INTRODUCTION

The geological evolution of the Xolapa Complex, recently described by Ducea et al. (2004), is important in the tectonic history of southern Mexico. However, incorrectly located samples, inadequate mapping and structural interpretations, and imprecise dates undermine the conclusions they presented.

MAPPING ERRORS

Puerto Angel Transect

Ducea et al. (2004, p. 1017) state “All rocks studied here are part of the Xolapa terrane.” However, all of the samples in the Puerto Angel transect are plotted within the Oaxacan Complex according to their Table 1 (Fig. 1). Thus, they actually dated samples belonging to Grenvillian basement rocks rather than the Xolapa terrane.

Puerto Escondido Transect

The contact between the Oaxacan and Acatlán Complexes, in Figure 1C of Ducea et al. (2004), is mapped incorrectly (see Ortega-Gutiérrez et al., 1999; Elías-Herrera and Ortega-Gutiérrez, 2002). When correctly located (Fig. 1), it is clear that the samples of Ducea et al. (2004) do not fall in the Mixteco (Acatlán) domain but, instead, south of the Late Permian to Triassic Juchatengo terrane. The 272 ± 10 Ma age they report is consistent with published ages for the Juchatengo terrane (Grajales-Nishimura et al., 1999, and references therein).

Three of the samples in this transect (M01-26, M01-27, and M01-28) are from post-Xolapa Cenozoic plutons, a fact that contrasts with the statement on page 1017 of Ducea et al. (2004). Moreover, the location of sample M01-17 is ambiguous: according to the authors, it was either collected: (1) “south of Puerto Escondido” (p. 1020), i.e., in the sea; (2) “~7 km north of the Pacific Coast at Puerto Escondido” (p. 1021); or, using the coordinates presented in their Table 1, (3) in the Xolapa terrane, but just south of the Juchatengo terrane (Grajales-Nishimura et al., 1999). Moreover, the location of sample M01-17 is ambiguous: according to the authors, it was either collected: (1) “south of Puerto Escondido” (p. 1020), i.e., in the sea; (2) “~7 km north of the Pacific Coast at Puerto Escondido” (p. 1021); or, using the coordinates presented in their Table 1, (3) in the Xolapa terrane, but just south of the Juchatengo terrane (Grajales-Nishimura et al., 1999).

Puerto Escondido Transect

Using the coordinates presented in Table 1 of Ducea et al. (2004), three errors materialize: (1) sample M01-02 falls in the Pacific Ocean (more than 3 km from the coast); (2) sample M002 falls within the 30 Ma Ocotito granite; and (3) sample M01-04 occurs along the coast instead of “along the new Highway 95” (p. 1020; see Fig. 1 here).
INTERPRETIVE PROBLEMS

Ducea et al. (2004) discuss (p. 1021) the left-lateral displacement of the Chacalapa fault and the narrowness of the Xolapa terrane in the Puerto Angel vicinity, invoking the Oaxaca fault. The Oaxaca fault, however, is only known and described ~350 km north of the studied area; it has never been traced toward the Pacific coast. Unfortunately, Ducea et al. (2004) adduce no new evidence to support an extension of this fault.

The authors’ conclusion that “...the plutons dated as Late Jurassic–Early Cretaceous are in fact syntectonic, being contemporaneous with ductile deformation” (p. 1023) is likewise unsupported. It has been well documented that the Xolapa Complex is polydeformed (e.g., Ortega-Gutiérrez, 1981; Corona-Chávez, 1997). Recently, Torres de León and Solari (2004) presented structural as well as isotopic data on a ductile-deformed granitoid cutting across migmatites on the northern margin of the Xolapa Complex. They reported an igneous age of 130 Ma, which postdates deformation and migmatization in the Xolapa rocks.

The combined age data for Cenozoic plutons shown in Ducea et al. (2004, their Fig. 7) do not show sufficient resolution to support the claim of along-strike migration of Tertiary magmatism. These data could equally be interpreted to show diachronism along the length of the Xolapa Complex.

