW-SE trend lineaments located in the CAVZ. The graben is bordered by NW–SE trending normal sinistral faults (Pabellon and Cachimba faults) that reach 18 km length and associated have minor faults (subsidiary faults) that affect the downward block. The mean trend of main faults is N63W, the dip is variable between 45 and 50º, and its net displacement between 3 and 30 m. The subsidiary faults, nearly parallels to main faults, have length that reach 6.5 km, its dips varying between 60 to 70º. The movements both main and subsidiary faults are indicated mainly by striae, riedel criteria and truncated lava flows. Main and minor faults cut the *Stage IV* porphyry and vesicular biotite dacitic lava flows (1.1±0.2 Ma), while glassy dacitic lava domes (0.14±0.08 Ma to 0.05±0.01 Ma) are emplaced over northeasternmost main fault. Consequently, the time of deformation has been constrained between Lower and Upper Pleistocene. The deformation seems to be related to change of tectonic regime from compressive to extensive during Upper Pleistocene, when giants NW-SE lineaments (e.g. Pastos Grandes-Lipez-Coranzulli; Olacapato-El Toro; Archibarca-Cerro Galan) were formed [12].

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