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Mesozoic arc magmatism along the southern Peruvian margin during Gondwana breakup and dispersal

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A high-resolution U–Pb zircon geochronological study of plutonic units along the south Peruvian margin between 17° and 18°S allows the integration of the geochemical, geodynamic and tectonic evolution of this part of the Andean margin. This study focuses on the composite Jurassic–early Cretaceous Ilo Batholith that was emplaced along the southern Peruvian coast during two episodes of intrusive magmatism; a first period between 173 and 152 Ma (with a peak in magmatic activity between roughly 168 and 162 Ma) and a second period between 110 and 106 Ma. Emplacement of the Jurassic part of the composite Ilo Batholith shortly post-dated the accumulation of the volcanosedimentary succession it intruded (Chocolate formation), which allows to estimate a subsidence rate for this unit of ~3.5 km/Ma. The emplacement of the main peak of Jurassic plutonism of the Ilo Batholith was also closely coeval with widespread and repeated slumping (during deposition of the Cachíos Formation) in the back-arc region, suggesting a common causal link between these phenomena, which is discussed in the context of an observed 100 km trenchward arc migration at ~175 Ma, and the relation with extensional tectonics that prevailed along the Central Andean margin during Pangaea break-up.

1. Introduction

Changes in the temporal and spatial evolution of volcanic arcs partly reflect changes in the kinematics of subduction zones at plate margins. Intermittently magmatic arcs in Peru have been active since ~550 Ma (Cawood, 2005) as a consequence of subduction of Pacific plates beneath western South America. Therefore southern Peru can be considered as a type locality for long-lived, active continental margins (Chew et al., 2007; Mišković et al., 2009; Mukasa, 1986; Pindell and Tabbutt, 1995). Unlike other sections of the western South American margin, the Peruvian margin has not been modified by terrane accretion since the onset of subduction (Loewy et al., 2004; Mišković et al., 2009), mainly preserving original rock relationships, providing the opportunity to construct a chronostratigraphic framework for the evolution of the Jurassic arc system. This contribution presents geochronological and geochemical data from the Jurassic arc in southern Peru, which is used to constrain the tectonic evolution of the region during and subsequent to the fragmentation of Gondwana.

The Jurassic continental arc has been documented along almost the entire length of western South America, which formed during increased subduction-related magmatism after the fragmentation of Gondwana (Fig. 1). Plutonic, subduction-related rocks intrude Palaeozoic metamorphic rocks and Triassic high-temperature metamorphic rocks that formed during periods of extension associated with rifting in western Gondwana. Jurassic subduction is part of the active margin stage of the Pacific Wilson cycle along the Peruvian margin, although the exact timing of arc magmatism and the evolution of the continental margin have been poorly studied in southern Peru.

The composite Ilo Batholith fringes the coastline of southern Peru (17°–18° S), and forms the northern termination of the continuous Jurassic plutonic belt that extends southwards to central Chile (28°S). Jurassic plutonic rocks of the Ilo Batholith were emplaced as a large-scale tabular body within an extensional regime that has been documented during the Middle and Late Jurassic (Sempere et al., 2002). Slab roll-back and the formation of local pull-apart basins formed during southeast-directed oblique subduction of the Paleo-Pacific plate under the South American plate (Grocott et al., 1994; Jaillard et al., 1990; Scheuber and Gonzalez, 1999).

The Ilo Batholith intrudes through sparsely exposed, Grenvillian-aged basement (Loewy et al., 2004; Ramos, 2008b) of the Arequipa Massif (Fig. 1), which is defined by its radiogenic Pb isotopic compositions with low $^{206}Pb/^{204}Pb$ ratios, typical of high-grade rocks (Mamani et al., 2010), and is exposed along the coastal region of southern Peru and northern Chile. The highest levels of the Ilo Batholith intrude Late Triassic–Jurassic volcanic and volcaniclastic rocks of the Chocolate Formation (Romeuf et al., 1995).