IMPRECISE AGES

The imprecision of the ages presented in Ducea et al. (2004) ultimately undermines their conclusions. For instance, Ducea et al. (2004) stated that the dates obtained from the Precambrian Puerto Angel samples (their Fig. 4 and Data Repository table) are concordant. Yet, a concordance of less than 1% (2σ errors), almost an order of magnitude less than the error presented in Ducea et al. (2004), would still be inadequate to resolve the timing of the synorogenic events discussed above. Keppie et al. (2001, 2003), Solari et al. (2003), and Ortega-Obregón et al. (2003) have all recognized the following sequence in the Oaxacan Complex: (1) deposition prior to ca. 1150 Ma; (2) intrusion of rift-related plutons at ca. 1150 Ma; (3) intrusion of an alkaline pluton at ca. 1115 Ma; (4) deformation and migmatization at ca. 1100 Ma; and (5) intrusion of an anorhostite-mangerite-charnockite-granite suite at ca. 1010 Ma; (6) polyphase deformation at granulite facies ca. 990 Ma; and (7) intrusion of a calc-alkaline granite at ca. 920 Ma. Of the laser ablation–multicollector–inductively coupled plasma–mass spectrometry ages given in Ducea et al. (2004), none of these events is clearly identifiable; instead their data indicate a broad smear between ca. 1260 Ma and ca. 1000 Ma, suggesting mixing between the two end members. We suspect that this may be a function of their method, which produced an order of magnitude greater error than the 0.5% (2σ relative errors) generally achievable by isotope dilution–thermal ionization mass spectrometry, the method used in the other studies cited here.

CONCLUSIONS

Ducea et al. (2004) attempted to resolve basic questions about the evolution of the Xolapa Complex. However, as is clear from their Figure 8, none of their geochronological data advances our current understanding of the Xolapa Complex (e.g., Morán-Zenteno, 1992; Herrmann et al., 1994; Schaaf et al., 1995). Errors in sample location, analytical methods lacking in necessary refinement, and insufficient familiarity with the regional geology of southern Mexico (e.g., the Oaxaca fault) mean that their age data cannot constrain their conclusions, and ultimately undermine their efforts to answer the geological questions they’ve posed.

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DISCUSSION AND REPLY


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DISCUSSION AND REPLY

Reply

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Solari and Schaaf (2006) criticize data and interpretations presented in a recently published paper aimed at better understanding of the base ment geologic history of the Xolapa Complex (Ducea et al., 2004). The data presented in Ducea et al. (2004) are zircon U-Pb ages used to address some of the important questions surrounding the poorly understood Xolapa Complex (DeCserna, 1965), also referred to as the Xolapa or Chatino terrane (Campa and Coney, 1983; Sedlock et al., 1993), such as (1) what is the age distribution of deformed versus undeformed plutonic rocks in the region, (2) was there an easterly sweep in Cenozoic magmatism, as previously proposed (e.g., Hermann et al., 1994), and (3) is Xolapa a far-traveled terrane or the in-place arc proposed (e.g., Hermann et al., 1994? and (3) is Xolapa a far-traveled terrane or the in-place arc of a long-lived subduction system beneath mainland southern Mexico?

Solari and Schaaf identify what they perceive as: (1) mapping errors, (2) interpretative problems, and (3) geochronology problems. Here, we respond point by point to their discussion.

MAPPING ERRORS

The mapping errors outlined by Solari and Schaaf are a reflection of the poor knowledge of the Xolapa Complex boundaries. We point out that we did not map the Xolapa Complex, and have not claimed to do that. Consequently, the choice of sample locations was based on previously published literature. Solari and Schaaf refer to Ortega-Gutiérrez et al. (1999) as a source for the location of tectonic boundaries relevant to Xolapa. Instead, we chose the more widely used reference of Campa and Coney (1983), which proposes different boundaries between Oaxaca and Xolapa, and Mixteco (Acatlán)-Xolapa. Clearly, one needs to give credit to Ortega-Gutiérrez et al. (e.g., Ortega-Gutiérrez, 1981), since our findings agree with his proposed location of the Xolapa-Oaxaca boundary. However, we were cautious about the possibility that those Oaxacan basement rocks described in our paper may represent the framework to Xolapa plutons that extend inland from the Ortega-Gutiérrez et al. (1999) boundary. Further studies may help resolve that question.

The second issue regarding so-called mapping errors has to do with the definition of the Xolapa Complex—-we considered all basement rocks to be part of the Xolapa Complex, including the postkinematic Cenozoic plutons. The semantic argument of Solari and Schaaf that these are “post-Xolapa” rather than postkinematic merits this clarification, but in our view is not really an issue of substance.

