Lithos 308–309 (2018) 83–103

Contents lists available at ScienceDirect

Lithos

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

Subduction of Proterozoic to Late Triassic continental basement in the Guatemala suture zone: A petrological and geochronological study of high-pressure metagranitoids from the Chuacús complex

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ARTICLE INFO

Article history:
Received 17 November 2017
Accepted 26 February 2018
Available online 06 March 2018

Keywords:
Continental subduction
Guatemala suture zone
Chuacús complex
High-pressure metagranites
Thermobarometry
U-Pb geochronology

ABSTRACT

Many continental subduction complexes contain abundant granitic rocks coexisting with minor volumes of eclogite-facies rocks. Characterization of granitic protoliths is crucial to decipher the origin of subducted continental crust, whereas knowledge of its metamorphic evolution is required to constrain the mechanisms of burial and exhumation. In this work we present geochronological and petrological evidence that demonstrate the occurrence of a subducted Proterozoic to Late Triassic granitic basement in the Chuacús complex of central Guatemala. Metagranitoids exposed in this area are interlayered with eclogite and other high-pressure rocks, and their structure is considerably variable due to strain partitioning during deformation. Laser ablation-inductively coupled plasma-mass spectrometry U-Pb zircon data from two ferroan metagranites yield protolith crystallization ages of ca. 1.1 Ga and their trace-element abundances suggest an origin related to intraplate magmatism, while a high-silica, peraluminous metagranite is dated at 1.0 Ga and was probably originated by partial melting of a high-grade continental crust. On the other hand, two megacrystic to augen metagranitoids yield protolith crystallization ages of ca. 224 Ma, which are identical within errors to the protolith age of hosted eclogitic metabasites. Their high incompatible trace element abundances together with the observed spatial-temporal relationships with mafic protoliths suggest that Late Triassic bimodal magmatism in the Chuacús complex was probably originated in a within-plate setting. Regardless of their age or structure, the studied metagranites preserve evidences for high-pressure metamorphic equilibration, such as the occurrence of Ca-rich garnet (X_{Ca} up to 0.52) in association with phengite (Si contents of up to 3.4 pfu) and rutile. The integration of Zr-in-rutile thermometry and phengite barometry allows the peak metamorphic conditions to be constrained at ~640–680 °C and ~13 kbar. This pressure-temperature estimate indicates that metagranitoids underwent high-pressure metamorphism but equilibrated at significantly lower pressures than associated eclogite-facies rocks, and, therefore, they do not necessarily share a common high-pressure metamorphic evolution. The new data show that the Chuacús complex in the study area represents a Proterozoic (1.1–1.0 Ga) to Late Triassic (220 Ma) continental basement that was subducted, and consequently metamorphosed under high-pressure conditions, during the Cretaceous evolution of the North America-Caribbean plate boundary.

1. Introduction

Granitoids constitute an important part of the continental crust, being present in a variety of settings and along the geological time. Several studies in high-pressure (HP) and ultrahigh-pressure (UHP) terranes have shown that granitic crust is commonly involved in continental subduction processes (e.g. Carswell et al., 2000; Compagnoni and Rolfo, 2003; Le Goff and Ballèvre, 1990). In most cases, metagranitoids are volumetrically dominant and often closely related to minor volumes of eclogite and other HP rocks. Determining the age and nature of granitic protoliths is a crucial aspect to decipher the origin of subducted continental crust and establish plausible regional correlations (e.g. Hacker et al., 1998; Liu et al., 2004; Rowley et al., 1997). Petrological studies, in addition, allow comparison between the pressure-temperature (*P-T*) conditions experienced by both metagranites and hosted HP rocks, which provides insight into the mechanisms of burial and exhumation during subduction.

