Gondwana Research 35 (2016) 124–143

Contents lists available at ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Characterisation of Triassic rifting in Peru and implications for the early disassembly of western Pangaea

R. Spikings [a,*], M.J. Reitsma [b], F. Boekhout [c], A. Mišković [d], A. Ulianov [e], M. Chiaradia [a], A. Gerdes [f], U. Schaltegger [a]

[a] Department of Earth Sciences and the Environment, University of Geneva, Rue des Maraichers 13, Geneva 1205, Switzerland
[b] HRH Geology, 19 Silverburn Place, Aberdeen AB23 8GE, United Kingdom
[c] Institut für Geologie und Paläontologie, Corrensstrasse 24, D-48149 Münster, Germany
[d] Deptartment of Earth, Ocean and Atmospheric Sciences, The University of British Columbia, Vancouver V6T 1Z4, Canada
[e] Institute of Mineralogy and Geochemistry, University of Lausanne, Switzerland
[f] Institute of Geosciences, Mineralogy, J. W. Goethe University, Frankfurt 60438, Germany

ARTICLE INFO

Article history:
Received 8 December 2015
Received in revised form 10 February 2016
Accepted 17 February 2016
Available online 1 April 2016

Handling Editor: F. Pirajno

Keywords:
Pangaea
South America
Triassic rifts
Geochronology
Geochemistry
Mitu Group

ABSTRACT

Triassic igneous and sedimentary rocks exposed within the basement of the Andes were deposited in a series of rifts, and may record the early disassembly of western Pangaea. These rocks are sporadically exposed along almost the entire length of western South America, although reliable geochronological and isotopic data are sparse. We combine new geochronological (zircon U–Pb), isotopic (Hf, Nd) and geochemical data with stratigraphic observations to constrain the age and tectonic setting of the Mitu Rift of southern Peru. The Peruvian Mitu Rift is compared with other Triassic rifts in Colombia and Ecuador (Palanda Rift; 240–225 Ma), Bolivia (Mitu Rift; Triassic), Bolivia, Chile and Argentina (e.g. Cuyo Basin; 246–230 Ma), and conclusions are reached regarding the relationship between Triassic extension along the western margin of Pangaea, and the eventual formation of the Proto-Caribbean and Central Atlantic oceans. The Mitu Rift (Peru) was active during ~245–240 to ~220 Ma and was synchronous with rifting along the Pacific margin of Colombia and Ecuador, along the Chilean margin and western Argentina, and probably rifting within Bolivia. Rifting north of the Huancabamba Deflection was accompanied by subduction and led to seafloor spreading, whereas rifting along the Peruvian and Chilean margins mainly occurred in the absence of subduction and terminated prior to the formation of extensive transitional crust. Extension within Peru and Chile probably occurred via a combination of transtension, steepening and detachment of an arrested slab. We propose that plate tectonic forces initiated the early break-up of Pangaea by attenuating its margins and enhancing mantle upwelling. Prolonged extension may have propagated along pre-existing weak zones that extended into the continental interior, captured melts derived from the upwelled mantle forming a LIP (e.g. Central Atlantic Magmatic Province), became hot and weak and eventually lead to the formation of a juvenile ocean (e.g. Central Atlantic).

1. Introduction

The amalgamation of Pangaea in the Carboniferous–Permian coincided with a drastic reduction in plate velocities and an almost complete pause in continental drift during the Late Permian–early Jurassic (Vilas and Valencio, 1978). This relatively stationary period was characterised by heat accumulation, the production of large volumes of magmas (e.g. Kay et al., 1989) and geographically extensive extension along western South America (e.g. Charrier et al., 2007; Spikings et al., 2015). Increased plate velocities in the latest Triassic–earliest Jurassic were coeval with the disassembly of Pangaea, although the relationship between Triassic extension and the final disassembly of Pangaea is unclear. We present a detailed stratigraphic, geochronological and geochemical study of the Triassic 'Mitu' rift of Peru, and compare this phase with Middle–Late Triassic rifts in Colombia, Ecuador, Bolivia, Argentina and Chile. This compilation provides a means to assess the overall timing of extension along western Pangaea prior to its disassembly, examine the nature of the forces that drove extension, and discuss their influence on the break-up of Pangaea.

Extension along the northern sections of western South America resulted in the formation of oceanic lithosphere that separated South America from crust that currently forms part of Central America and Mexico (Cochrane et al., 2014a; Spikings et al., 2015). However, extension along the Peruvian and Chilean margins terminated before oceanic lithosphere could form. The aborted Mitu Rift of southern Peru experienced the highest amount of extension along the Peruvian margin, forming depocenters for syn-rift volcanic and sedimentary units (Mitu Group; Fig. 1) that are still partly preserved. The Mitu Group was traditionally assigned to the Permo-Triassic (Dalmayrac et al.,

* Corresponding author.
E-mail address: richard.spikings@unige.ch (R. Spikings).