INTERPRETATION ISSUES

1. The role of the Oaxaca fault. We briefly speculated on the possibility that the elusive Oaxaca fault could be responsible for the along-strike differences in the width of the Xolapa Complex. Our discussion was based not on our own geologic mapping, but rather built on previously published papers (Martiny et al., 2000; Morán-Zenteno et al., 1999), which have extended the mapped fault southward into the Xolapa Complex. The problem with the Oaxaca fault and the lack of evidence for strike-slip displacements on this fault during the Cenozoic was discussed in our paper, and not its mapped location. Regardless, the severe narrowing of the Xolapa Complex east of Puerto Angel needs a geometric and geologic explanation. The purpose of our section on the Oaxaca fault was to discuss that aspect, while admitting that there is no good answer to that question.

2. Age of ductile deformation. We agree that the Xolapa Complex is polydeformed. The argument in Ducea et al. (2004) is that orthogneisses that make up much of the Xolapa Complex experienced ductile deformation while they were emplaced as igneous rocks or, subsequently, as they resided relatively deep in the crust. This is a fairly common interpretation in tectonics. Based on that line of thinking, we provided an educated guess for when ductile deformation must have ceased in the Xolapa Complex. We obviously did not have access to the abstract by Torres de Leon and Solari, which was presented after the publication of this paper. Torres de León and Solari (2004) provide evidence for the existence (at least locally) of one early Cretaceous postkinematic granitoid, which is not inconsistent with our model.

3. Along-strike migration of magmatism. Solari and Schaaf argue that we did not have enough resolution to argue for along-strike migration of Cenozoic magmatism. We agree: in fact our discussion (starting at p. 1023) was entitled “Evidence Against Along-Strike Migration of Eocene-Oligocene Arc Magmatism.”

GEOCHRONOLOGY QUESTIONS

Solari and Schaaf are generally critical of our geochronologic methods because the uncertainties of LA-ICP-MS (laser ablation–inductively coupled plasma–mass spectrometry) analyses are greater than the errors that they and others have generated by ID-TIMS (isotope dilution–thermal ionization mass spectrometry) analysis. They point out in particular that we were not able to identify igneous components of ca. 1150 Ma, ca. 1115 Ma, ca. 1010 Ma, and ca. 920 Ma in our Puerto Angel samples, which they and others have found in the Oaxaca Complex. A comparison of the two sets of ages, however, indicates that there is a good match between the two data sets: we reported an age of ca. 1163 Ma, which is similar to their age of ca. 1150 Ma, and we reported ages of ca. 1109 and ca. 1119 Ma, which are similar to their age of ca. 1115 Ma. The main differences in the data sets are that we did not find igneous rocks of ca. 920 Ma or ca. 1010 Ma, and that we identified a minor older component (ca. 1244 Ma and ca. 1252 Ma) in two of our samples. The former is not surprising given that we analyzed only three samples from this region, and the latter would probably have been

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missed in the ID-TIMS analyses due to the lack of spatial resolution.

With regard to the general comment that LA-ICP-MS analyses are not as precise as ID-TIMS analyses, we agree that an individual LA-ICP-MS analysis is not as precise as a single ID-TIMS analysis. We would argue, however, that for terranes such as the Xolapa Complex, where zircons commonly display inheritance and/or isotopic disturbance, LA-ICP-MS (or ion probe) analyses may be more informative (and accurate) than ID-TIMS analyses because it is possible to analyze discrete portions of many different crystals.

OTHER ISSUES

In addition to the substantive issues raised by Solari and Schaaf, they correctly point out some errors in reporting sample locations, as they were published in the Ducea et al. (2004) paper. We use this opportunity to provide an erratum to the paper; Table 1 here has the correct geographic coordinates of the studied samples.

CONCLUSIONS

Solari and Schaaf raise some interesting and thoughtful questions about the data and interpretations presented in Ducea et al. (2004). These questions are (at least in part) caused by the major gaps in basic geologic knowledge of the Xolapa Complex, and are welcomed by us as healthy scientific debate. This debate is likely to promote new, better-focused tectonics research within the Xolapa Complex proper, and southern Mexico in general.

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