The Caribbean suture system delineates a continental-scale tectonic feature comprising both oceanic and continental subduction complexes. In the westernmost part of this system, the Chuacús complex (Ortega-Gutiérrez et al., 2004) of central Guatemala records continental subduction and collision of the North American plate beneath the

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https://doi.org/10.1016/j.lithos.2018.02.030
0024-4937/

Greater Antilles Arc during the Cretaceous (Maldonado et al., 2018; Martens et al., 2012). Recent studies have corroborated that the geological record of the Chuacús complex includes a prolonged magmatic activity, which is reflected by Ordovician, Silurian, Triassic and Jurassic protolith ages from both felsic and mafic metaigneous rocks (Maldonado et al., 2018; Martens et al., 2012; Ratschbacher et al., 2009; Solari et al., 2011), as well as an episode of HP subduction-zone metamorphism during the mid-Cretaceous, and a subsequent Late Cretaceous amphibolite-facies overprint (Maldonado et al., 2018; Martens et al., 2012). Furthermore, the available U-Pb zircon geochronological data not only from the Chuacús complex but also from other localities in Central America have revealed a pervasive Proterozoic inherited component in a diversity of rock types (e.g. Gomberg et al., 1968; Martens et al., 2012; Ortega-Gutiérrez et al., 2004; Ratschbacher et al., 2009; Solari et al., 2009; Solari et al., 2011), however the presence of an exposed basement of such age has not yet been confirmed.

The HP metamorphic event in the Chuacús complex is mostly documented on the basis of the occurrence of eclogite bodies hosted by a predominant gneissic sequence (e.g. Martens et al., 2017; Ortega-Gutiérrez et al., 2004). In addition, recent petrological studies have shown that the spatially associated metasedimentary rocks share a common HP metamorphic evolution (Maldonado et al., 2016; Maldonado et al., 2018). However, the metamorphic conditions experienced by other lithological units, including eclogite-hosting metagranitoid, are poorly constrained. The available U-Pb data show that this rock type underwent a Late Cretaceous thermal perturbation at ca. 74 Ma, which is equivalent to metamorphic U-Pb ages reported from hosted eclogite bodies (Martens et al., 2012; Ratschbacher et al., 2009). This indicates that felsic and mafic igneous protoliths have a primary structural relation predating this metamorphic event and, therefore, that the whole sequence share at least a common Late Cretaceous metamorphic history. Nevertheless, in view of recent petrochronological evidence indicating an earlier (pre-collisional) HP metamorphic stage (Maldonado et al., 2018), as well as the paucity of petrological data, it is still necessary to demonstrate if metagranitoids also experienced the same HP evolution.

In this study, we present new petrological, geochronological and geochemical data that contribute to enlarge the Caribbean zone database and that demonstrate that part of the subducted crust of the Chuacús complex represents a remnant of a Proterozoic granitic basement. We also discuss the significance and tectonic implications of bimodal Late Triassic magmatism recorded in this area, as well as its probable connections with other contemporary American granitic belts. Finally, we show that this Proterozoic to Late Triassic granitic basement experienced HP metamorphism, but the obtained *P-T* conditions considerably differ from those reported for eclogite and associated HP metasediments, an issue that is also discussed.

2. Geological background and field relations

The Chuacús complex is a medium- to high-grade metamorphic belt that extends ca. 220 km along the current North American-Caribbean plate boundary in Central America (Fig. 1a). This belt represents a fault-bounded block of continental crust in the Guatemala suture zone (Brueckner et al., 2009; Fig. 1b) and records subduction to >70 km depth of the passive continental margin of southern North America during the mid-Cretaceous (Maldonado et al., 2018; Martens et al., 2012; Ortega-Gutiérrez et al., 2004; Ratschbacher et al., 2009). A synthesis of the regional setting of the Guatemala suture zone has been recently presented in Flores et al. (2013), Maldonado et al. (2016) and Martens et al. (2017), so the reader is referred to these works for a detailed description of this region.

