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NEW DATA OF SURFACE GEOLOGY, PETROLOGY AND Ar-Ar GEOCHRONOLOGY OF THE ALTIPLANO-PUNA VOLCANIC COMPLEX (NORTHERN CHILE) IN THE FRAMEWORK OF FUTURE GEOTHERMAL EXPLORATION

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The Altiplano Puna Volcanic Complex (hereafter APVC) is a large zone of silicic volcanism occupying the 21-24° S segment of the Central Volcanic Zone (hereafter CVZ) of the Andes (de Silva, 1989; de Silva et al., 1994) where eruptions of regionally extensive ignimbrites from several caldera complexes dominated the volcanic evolution from the late Miocene to the Pleistocene. Although no major ignimbrite eruptions of < 1 Ma are known in the APVC, relatively young silicic lava domes (*tortas*) and the presence of active geothermal fields (i.e El Tatio and Sol de la Mañana) and volcanic fumaroles might indicate that the magmatic system of the APVC is currently active (de Silva, 1989). In addition, complex stratovolcanoes within the APVC, such as Ollagüe, have been continuously active until the Upper Pleistocene. Although the regional tectonic environment of the Central Andes is dominantly compressive, the high plateau region of the APVC is characterized by neutral or extensional stresses (Froidevaux and Isacks, 1984; de Silva, 1989).

The present research was carried out during the years 2002 and 2004 and was financially supported by the Italian Government, in order to acquire useful data for geothermal exploration. The geological study was focussed on the structural geology, petrology and geochronology of the Altiplano-Puna area between the Ollagüe volcano and the northern sectors of the Salar de Atacama (Fig.1). The investigation consisted of:

- interpretation of satellite Landsat (TM) imagery and aerial photos;

- litostratigraphy and field mapping as concerning structural analyses (e.g. age and kinematics of structures, stress calculations, etc.);
- detailed geological mapping of some stratovolcanoes with different age (e.g.: Cerro Peineta and Ollagüe);
- elaboration of maps and cross-sections in GIS laboratory with associated data base;
- petrographic and geochemical analyses of Quaternary volcanic rocks (mostly from the monogenetic rhyolitic-dacitic domes and the Ollagüe stratovolcano);
- Ar-Ar radiochronological datings of the youngest volcanic formations (e.g. Cerro Pabellon dome near "Pampa Apacheta", "La Torta" dome, Ollagüe dome);
- developement of 3D geological models.

The main aim of our work was to unravel the relations between tectonics and volcanism in the APVC from Miocene to Quaternary, trying to understand (i) regional tectonics leading to the main faults in the area and flank failure of some stratovolcanoes and (ii) magmatic processes at different crustal levels during the Quaternary. A structural field survey between 20°50'S and 22°50'S enabled us to recognise a series of compressional tectonic events followed by an extensional tectonic phase during Neogene-Quaternary times. The older events are characterized by contractional deformation, a horizontal greatest principal stress (σ_1) trending E-W to NW-SE, and a horizontal intermediate principal stress (σ_2). The youngest compressional event is given by pervasive strike-slip faulting with a NW-SE-trending σ_1 and a horizontal NE-SW-trending least principal stress (σ_3). These were followed by the last tectonic phase that shows another rotation of stress tensor following normal faulting and pervasive jointing: σ_3 is horizontal and trends NE-SW whereas σ_2 is horizontal and trends NW-SE, indicating a replacement of σ_1 with σ_2. This last tectonic event, which can be seen as a relative magnitude decrease of the stresses acting in the horizontal plane, could have allowed the distribution of volcanic vents from just localized well established conduits, corresponding to central stratovolcanoes or large caldera silicic system, also to diffuse short-living monogenetic centres. Relaxation of crustal stresses could have favoured magma rising also in small batches up to the surface in several newly-established conduits. As concerning the reconstruction of the geological history of single volcanic edifices, the Ollagüe volcano had a very complex evolution, comprising

basaltic andesite-andesite lava flows, pyroclastic products, rhyodacite domes and more than one sector collapses during its long-lived history of ca. 1 Ma. (Clavero et al., 2005). According to new Ar-Ar geochronology the youngest summit dome of the Ollagüe volcano (characterized by a persistent fumarolic steam plume) is only 65 ka old. The two areas of "Pampa Apacheta" and "La Torta", which are serious candidates for future geothermal exploration, represent other "case studies" where we carried out structural geology in the field, new petrological data and Ar-Ar datings. For example, the area of "Pampa Apacheta" was focused in detail to understand the most recent uprising of magma (Pabellon dome) along an important tectonic lineament (Inacaliri Graben). Age of faulting of the graben and successive outpouring of the small rhyodacitic Pabellon dome were thus established.

