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La Peligrosa caldera (47° 15′S, 71° 40′W): A key event during the Jurassic ignimbrite flare-up in Southern Patagonia, Argentina

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ABSTRACT

Pyroclastic and lava vent-facies, from the Late Jurassic El Quemado Complex, are described at the southern Lake Ghío, in the Cordillera Patagónica Austral. Based on the comprehensive study of lithology and structures, the reconstruction of the volcanic architecture has been carried out. Four ignimbrites and one rhyolitic lava unit, affected by oblique-slip normal faults have been recognized. The evolution of La Peligrosa Caldera has been modeled in three different stages:1) initial collapse, consisting of a precursory downsag subsidence, related to a dilatational zone, which controlled the location of the caldera, 2) main collapse, with the emplacement of large volume crystal-rich ignimbrites and megabreccias, under a progressive subsidence controlled by a pull-apart structure related to a transtensional regime and 3) post-collapse, in which lava flows and associated domes were emplaced under an oblique-extensional regime. The caldera records a remarkable change from transtension to oblique extension, which may represent an important variation in regional deformation conditions during Jurassic times. La Peligrosa Caldera may be considered a key event to understand the eruptive mechanisms of the flare-up volcanism in the Chon Aike Silicic Province.

1. Introduction

Ancient calderas offer exceptional insight into those lithofacies and structures commonly buried in modern calderas. In particular, collapse-related breccias may be exposed in deeply eroded cases, giving the opportunity to explore both mechanisms and timing of the caldera collapse. In addition, the role of regional tectonics in controlling the caldera inception may be assessed.

Unlike other ancient and large-volume ignimbrite fields, where collapse calderas are commonly recognized (Lipman, 1975; Steven and Lipman, 1976; Busby-Spera, 1984; Lipman, 1984; Swanson and McDowell, 1984; Aguirre-Díaz et al., 2008), only a few well-documented calderas were assumed to be associated with Jurassic Patagonian volcanism (Sruoga, 1994; Aragón et al., 1996; Fernández et al., 1996; Chernicoff and Salani, 2002; Guido, 2004; Echavarría et al., 2005; Sruoga et al., 2010). Several factors may be considered responsible for the poor preservation of structural or lithological evidence which may be undoubtedly related to caldera-forming eruptions. Particularly, the overlapping of many successive large-volume ignimbrite events during ~35 Ma along the southwestern margin of Gondwanaland (Fig. 1a), combined with a low post-Jurassic erosion rate in the extra-Andean domain, led to the concealment of eruptive centers.

On the northeastern flank of the Sierra Colorada at 47°S (Fig. 1b), Tertiary Andean thrusting and Cenozoic strong glacial erosion permitted the exhumation of the roots of the deeply dissected La Peligrosa caldera (Sruoga, 1994; Sruoga et al., 2008, 2010). Moreover, it is a unique window from where the eruptive mechanisms prevailing throughout the Jurassic ignimbrite flare-up in the southwestern margin of Gondwana might be examined.

The aim of this paper is to describe complex intracaldera stratigraphy and structures, and to propose a model for the evolution of La Peligrosa caldera. Key pieces of evidence have been taken into account to reconstruct the volcanic center and to unravel the collapse mechanisms leading to the caldera formation. Particularly, the megabreccia, herein described and interpreted as a collapse breccia deposit for the first time, provides relevant evidence for the caldera reconstruction. In addition, the role of previous structures in controlling the caldera development is discussed. As the original dimensions are no longer preserved no volume calculation has been carried out.

2. Geological setting

In Patagonia, the Jurassic (188 to 153 Ma, Pankhurst et al., 2000) silicic magmatic rocks are known as the Chon-Aike Province, one of the two Gondwana Granite–Rhyolite Provinces defined by Kay et al. (1989). The Chon-Aike Province (Fig. 1a) was emplaced in the first