Most of the Chuacús complex is dominated by greenschist- to amphibolite-facies assemblages. The deepest portion of the belt is exposed in the Rabinal-Palibatz area of the Sierra de Chuacús (Fig. 1c), where a diversity of eclogite-facies rocks has been recognized (e.g. Maldonado et al., 2016; Martens et al., 2017; Ortega-Gutiérrez et al., 2004). The metamorphic sequence in this region is composed of: 1) a metaigneous unit, which comprises variably deformed metagranitoid, amphibolite, as well as subordinated eclogite and pyroxenite bodies, and 2) a metasedimentary unit, consisting of intercalated pelitic-psammitic schist, paragneiss, marble, quartzite and calcsilicate rocks, a sequence that denotes a passive continental margin origin (Maldonado et al., 2016; Maldonado et al., 2018; Martens et al., 2012; McBirney, 1963; Ortega-Gutiérrez et al., 2004; Ratschbacher et al., 2009). The predominant structural trend is defined by a NW-SE-striking, SW-dipping axial-plane foliation (S_{n+2}) produced largely by the tight-isoclinal folding of an earlier high-grade foliation (S_{n+1}). Locally developed high-strain shear zones (S_{n+3}) overprint S_{n+2} on the scale of meters to kilometers, indicating later NE-vergent folding-thrusting (Fig. 1c).

Metagranitoid make up the most abundant rock type in the Sierra de Chuacús. Available geochemical data show that whole-rock compositions are variable in terms of major element relations, probably reflecting a variety of granitoid protoliths, while trace-element patterns suggest an origin related to continental arc magmatism (Solari et al., 2011). U-Pb zircon ages indicate that granitic precursors mostly crystallized during a Late Triassic magmatic pulse (ca. 220 Ma; Ratschbacher et al., 2009; Solari et al., 2011; Martens et al., 2012; this work), but some older protolith ages from the Ordovician (ca. 450 Ma; Solari et al., 2011) to the Cambrian-Ediacaran (Ratschbacher et al., 2009), as well as from the Mesoproterozoic (this work) have also been reported. Mafic rocks (i.e. amphibolites and eclogites) occur as centimeter- to meter-scale bands and lenses concordantly hosted by both gneissic metagranitoids and metasedimentary rocks. These bodies are fairly homogeneous regarding their major element compositions, and their trace-element abundances indicate a MORB affinity (Solari et al., 2011). In addition, zircon U-Pb protolith ages of ca. 425, 227 and 167 Ma from eclogites indicate that mafic precursors in the Chuacús complex were originated at least in three different tectono-temporal settings during Silurian, Triassic, and Jurassic magmatic episodes (Maldonado et al., 2018; Martens et al., 2012).

Metasedimentary rocks are widely distributed in the Sierra de Chuacús, but the most prominent outcrops are exposed in the southwestern and northeastern zones of the studied area (Fig. 1c). These rocks cover a wide range of whole-rock compositions. In particular, semipelitic to pelitic levels are predominant and several localities (Fig. 1c) preserve diagnostic assemblages of HP metamorphism (Maldonado et al., 2016; Maldonado et al., 2018; Ortega-Gutiérrez et al., 2004). Their overall chemical features are typical of hemipelagic sedimentation, and the incompatible trace-element patterns suggest a mature upper crust provenance (Solari et al., 2011). Depositional ages of sedimentary protoliths are uncertain, but the available U-Pb detrital zircon age spectra suggest that sedimentary protoliths could have been formed during at least two different periods of sedimentation, an older one of pre-Ordovician age (Solari et al., 2009) and a younger period that occurred after the Late Triassic (Martens et al., 2012; Solari et al., 2011).

Recent garnet/whole rock Lu-Hf data indicates that HP, subduction-related metamorphism in the Chuacús complex occurred during the Albian-Cenomanian (ca. 100 Ma; Maldonado et al., 2018), while a medium-pressure overprint related to collision and partial exhumation took place from the Campanian (76–56 Ma; Sutter, 1979; Ortega-Gutiérrez et al., 2004; Ortega-Obregón et al., 2008; Ratschbacher et al., 2009; Solari et al., 2011; Martens et al., 2012; Maldonado et al., 2018). This metamorphic evolution was characterized by an early prograde stage of HP metamorphism at 19–20 kbar and 530–580 °C finally reaching minimum pressure-peak conditions of 23–25 kbar and 620–690 °C (Maldonado et al., 2018). After pressure peak, an initial stage of isothermal decompression produced metamorphic equilibration at 13 kbar and 660 °C (Ratschbacher et al., 2009). From this stage, the subduction-related regime was replaced by higher thermal conditions (ca. 20 °C/km) coeval with partial exhumation to shallow depths,