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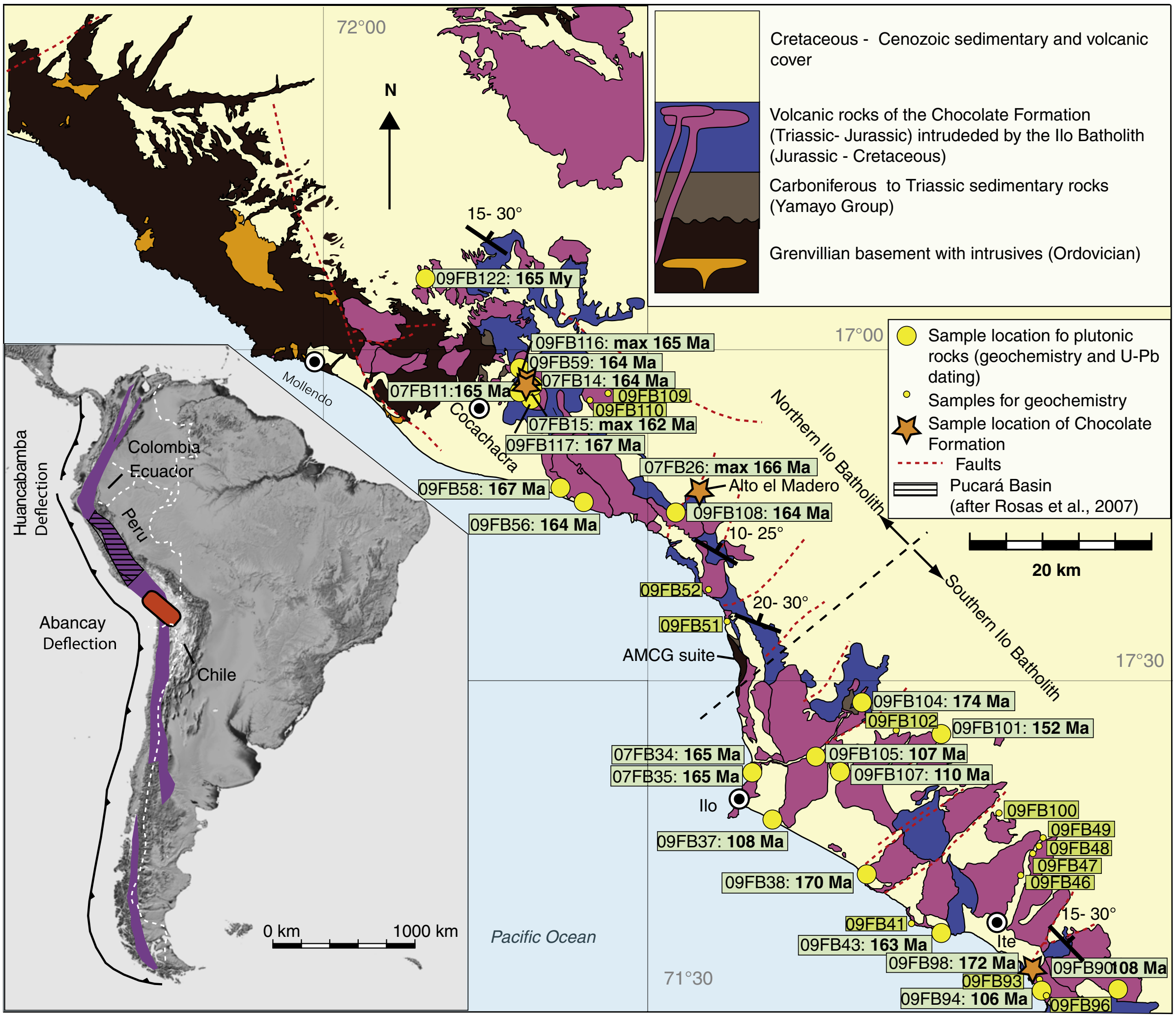

Fig. 1. Geological map of the plutonic belt of southern Peru illustrating the locations of samples and distribution of U–Pb ages of intrusives of the Ilo Batholith and intruded Chocolate and Puente formations (see Table 1 for U–Pb age data of plutonic rocks). Inset: Schematic representation of the Jurassic arc system along the western margin of South America. For references see text in Section 1.

We construct a detailed chronostratigraphy for the Jurassic arc along coastal southern Peru, and provide new age constraints for plutons of the Ilo Batholith, and volcanic and volcaniclastic rocks of the Chocolate Formation. Zircon U–Pb ages were obtained using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), and chemical abrasion-isotope dilution-thermal ionization mass spectrometry (CA-ID-TIMS) analyses of magmatic and detrital zircons. The geochronological data have been combined with field observations, geochemical trace and major element analyses, and whole-rock Nd, Sr and Pb isotopes to investigate the evolution of Jurassic, plate-margin magmas, and the nature of the magmatic sources of the arc through time. The combination of these new data provides constraints on the temporal relationships between arc magmatism, back-arc extension and sedimentation along the southern Peruvian margin during the Jurassic.

2. Geological framework

2.1. Jurassic subduction related magmatism

Jurassic magmatic arcs are exposed semi-continuously along the entire western margin of South America (Fig. 1 inset), extending from Colombia to Patagonia. Jurassic magmatism in the Northern Andes (north of 5°S) occurred during 183–145 Ma, and may have been continuous into the Early Cretaceous (Cochrane et al., 2011); using the geologic timescale of Gradstein et al. (2004). Plutons were emplaced within an extensional setting coeval with sub-aerial, back-arc sedimentation and sporadic fore-arc marine deposits (Litherland et al., 1994). A NNE-trending belt of calc-alkaline, I-type intrusions (e.g. the Ibagué, Abitagua and Zamora batholiths) is associated with Jurassic (Cochrane et al., 2011) volcanic rocks (Misahualli Fm) in Colombia and Ecuador (e.g. Litherland et al., 1994; Villagómez et al., 2011).

Within the Central Andean Segment, south of 5°S, the Jurassic arc in southern Peru was flanked along its northeast side by a marine back-arc basin. The Jurassic volcanic to volcaniclastic succession (the Chocolate Formation) is intruded by partly coeval plutonic rocks (e.g. Clark et al., 1990), including the Ilo Batholith, as its equivalent in northern Chile (e.g. Oliveros et al., 2006). Jurassic volcanism in northern Chile (La Negra Formation) commenced over a large regional scale at ~200 Ma (Oliveros et al., 2006), although the precise time of arc initiation is enigmatic due to a pervasive hydrothermal overprint. Geochronological ages ($^{40}Ar/^{39}Ar$) span between 200 and 150 Ma (Lucassen et al., 2006), and indicate that magmatic activity was nearly continuous during almost the whole Jurassic, as a consequence of NW–SE plate convergence.

Late Jurassic continental break-up related to the opening of the Weddell Sea from 160 Ma onwards (Ghidella et al., 2002; Ramos, 2008a) formed a back-arc basin in Patagonia (the Rocas Verdes basin)