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28-31 AUGUST 2018

15th Quadrennial International Association on the Genesis of Ore Deposits Symposium

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APATITE (U-Th)/HE THERMOCHRONOLOGY IN THE CENTRAL ANDES (31°30'S), MAIN CORDILLERA SAN JUAN, ARGENTINA: IMPLICATIONS FOR PORPHYRY TYPE Cu (Au) MINERALIZATION

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BACKGROUND

The study region (31°30' S, 70° 15' W) is located in the southwestern sector of San Juan Province (Argentina), in the southern portion of the Pampean flat-slab segment and northeast end of the la Ramada fold and thrust belt of the Andes Main Cordillera. This region is a continuation of the Miocene and Pliocene porphyry copper belt of Chile that hosts three of the largest copper deposits in the world (El Teniente, Río Blanco - Los Bronces and Los Pelambres). Numerous Cu (Au) prospects with high mining potential have been discovered in this area. Some of them show the overlap between porphyry-type and high sulfidation epithermal deposits, indicating a high degree of uplift during their formation.

The Altar deposit is a large porphyry Cu (Au-Mo) with associated high sulfidation epithermal veins (measured resources of 995 Mt @ 0.35% Cu and 0.083 g/t Au, Maydagán *et al.*, 2014). The basement of the area is characterized by a late Carboniferous tonalitic batholith (~ 297 Ma, U-Pb, Maydagán, 2012) that crops out to the east of the Altar district. Cretaceous volcanic rocks outcrop to the west, in the Chile-Argentina border, between the Pantanosa Fault to the east and Tres Quebradas Fault to the west (Bergoeing, 2016).

Early Miocene volcanic rocks that crop out in the study area (Lower Volcanic Complex, Maydagán *et al.*, 2011) were intruded by porphyritic stocks of andesitic-dacitic composition in the middle to late Miocene (Maydagán *et al.*, 2011, 2014) that contains most of the Cu-Au mineralization.

Igneous rocks of Altar region were grouped in the lower Miocene early volcanic complex (21.6 ± 1.2 Ma to 20.8 ± 0.3 Ma, U-Pb zircon, Maydagán *et al.*, 2014), that consist of an intercalation of basaltic andesite and porphyritic andesite-dacite lavas, levels of andesitic- dacitic lapilli tuff, and pyroclastic breccia that grade upwards to an upper unit of compacted and thick rhyolitic tuff, and the upper subvolcanic suite of middle-late Miocene age (11.75 ± 0.24 Ma, 8.9 ± 0.4 Ma, U-Pb zircon, Maydagán *et al.*, 2014) that consists of a series of porphyritic intrusions, dykes, and magmatic-hydrothermal breccias.

LA-ICPMS U-Pb zircon ages from the Altar porphyries indicate four discrete events of intrusions over an extended magmatic life time of ca. 3 m.y. It comprises a pre- mineralization porphyry (11.75 ±0.24 Ma), three mineralized porphyries (11.62 ± 0.21 and 11.68 ± 0.27 Ma, 11.13 ± 0.26 Ma, 10.35 ± 0.32 Ma) related to hydrothermal breccias, two post-mineralization intrusions, and a post-mineralization breccia (8.9 ± 0.4 Ma, Maydagán *et al.*, 2011, 2014).

In this study we present new apatite (U-Th)/He data (AHe) in order to quantify the extent of tectonic-related exhumation in the Andes Main Cordillera in Argentina and compare the results with the exhumation patterns from the Coastal, Frontal and Main Cordilleras at similar latitudes in Chile. The aim of our research is to identify possible pulses of tectonic exhumation in the region given their importance to emplacement of subvolcanic intrusions related to Cu (Au) mineralization.

METHODS

We present preliminary U-Th/He ages of apatite from 7 igneous rock samples obtained in the Altar region. The preparation of the samples for U-Th/He analysis of apatites was done in the laboratory of the University of Padova (Italy) and the U-Th/He ages were obtained in the University of Arizona, Tucson (USA). Three apatite crystals (euhedral shape, width greater than 90 Mm and without inclusions) were selected per sample. The ages that are presented correspond to the average of apatite crystals analyzed in each sample.

RESULTS

AHe ages present a broad distribution ranging from 9.96 to 56.83 Ma, but the majority of them show middle Miocene ages. Two samples from the tonalitic batholith of Late Carboniferous age (~ 297 Ma dating U-Pb in zircons, Maydagán, 2012) showed AHe ages of 14.3 and 11.87 Ma. AHe ages from the subvolcanic stocks from the middle to late Miocene showed ages between 13.45 and 11.17 Ma.

CONCLUSIONS

The U-Th/He ages ranging between 14.3 and 11.17 Ma obtained for the late Carboniferous tonalite and for the subvolcanic stocks indicate an exhumation pulse of the region during the middle Miocene. This lapse of time

partially overlaps with the period of emplacement of the subvolcanic porphyries in the Altar deposit, which have U-Pb crystallization ages between 12.0-10.3 Ma (Maydagán *et al.*, 2011, 2014). Therefore, thermochronological data indicate that the intrusion of subvolcanic bodies in the study region coincide with the final stage of the regional exhumation event.

In the study area, Triassic and Jurassic sedimentary rocks are tectonically overlain by the late Carboniferous tonalite along the E-vergent Mondaquita reverse fault (Perelló *et al.*, 2012). U-Th/He ages obtained in the tonalite could be therefore related to vertical displacements associated to the Mondaquita Fault. To the west, the Pachón Fault brings the Miocene sequence (early volcanic rocks and middle-late Miocene subvolcanic stocks) on the late Carboniferous tonalite. As the AHe ages obtained from both sides of the Pachon Fault are similar we can hypothesize that the entire area (irrespective of the Pachon Fault) was exhuming between 14 and 11 Ma.

The overlap of U-Pb and AHe ages recognized in the samples of the middle Miocene porphyritic intrusions analyzed (Altar North and Altar East) suggests that these AHe ages are related not to exhumation, but rather to igneous cooling and, thus, that the intrusion depth of these porphyritic stocks was shallow, probably in the upper ~2-3 km.

In the Frontal Cordillera of Chile, to the west, Rodríguez Montecinos (2013) obtained fission-track ages significantly older than AHe ages in Late Cretaceous, Paleocene, and Eocene intrusions, therefore demonstrating that these magmatic bodies were intruded at deeper levels. However, the AHe ages obtained by these authors are Miocene (18.1-6.9 Ma) reflecting a similar time of exhumation in the Frontal Cordillera of Chile and the study area.

The period of exhumation reflected by AHe ages also coincide with the collision and passage of the Juan Fernández Ridge below the flat-slab segment at these latitudes. The new data confirm a temporal connection between ridge arrival, exhumation, and porphyry copper formation in the study region.

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