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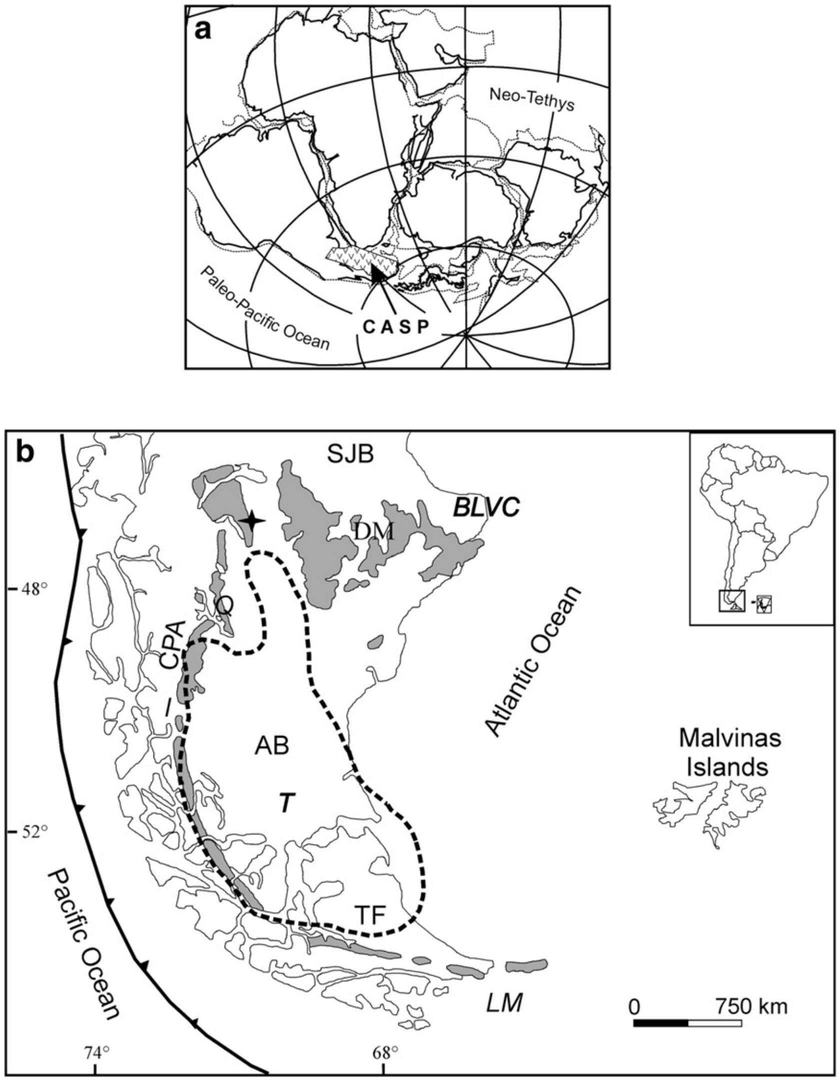

Fig. 1. a) Location of the Chon Aike Silicic Province (CASP) in Gondwanaland adapted from Vaughan et al. (2005). b) Sketch map of Southern Patagonia showing the main outcrop areas of South CASP. SJB: San Jorge Basin. AB: Austral Basin. DM: Deseado Massif. CPA: Cordillera Patagónica Austral. TF: Tierra del Fuego. Main local stratigraphic names are included (BLVC: Bahía Laura Volcanic Complex, Q: El Quemado Complex, I: Ibáñez Formation, T: Tobífera, LM: Lemaire Formation). The study area is indicated with a star.

stages of Gondwana breakup, within a complex and dynamic tectonic setting. A combination of slow subduction rates at the proto-Pacific margin with the activity of the Karroo mantle plume and a clockwise rotation of the axes of the Pacific magmatism since the Triassic has been proposed (Storey et al., 1992; Rapela et al., 2005). The province covers an area of *ca*. 700,000 km^2, including the subsurface of the San Jorge and Austral oil-productive basins, the Continental Platform and the Antarctic Peninsula. A minimum volume of 235,000 km^3 has been estimated (Pankhurst et al., 1998). Based on its huge size and monotonous silicic composition, it was defined as a silicic LIP by Pankhurst et al. (1998) and renamed as the Chon-Aike Silicic Province (CASP) by Sruoga et al. (2010). It extends from the Atlantic to the Pacific coast and it is better exposed in the North Patagonian and Deseado massifs and along the Andean Cordillera, where it has local stratigraphic names (Fig. 1b). Distinctively, the volcanic province includes either silicic-dominated monotonous series or bimodal assemblages. It encompasses large-volume ignimbrite plateaus and granites, with subordinated lavas, domes and dykes, and interbedded epiclastic rocks. Locally, andesites and trachyandesites are relatively abundant (Sruoga, 1989; Pankhurst and Rapela, 1995; Pankhurst et al., 1998).

In the southern CASP, the volcanic rocks are remarkably similar in their lithology and geochemical composition and they may be distinguished only on the basis of post-Jurassic tectonic deformation.

In the Deseado Massif, where many low sulfidation gold and silver deposits are associated with the Bahía Laura Volcanic Complex (Schalamuk et al., 1999; Guido and Schalamuk, 2003), the volcanic rocks are predominantly flat-lying and relatively undeformed. They overlie Early Paleozoic to Early Jurassic sedimentary and igneous rocks. In contrast, the silicic rocks in the Andean Cordillera have been variably deformed during the Cenozoic Andean orogeny. Locally known as El Quemado Complex (Riccardi, 1971), Tobífera (Thomas, 1949) and Lemaire Formation (Borrello, 1969) they extend from the province of Chubut (42° S) to Tierra del Fuego and Isla de los Estados (51° S) (Fig. 1b). This unit overlies a Paleozoic low-grade metamorphic basement, known as Río Lácteo Formation. It consists of black shales, interbedded metagreywackes and quartz phyllites and it was tentatively assigned to the Devonian–Carboniferous (Riccardi and Rolleri, 1980). During the Permian, the basement was deformed (Ramos, 1982) resulting in a NNE to N–S structural grain (Giacosa and Franchi, 2001). In Jurassic times, a regional and long-lasting extensional regime resulted in a system of grabens and half-grabens, controlled by NW–SE trending faults (Ramos, 1989; Kraemer et al., 2002). According to Homovc et al. (1996) the main NNW trending structures show evidence of transtensional behavior since the Early Jurassic. Elsewhere, Japas et al. (2007, 2013a) and Sruoga et al. (2010) studied the close relationship between the Chon-Aike silicic volcanics and the normal faulting system