http://dx.doi.org/10.1016/j.gr.2016.02.008
1342-937X/

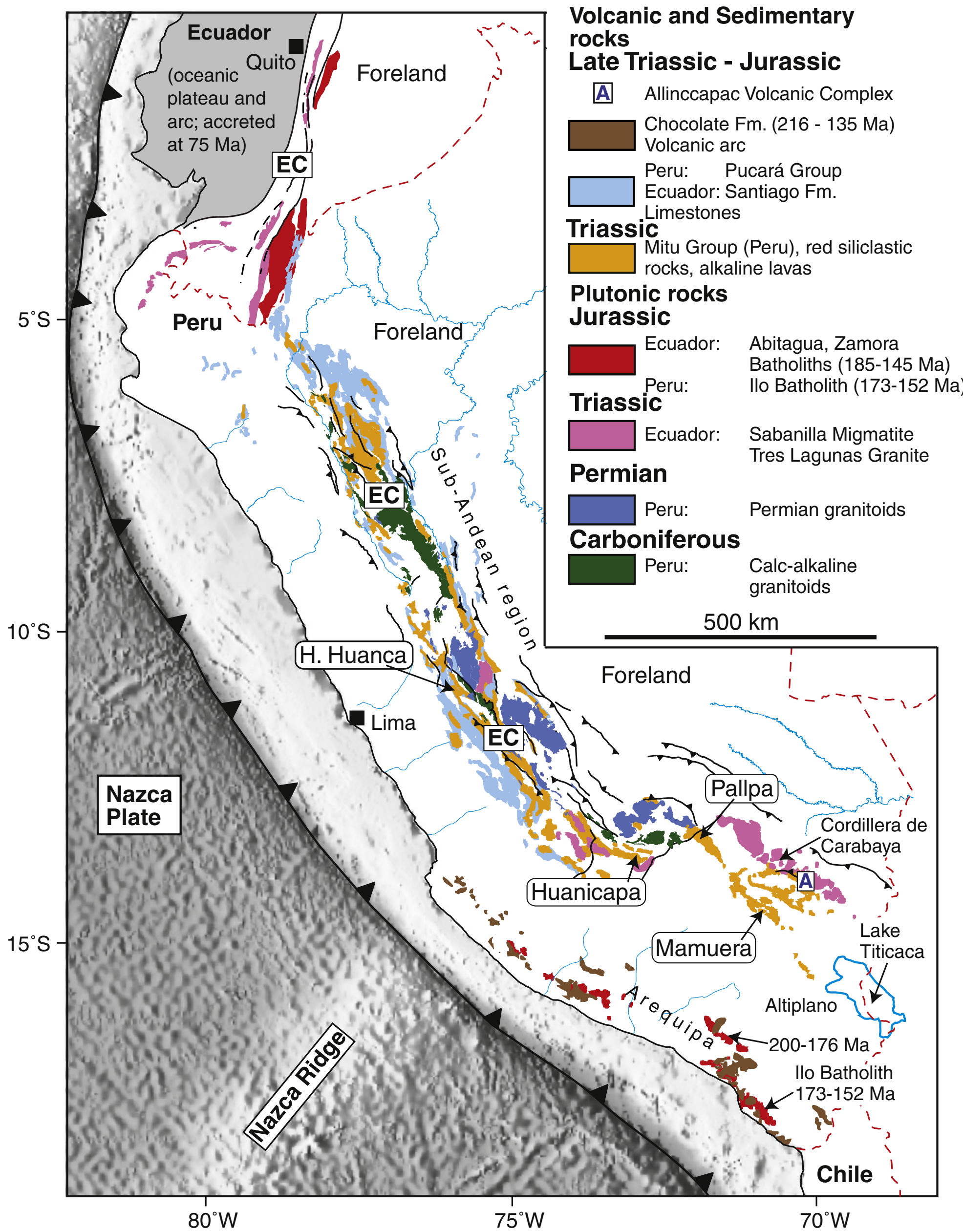

Fig. 1. Simplified geological map of the Eastern Cordillera and coastal region of the Arequipa Terrane of Peru (Leon et al., 2000), and the southern Eastern Cordillera of Ecuador (Litherland et al., 1994), showing the distribution of Carboniferous to Jurassic rocks. Sampled sections through the Mitu Group and the cordilleras Andahuaylas and Carabaya are labeled. U–Pb (zircon) age ranges for the Jurassic batholiths are taken from Boekhout et al. (2012; Peru) and Spikings et al. (2015; Ecuador), and ages for the Chocolate Fm. are from Boekhout et al. (2013). Red boxes labeled A, B are the map regions shown in Fig. 2a, and b, respectively. EC: Eastern Cordillera.

1980; Carlotto, 1998; Kontak et al., 1990; Sempere et al., 2002), although a paucity of fossils has hindered accurate estimates of its age and duration, which were largely based on the ages of the bracketing formations. The upper levels of the underlying Copacabana Group have been constrained by palynology and foraminifera to the Artinskian (Doubinger and Marocco, 1981; Dalmayrac et al., 1980; the timescale of Gradstein et al. (2012) is used throughout this manuscript). An angular unconformity related to the Tardi-Hercynian Orogeny (Laubacher, 1978; Rosas et al., 2007) separates the Copacabana and Mitu groups and renders the age estimate for the basal Mitu Group imprecise. The Pucará Group, regarded by Rosas et al. (2007) to represent a thermal sag phase that occurred subsequent to extension and deposition of the Mitu Group, is attributed to the Late Triassic–Early Jurassic on the basis of ammonite fossils and U-Pb zircon ages from ash beds (Jaillard et al., 1990; Schaltegger et al., 2008; Wotzlaw et al., 2014).

This study presents stratigraphic, geochronological (U–Pb zircon), geochemical and isotopic (Hf and Nd) data from the sedimentary and volcanic rocks of the syn-rift Mitu Group, and coeval granitoid intrusions of the southern Eastern Cordillera of Peru. These data are used to develop a temporal and general tectonic framework for the rift sequence, and to propose driving forces for its formation and termination.

2. Geological framework and previous work

Most of Peru was covered by an epeiric sea in the earliest Permian, giving rise to deposition of carbonates of the Copacabana Group (Fig. 2; e.g. Dalmayrac et al., 1980), which contain abundant shallow marine fossils, and intercalations of sandstone and shale. Siliciclastic input becomes dominant in the final stages (Laubacher, 1978; Doubinger and Marocco, 1981; Reitsma, 2012) of the upper levels of