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Nd isotopic data indicating Oaxacan source of Ordovician granitoids in the Acatlán Complex, southern Mexico: Paleogeographic implications

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ABSTRACT

Ordovician megacrystic granitoids intrude the Neoproterozoic-Paleozoic Acatlán Complex of southern Mexico, which consists of rift-passive margin, clastic rocks and rift-related igneous rocks. Most of the Neoproterozoic-Ordovician rocks were folded at greenschist-amphibolite facies metamorphism, however some rocks underwent polyphase deformation, underthrusting under high-pressure metamorphism followed by extrusion during the Late Devonian-Carboniferous (365–330 Ma). Most of our new Nd isotopic data for Ordovician granitoids have $\varepsilon_{Nd(T)}$ ranging between −4.5 and −7.2 with T_{DM} ages of 1.3–1.6 Ga that are similar to most published data from such Ordovician plutons: $\varepsilon_{Nd(T)}$ of −0.2 to −6.6 and T_{DM} ages of 1.2–1.8 Ga. These values are comparable to the range shown by the Oaxacan Complex, which confirms the conclusion reached using zircon U-Pb isotopic data indicating an Oaxacan source. One exception is the Ordovician Teticic granitoid that has $\varepsilon_{Nd(T)}$ of −4.8 to −5.8 and T_{DM} ages of 2162–2946 Ma. The combination of ca. 1.5 and 2–3 Ga T_{DM} ages is also recorded in northwestern Amazonia, which is consistent with previous correlations of Oaxaquia with Amazonia. The transfer of Oaxaquia from Amazonia to southern Laurentia occurred during the amalgamation and breakup of Pangea, where the suture was roughly parallel to their relative motion: this resulted in dextral strike-slip faulting generally attributed to the Mojave-Sonora megashear.

1. Introduction

Mexico consists of numerous terranes accreted to Laurentia during either the Paleozoic (e.g. Oaxaquia terrane), or Mesozoic (Fig. 1). The Mixteca terrane (also called the Acatlán Complex) (Fig. 1) is inferred to have formed on the western margin of Oaxaquia before Pangea amalgamation, However the Mixteca-Oaxaquia contact is faulted, which may have disrupted original relationships (Keppie et al., 2008a, 2008b; Keppie et al., 2012). The Mixteca terrane in southern Mexico consists mainly of Neoproterozoic-Paleozoic, greenschist facies, psammitic-pelitic rocks and tholeiitic, rift-related igneous rocks. Several high pressure (HP) fault slices are incised into the greenschist rocks: some or all of the HP slices have been interpreted either as oceanic sutures (Vega-Granillo et al., 2007, 2009), synformal keels in an allochthonous oceanic nappe (Ortega-Gutiérrez et al., 1999), or as HP slices extruded into the Acatlán Complex during the subduction-extrusion process (Keppie et al., 2008a, 2012, 2016). Thus the Acatlán Complex may consist of several distinct terranes or one terrane, respectively. Although the similarity of the geological record across all these HP slices favours one terrane, the Nd isotopic signatures of Ordovician megacrystic granitoids presented in this paper and in previous publications provide a further test of the one versus multiple terrane hypotheses. The granitoids intrude all parts of the Acatlán Complex, including both low- and high-grade rocks, and isotopic data provide the age of their source. U-Pb zircon data yield 450–480 Ma intrusive ages with inheritance ages of ca. 1.0–1.3 Ga, which are similar to those recorded in Oaxaquia (Keppie et al., 2008a). This paper presents Nd isotopic data that show derivation of the megacrystic granitoids from a Oaxaquia-type basement that is inferred to underlie the Acatlán Complex. Paleogeographic implications are consistent with derivation of Oaxaquia from northwestern Amazonia with transfer occurring during the amalgamation and breakup of Pangea.

