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Synthesis and tectonic interpretation of the westernmost Paleozoic Variscan orogen in southern Mexico: From rifted Rheic margin to active Pacific margin

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Abstract

Paleozoic rocks in southern Mexico occur in two terranes, Oaxaquia (Oaxacan Complex) and Mixteca (Acatlán Complex) that appear to record: (1) Ordovician rifting on the southern margin of the Rheic Ocean, (2) passive drifting with Amazonia during the Silurian, (3) Devonian-Permian subduction beneath southern Mexico producing an arc complex that was partially removed by subduction erosion, subjected to HP metamorphism and Mississippian extrusion into the upper plate, followed by reestablishment of a Permian arc.

In the Oaxaquia terrane, the 920–1300 Ma basement is unconformably overlain by a ~200 m uppermost Cambrian–lowest Ordovician shelf sequence containing Gondwanan fauna (Tiñu Formation), unconformably overlain by 650 m of shallow marine-continental Carboniferous sedimentary rocks containing a Midcontinent (USA) fauna.

In the Mixteca terrane, the low-grade Paleozoic sequence is composed of: (a) a ?Cambrian–Ordovician clastic sequence intruded by ca. 480–440 Ma bimodal, rift-related igneous rocks; and (b) a latest Devonian-Permian shallow marine sequence (>906 m) consisting of metapsammites, metapelites and tholeiitic mafic volcanic rocks. High pressure (HP) metamorphic rocks in the Mixteca terrane consists of: (i) a Cambro-Ordovician rift-shelf intruded by bimodal rift-related intrusions that are similar to the low-grade rocks; (ii) periarc ultramafic rocks, and (iii) arc and MORB rocks. The Ordovician granitoids contain concordant inherited zircons that range in age from ca. 900 to 1300 Ma, indicating a source in the Oaxacan Complex. Concordant ages of detrital zircons in both the low- and high-grade Cambro-Ordovician metasedimentary rocks indicate a provenance in local Ordovician plutons and/or ca. 1 Ga Oaxacan basement, and distal northwestern Gondwana sources with a unique source in the 900–750 Ma Goiás magmatic arc within the Brasiliano orogen. These data combined with the rift-related nature of the Cambro-Ordovician rocks are most consistent with an origin along the southern margin of the Rheic Ocean. Latest Devonian-Permian deposition was synchronous with Mississippian extrusion of the HP rocks into the upper plate during extensional deformation. The HP Cambro-Orodivician rift-shelf rocks are inferred to have originated in the forearc region of the upper plate that was removed by subduction erosion, carried down the subduction channel, and then extruded into the upper plate in the middle of the Mixteca terrane. The presence of arc-related rocks in the HP assemblage suggests that the arc complex was also removed, whereas the MORB rocks may have been derived from the subducting slab. Detrital zircons in the Carboniferous rocks of both the Mixteca and Oaxaquia terranes contain Devonian detrital zircons and volcanic clasts that are inferred to have come from the removed Devonian arc on the western margin of the Mixteca terrane and/or from exhumed HP rocks. During the Permian, arc-related intrusions in both the Mixteca and Oaxaquia terranes were accompanied by dextral transtensional deformation and deposition of clastic rocks containing Permian detrital zircons and carbonates in periarc, pull-apart basins. Empirical relationships between the dip of the Benioff zone and the widths of arc and forearc indicate that the Permian trench lay beneath the eastern edge of the Mesozoic Guerrero terrane.

Keywords: Paleozoic; Southern Mexico; Acatlán Complex; Tectonics; Rheic Ocean; Paleo-Pacific Ocean

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1. Introduction

Paleozoic rocks in southern Mexico are restricted to the Mixteca terrane and small outliers in the Oaxaquia terrane (Fig. 1). Knowledge of the Paleozoic geology of southern Mexico, especially in the Mixteca terrane (Fig. 2), during the twentieth century was hampered by generally poor preservation of fossils and a lack of reliable age dates. However, the last decade has seen a rapid increase in such data supplemented by geochemistry (Ortega-Gutiérrez et al., 1999; Elías-Herrera and Ortega-Gutiérrez, 2002; Vachard and Flores de Dios, 2002; Keppie et al., 2004a,b; Sánchez-Zavala et al., 2004; Vachard et al., 2004; Talavera-Mendoza et al., 2005; Keppie et al., 2006; Nance et al., 2006; Murphy et al., 2006a,b; Miller et al., 2007; Nance et al., 2007; Middleton et al., 2007; Elías-Herrera et al., 2007; Landing et al., 2007; Vega-Granillo et al., 2007; Keppie et al., 2008; Morales-Gámez et al., 2008; Ramos-Arias et al., 2008; Hinojosa-Prieto et al., 2008; Grodzicki et al., 2008). This has led to considerable revision of the geological history, which has recently been reviewed by Nance et al. (2006, 2007).