Recent geophysical investigation (deep seismic profile and tomography) pointed out that magmatism in the mid crust of the APVC is still an ongoing process (Zandt et al. 2003). Our fieldwork of structural geology and stratigraphy together with laboratory data of petrography, whole-rock geochemistry and geochronology allowed to define the geological evolution of distinct areas of the APVC whose volcanism, linked to crustal relaxation, is younger than 100 ka. Comparing extrusives with high-silica content, it is worth to note that the trace elements geochemical features of the youngest monogenetic rhyodacite *tortas* are different from those of both the late Miocene-Pleistocene caldera-forming ignimbrites and the Upper Pleistocene domes related to the stratovolcano edifices. In addition, recent petrologic data on aphyric high-K andesite with skeletal olivines of the Andean CVZ emphasized that some mantle-derived magmas, although modified by crustal contamination *en route* to the surface, were able to rise with negligible fractional crystallisation, by-passing the flanks of Quaternary stratovolcanoes (Mattioli et al., 2006).

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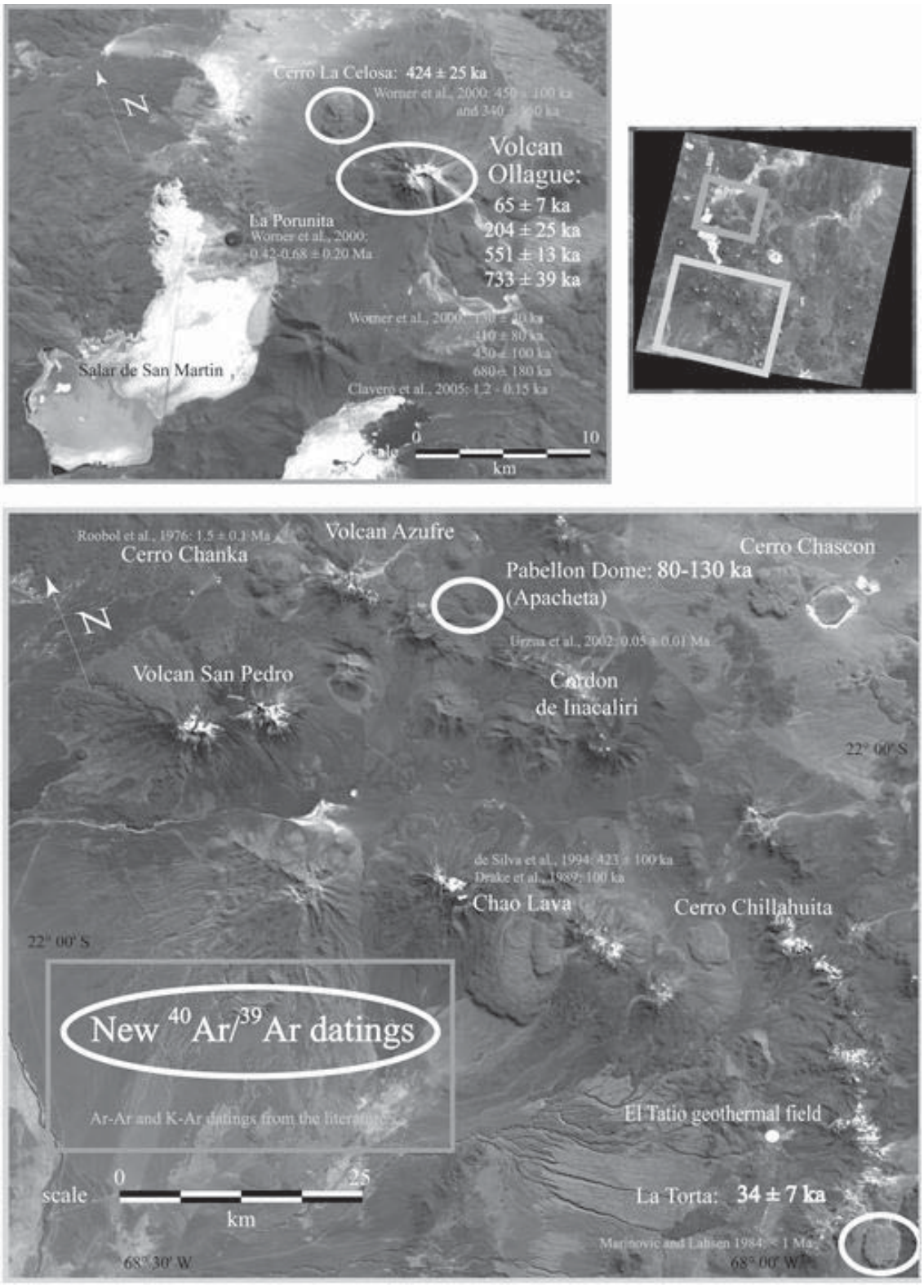

Fig. 1 – New and literature Ar-Ar and K-Ar datings of the APVC (Landsat imagery).