2. Geological setting

The predominantly Paleozoic Mixteca terrane is unconformatbly overlain by Cenozoic volcanic rocks of the Transmexican Volcanic Belt (Fig. 1). The other three boundaries are tectonic (Figs. 1 and 2): (i) to the east, a dextral Permian fault (N-S Caltepec Fault Zone, CFZ) separates the Mixteca and Oaxaquia terranes (Elías-Herrera and Ortega-

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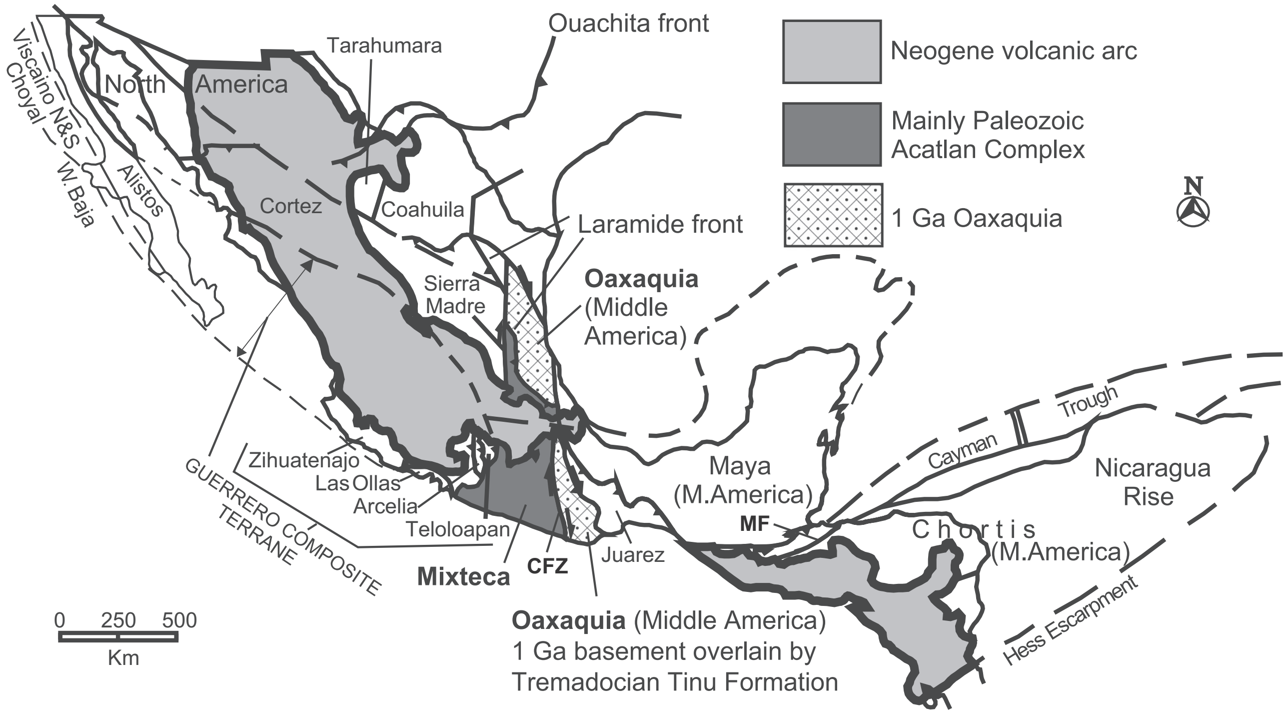

Fig. 1. Terrane map of Mexico showing location of Acatlán Complex (after Keppie et al., 2016).

Gutiérrez, 2002); (ii) to the south, a sinistral transtensional, Cenozoic fault (Chacalapa-La Venta Fault) juxtaposes the Mixteca and Juarez terranes; and (iii) to the west, a Mesozoic-Cenozoic, east-vergent thrust places Cretaceous rocks over the Mixteca terrane (Tolson, 2005).

