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The role of inherited tectono-sedimentary architecture in the development of the central Andean mountain belt: Insights from the Cordillera de Domeyko

A. Amilibia [a,*], F. Sàbat [a], K.R. McClay [b], J.A. Muñoz [a], E. Roca [a], G. Chong [c]

[a] Departament de Geodinàmica i Geofísica, Universitat de Barcelona, Zona Universitaria de Pedralbes s/n, 08018 Barcelona, Spain
[b] Fault Dynamics Research Group, Geology Department, Royal Holloway University of London, Egham, Surrey, TW20 0EX, UK
[c] Departamento de Ciencias Geológicas, Universidad Católica del Norte, Antofagasta, Chile

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ABSTRACT

The structure of the Cordillera de Domeyko is dominated by a number of elongated N–S-trending basement ridges. These ridges were uplifted by steep reverse N–S faults that deformed the Mesozoic–Cenozoic cover. The vergence of the fault system varies along strike, conferring an apparent doubly vergent "pop-up" geometry to the axial zone. Two Mesozoic pre-compressional extensional events were recorded in the area. New structural data presented in this paper indicate that most of the generated N–S-trending thrusts and related folds were controlled by the inversion of the pre-existing Mesozoic extensional faults. Thin-skin structures in the Mesozoic–Cenozoic cover are genetically linked to major basement upthrusts, which could be interpreted as basement short-cuts formed during inversion rather than as uplifted blocks associated with major Cenozoic strike-slip faults. Growth-strata geometries date the beginning of the Andean compressional event, which generates the Chilean Precordillera, as far back as 90 Ma ago; the resulting structural architecture is strongly controlled by inherited pre-Andean extensional structures. The association of porphyry intrusives with major reverse faults suggests that the emplacement of the Eocene–Oligocene porphyry Cu–Mo deposits in Northern Chile can be explained by an oblique-inversion Tectonics Model. The upper Eocene–lower Oligocene giant porphyry copper bodies (Chuquicamata, La Escondida, El Salvador) located in the Cordillera de Domeyko show an adakitic affinity. This magma affinity, together with structural evidence presented in this work, indicates that porphyry emplacement occurred at the end of the basement-involved contractional stage that generates the anomalous thickened crust needed to generate these magmas. This tectonic evolution is coherent with the existence of a flat-slab subducting beneath the Central Andes (22°–26° S) during early Cenozoic, that will also produce the eastward migrating of the compressional regime in the upper plate since Late Cretaceous.

1. Introduction

The Central Andes, between 22° and 25° south latitude, occupies the smooth transition between a nearly flat subduction to the south and a 30° east dipping subduction to the north. It includes several N–S-trending morphostructural units between the present-day subduction margin and foreland (Fig. 1). From west to east these units are: (1) Coastal Cordillera, (2) Longitudinal Valley, (3) Chilean Precordillera and pre-Andean Depression, (4) Western Cordillera (magmatic arc), (5) Altiplano – Puna, (6) Eastern Cordillera and (7) Sub-Andean Ranges (deformed foreland).

The studied area is located in the Cordillera de Domeyko, which belongs to the northern part of the Chilean Precordillera (Figs. 1 and 2). The Precordillera structure consists of several N–S-trending basement ridges parallel to the trench. These basement ridges are uplifted by high-angle reverse to oblique faults (Fig. 2). The deformation in the Mesozoic to Cenozoic cover is characterized by folds and low angle reverse faults.

Most of the major porphyry copper deposits in northern Chile are located within or adjacent to the Cordillera de Domeyko (Fig. 2) and present similar ages (40–30 Ma). This N–S alignment of contemporaneous deposits has given rise to the hypothesis that the emplacement of these Eocene–Oligocene intrusive complexes was controlled by an N–S strike-slip fault system called West Fault System (WFS) (Astudillo et al., 2007; Hoffmann et al., 2006; Reutter et al., 1996; Richards et al., 2001). According to previous authors, these faults developed in a transtensional regime as a result of the strain-partitioning expected along the margin, due to the oblique subduction of the Nazca plate beneath the South American plate (Fig. 3). Other authors consider that NW–SE lineaments also play

* Corresponding author.
E-mail addresses: aamilibiac@ub.edu, ken@gl.rhul.ac.uk (A. Amilibia).

