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Topaz magmatic crystallization in rhyolites of the Central Andes (Chivinar volcanic complex, NW Argentina): Constraints from texture, mineralogy and rock chemistry

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ABSTRACT

Topaz-bearing rhyolite lavas were erupted as domes and cryptodomes during the early history of the Late Miocene Chivinar volcano, in Central Andes. These are the only topaz rhyolite lavas recognized in Central Andes. Textural, mineralogical and geochemical data on the Chivinar rhyolites suggest that topaz crystallized from strongly residual, fluorine-rich, peraluminous silicate melts of topazite composition before the complete solidification of the lava domes. Crystallization of the rhyolitic magma began with sodic plagioclase and alkali feldspar phenocrysts in the magma chamber, followed by groundmass quartz + alkali feldspar + minor sodic plagioclase during dome emplacement, and terminated with quartz + topaz + vapour bubbles forming small scattered miaroles. Fluorine partitioning into the fluid phase occurred only in the final stage of groundmass crystallization. The magmatic origin of topaz indicates the presence of a fluorine-rich highly differentiated magma in the early history of the Chivinar volcano and suggests the possibility of rare metals mineralizations related to the cooling and solidification of a silicic magma chamber. A late fluid circulation phase, pre-dating the andesitic phase of the Chivinar volcano, affected part of the topaz rhyolite lavas. The presence of Nb, Ta and Mn minerals as primary accessories in the rhyolites and as secondary minerals in veins suggests a connection of the fluid circulation phase with the silicic magmatic system. Although at the edge of the active volcanic arc, the Chivinar topaz rhyolites are in correspondence of the transtensive Calama–Olacapato–El Toro fault system, suggesting preferred extensional conditions for the formation of magmatic topaz in convergent settings, consistently with evidence from other known cases worldwide.

1. Introduction

Although more frequently interpreted as the product of post-magmatic vapour-phase alteration (e.g.; Taylor, 2009), topaz is also a rare primary constituent of magmatic rocks, originated by the crystallization of peraluminous and fluorine-rich silicic magmas (Agangi et al., 2010; Lukkari, 2002; Scaillet and MacDonald, 2004). The silicate melts enriched in fluorine have particular physical properties, i.e. low viscosity and density (Aiuppa et al., 2009). These enhance the efficiency of the petrogenetic processes, allowing segregation of unusually low fractions of partial melt from the source, as well as favouring crystal-melt fractionation during magma ascent. By that, fluorine (F) promotes the production and release of very small volumes of felsic magma enriched in a wide variety of incompatible elements (Keppler, 1993) and, consequently, potentially related to economically interesting ore mineralizations (e.g.; Burt et al., 1982; Xie et al., 2013).

In this paper we report the occurrence and the mineralogical, petrographic and chemical characteristics of rhyolitic lavas bearing topaz from the Late Miocene Chivinar volcano, located in Central Andes (Fig. 1; Koukharsky et al., 1991; Orlandi et al., 2011). While several high-silica, topaz-bearing rhyolitic lavas of Cenozoic age have been recognized in North America (western United States and Mexico; Christiansen et al., 1986; Huspeni et al., 1984; Sinclair, 1986; Rodríguez-Ríos et al., 2007), the Chivinar topaz rhyolites are, to date, the only occurrence in the Andes of South America.

Owing to their location at the intersection of the Andean active magmatic arc with a major NW-striking fault system (Fig. 1A) and to their peculiar mineralogy, the Chivinar rocks present a two-fold interest. First, the knowledge of the petrogenetic processes responsible for the composition of these lavas may add new elements for the interpretation of the genesis and evolution of magmas at the arc-back-arc boundary in Central Andes (Acocella et al., 2011; Matteini et al., 2002). Second,

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understanding the origin of topaz in magmatic rocks may contribute to explain mineralizations in rare, economically interesting elements (Xie et al., 2013 and references therein). For both purposes, the determination of the primary (magmatic) vs. secondary (hydrothermal) origin of topaz is crucial. This contribution presents the textural, mineralogical and geochemical constraints to the magmatic origin of topaz in the Chivinar rhyolite and proposes a model for the magmatic crystallization of topaz rhyolite.