The Paleozoic rocks of the Acatlán Complex have been subdivided into two assemblages by Keppie et al. (2008a) (Fig. 2) and consist of:

(i) low-medium grade, clastic rocks of Neoproterozoic–Ordovician age intruded by ca. 480–440 Ma bimodal, rift-related igneous rocks, and low grade, psammitic/pelitic and tholeiitic rocks of uppermost Devonian–Permian age containing detrital zircons dated at 900–750 Ma and ca. 1 Ga; and

(ii) HP, periarc, arc and MORB mafic and ultramafic bodies associated with Neoproterozoic–Ordovician rift–shelf metapsammites containing concordant, 900–750 Ma and ca. 1 Ga, detrital zircons, intruded by bimodal, retrogressed eclogitic amphibolites and Ordovician granitoids with ca. 0.9–1.3 Ga inheritance that crop out in a N-S vertical zone (Piaxtla–Mimilulco median belt) and a series of klippes. The median HP belt is bounded above and below by a Carboniferous, east-vergent listric normal fault and a west-vergent thrust, respectively (Ramos-Arias et al., 2008; Galaz et al., 2013). This geometry is consistent with an extrusion zone for the median zone from which the klippes were derived (Keppie et al., 2008a, 2012), rather than earlier interpretations e.g. synformal keels of a single folded nappe rooted in the N-S Caltepec fault zone (Ortega-Gutiérrez et al., 1999) or many, fault-bounded zones representing distinct oceanic remnants (Talavera-Mendoza et al., 2005; Vega-Granillo et al., 2007, 2009). The similar protoliths of low- and high-grade assemblages led to the conclusion that they represent parts of the same sequence (Keppie et al., 2008a).

Ordovician metaigneous rocks of the Acatlán Complex are characterized by the occurrence of bimodal suites of mafic bodies composed of amphibolites and felsic intrusions represented by megacrystic metagranitoids. Both rock types are penecontemporaneous as they intrude and are intruded by each other (Ortega-Obregón et al., 2009). Amphibolites are usually coarse grained and are composed predominantly of amphibole and plagioclase, whereas metagranitoids are typically made up of megacrysts of K-feldspar set in the groundmass of quartz, plagioclase and muscovite. We have investigated megacrystic granites from the three bimodal suites - Piaxtla, Cuaulote and Xayacatlán. These sets are representative of the felsic members of the approximately coeval bimodal suites, which are scattered through the complex. The mafic members of these three suites were described by Keppie et al. (2008b, 2012). The metamorphosed mafic rocks of the three suites form mainly intrusive bodies and have chemical characteristics of within-plate-basalts/gabbros and displayed tholeiitic fractionation trends (Keppie et al., 2008b, 2012).

3. Analytical methods

Major element oxides were measured using a Regaku 3080E1 XRF spectrometer at the Analytical Institute of the Bureau of Geology and Mineral Resources, Hubei Province (BGMRHP). Analytical procedures are described in detail by Gao et al. (1995). Relative standard deviations for major element oxides are within 5%. Trace elements were analyzed at the State Key Laboratory of Geological Processes and Mineral Resources (GPMR), China University of Geosciences. The samples were digested by HF and HNO_3 in Teflon bombs and analyzed using an Agilent 7500a ICP-MS. The detailed procedure for ICP-MS analyses and analytical precision and accuracy for trace elements was described in Liu et al. (2008). Analytical precision (relative standard deviation) estimated from repeated analyses of three standard reference samples G-2, AGV-1 and GSR-3 is better than 5% for rare earth elements and 5–12% for other trace elements. Quality of trace element analyses can also be judged from the analyses of USGS international standard rocks AGV-1 and BHVO-2 (Table 1).

Nd and Sr isotope ratios as well as the abundances of Sm and Nd of the granitic rocks (Table 2) were determined at the Atlantic Universities Regional Facility, the Department of Earth Sciences of the Memorial University of Newfoundland (St. John's, Newfoundland, Canada) by a thermal ionization mass spectrometer. The isotopic ratios of $^{143}Nd/^{144}Nd$ were obtained using a multicollector Finnigan MAT 262 thermal ionization mass spectrometer operated in a static mode. Prior