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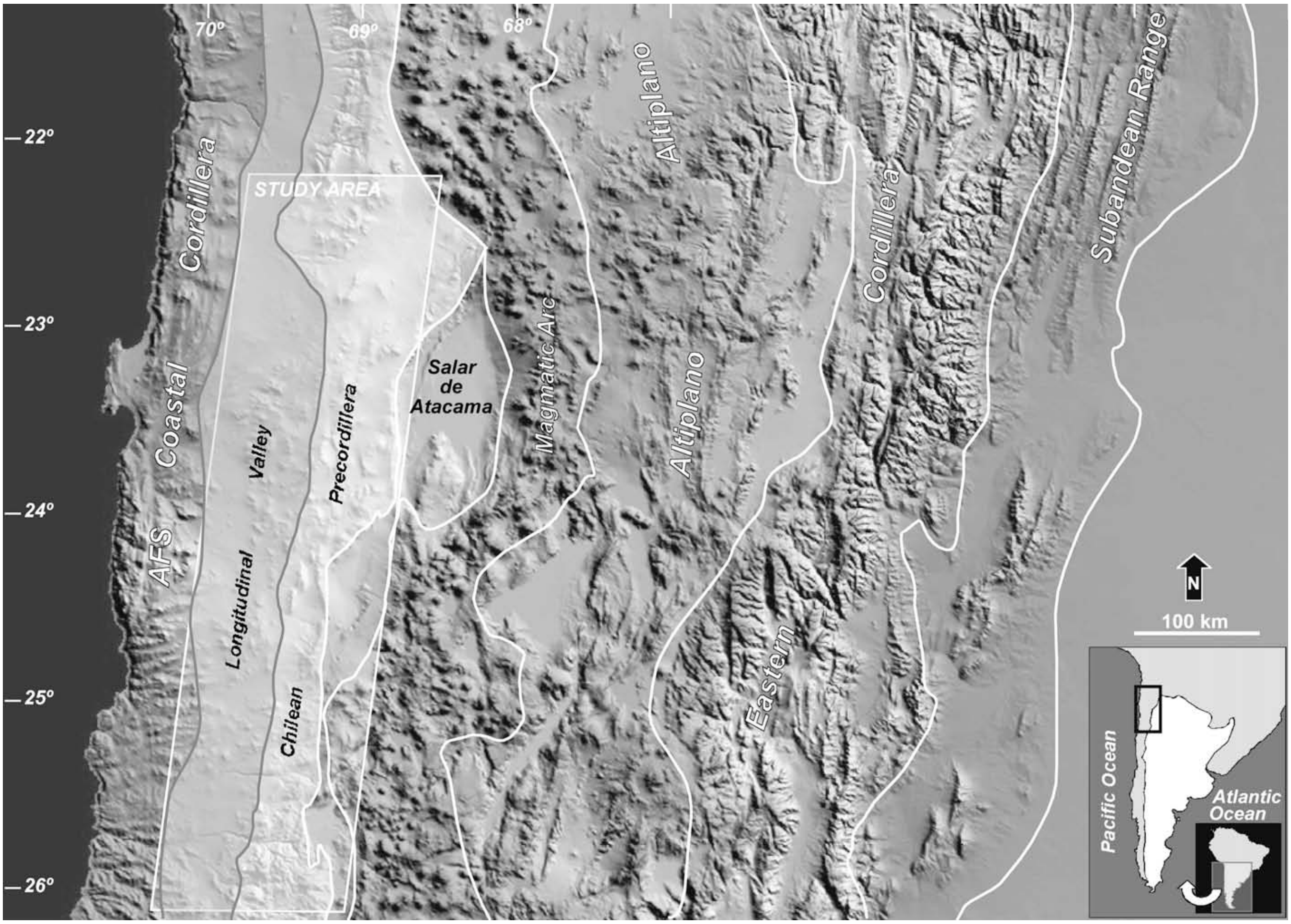

Fig. 1. Northern Chile and Argentina DEM base on Nasa SRTM dataset. The principal morphostructural units of the Central Andes are represented. The study area is located along the Chilean Precordillera morphostructural unit.

a role in the porphyry copper emplacement, especially when intersecting the N–S ones (Salfity, 1985; Chernicoff et al., 2002; Richards, 2003).

The aims of this work are: (1) to evaluate the influence of the pre-Andean structures in the structural style and evolution of the Cordillera de Domeyko and, (2) to validate the influence of the previously described mayor strike-slip faults in the area. Structural inheritance in mountain belts has been extensively described in the Alps, Apennines, Canadian Rocky Mountains as well as in the Argentinian Andes (Gillcrist et al., 1987; Butler, 1989; McClay et al., 1989; Grier et al., 1991; Buchanan and Buchanan, 1995; Uliana et al., 1995; Scisciani et al., 2002; Ramos et al., 2004; Tavarnelli et al., 2004; Butler et al., 2006; Carrera et al., 2006; Hongn et al., 2007). Previous work in the area (Mpodozis and Ramos, 1990; Amilibia et al., 2000; Amilibia, 2002) already suggested an important control on the geometry and localization of the newly developed contractional structures by the pre-existing Mesozoic extensional faults.

2. Geological background

2.1. Tectonic setting

The present-day structure architecture of the Cordillera de Domeyko is the result of the geodynamic evolution of the South American Plate west margin, in which two major stages can be differentiated. A pre-Early Jurassic stage, prior to Nazca subduction, and a Early Jurassic to present stage coeval with the subduction of this plate beneath South American plate.

2.1.1. Pre-subduction stage

During the first stage, the tectonic regime was characterized by: (1) Early to Late Paleozoic accretion and collision of terrains associated with the subduction along the Proto-Pacific plate boundary (Ramos, 1988), which resulted in the final assemblage of Gondwana; and (2) the development of an aborted continental rift between the Early Triassic and Early Jurassic (Figs. 4 and 5A), interpreted as the prolongation of the opening of the North Atlantic towards the south within the South American plate (Uliana et al., 1989; Suarez and Bell, 1992; Mpodozis and Cornejo, 1997; Franzese and Spalletti, 2001).

This continental rift, developed in the present-day western margin of the South American plate, was characterized by a set of NW–SE-trending Triassic half-graben basins arranged in an en-echelon pattern. They have been extensively described in the foreland ranges of south and central Argentina (Alvarez and Ramos, 1999; Franzese and Spalletti, 2001), disappearing under the present-day magmatic arc and reappearing to the west in selected outcrops along the Cordillera de Domeyko. The pre-existing Paleozoic suture zones controlled the location as well as the NW–SE orientation of the newly developed half-graben basins (Günther et al., 1997), as testified by the different geochemical signatures and independent magmatic evolution shown by the Paleozoic