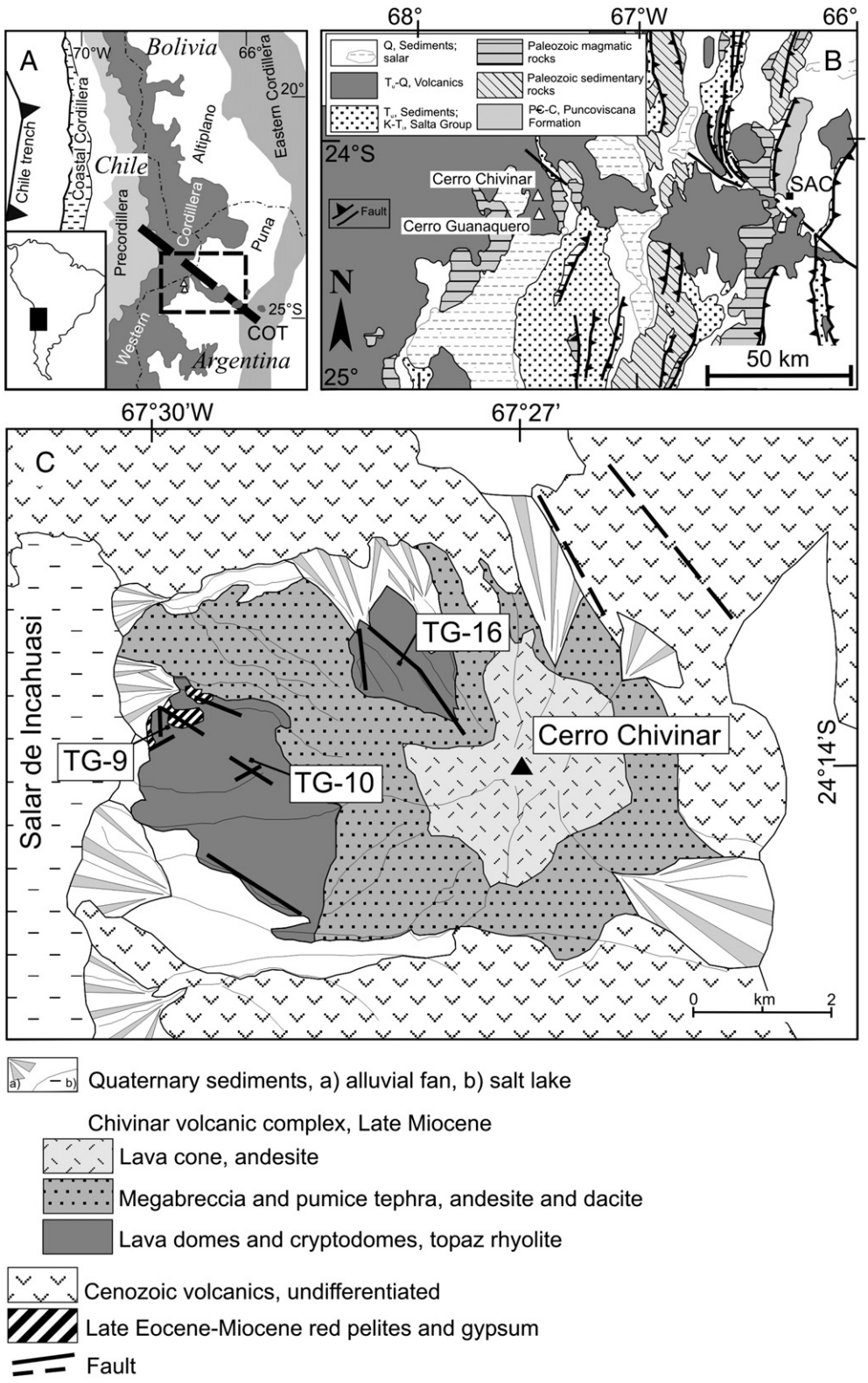

Fig. 1. Geological framework of the Chivinar volcanic complex. (A) Location of the studied area with respect of the morpho-structural units of the Central Andes. The Western Cordillera is the active magmatic arc. Miocene to Quaternary volcanism develops in the backarc along some transverse NW-trending lineaments as the Calama–Olacapato–El Toro (COT) fault system. (B) Regional geologic map of the Puna plateau showing the location of the Chivinar volcano at the boundary between the magmatic arc and backarc. SAC: San Antonio de los Cobres. (C) Geologic map of the Chivinar volcano based on our new field mapping. Location of the samples studied is shown.