Nance et al. (in review) have compiled histograms of detrital zircon ages to give a broad overview of potential sources that they argued were of dominantly local and Gondwanan provenence. Here we try to refine these conclusions by focusing on concordant data (c.f. Anderson, 2005) (Figs. 3 and 4) from which emerges a suite of 900–750 Ma detrital zircons that has a unique source in the Goiás magmatic arc within the Brasiliano orogen of Amazonia (Pimental et al., 2000). We separate the zircon populations according to the age of the unit (Ordovician, Carboniferous and Permian). During the Ordovician both the Iapetus and Rheic oceans were in existence and the characteristics of these zircons test whether they had Gondwanan or Laurentian provenance. On the other hand, during the Carboniferous and Permian, the location of southern Mexico in Pangea implies that both continents may have contributed to the zircon populations. The earliest evidence of a southern source for flysch deposits in the Ouachitan orogen occurs in the Mississippian (ca. 330 Ma: Arbenz, 1989). At about the same time, faunal interchange between Laurentia and Oaxaquia is documented with the appearance of Laurentian (Midcontinent USA) fauna in the Mississippian rocks of southern Mexico (Navarro-Santillan et al., 2002). Deformation associated with Laurentia–Gondwana collision started in the Pennsylvanian (Arbenz, 1989).

This paper, then, presents a tectonic interpretation of the Paleozoic geological record of southern Mexico, which

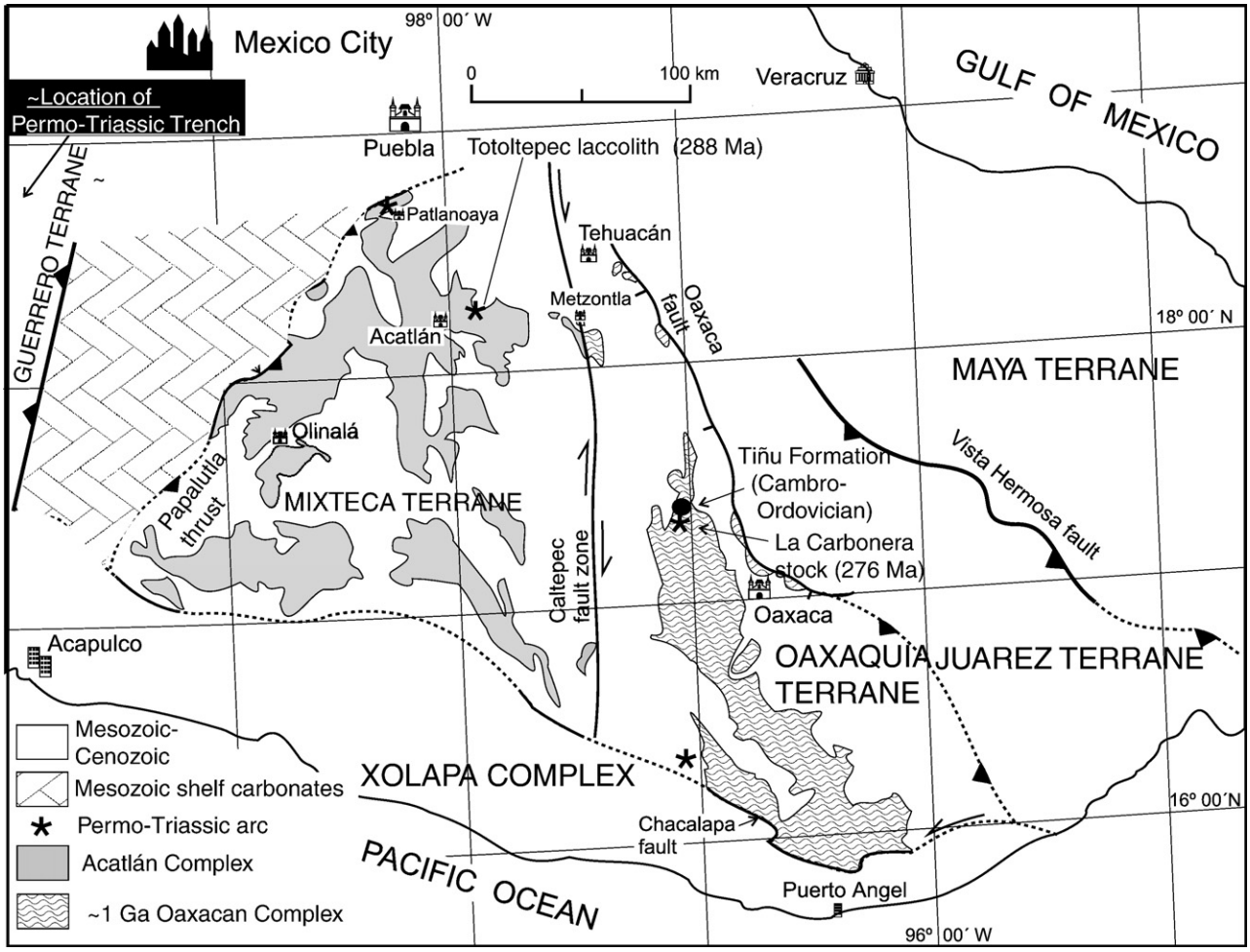

Fig. 1. Terrane map of southern Mexico showing the locations of the Oaxaquia, Mixteca and Guerrero terranes and Permian arc intrusions (modified from Keppie et al., 2003c).