Lithos 266–267 (2016) 309–331

Contents lists available at ScienceDirect

Lithos

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

High-pressure greenschist to blueschist facies transition in the Maimón Formation (Dominican Republic) suggests mid-Cretaceous subduction of the Early Cretaceous Caribbean arc

L. Torró [a,*], A. Garcia-Casco [b,c], J.A. Proenza [a], I.F. Blanco-Quintero [d], G. Gutiérrez-Alonso [e], J.F. Lewis [f]

[a] Departament de Mineralogia, Petrologia i Geologia Aplicada, Facultat de Geologia, Universitat de Barcelona (UB), Martí i Franquès s/n, 08028 Barcelona, Spain
[b] Departamento de Mineralogía y Petrología, Universidad de Granada, Fuentenueva s/n, 18002 Granada, Spain
[c] Instituto Andaluz de Ciencias de la Tierra, CSIC-UGR, Av. las Palmeras, 4, 18100 Armilla, Granada, Spain
[d] Departamento de Geociencias, Universidad de los Andes, Bogotá, Colombia
[e] Departamento de Geología, Universidad de Salamanca, 37008 Salamanca, Spain
[f] Department of Earth and Environmental Sciences, George Washington University, Washington, DC 20052, USA

ARTICLE INFO

Article history:
Received 26 July 2016
Accepted 24 October 2016
Available online 29 October 2016

Keywords:
Blueschist
HP/LT metamorphism
Maimón Formation
Dominican Republic
Caribbean
Volcanic arc

ABSTRACT

The Maimón Formation (Cordillera Central, Dominican Republic) is formed of metamorphosed bi-modal mafic-felsic volcanic rocks and sedimentary horizons of Early Cretaceous age deposited in the forearc of the nascent Caribbean island arc. Two structural-metamorphic zones depict an inverted metamorphic gradient: the Ozama shear zone, which records intense mylonitic and phyllonitic deformation and ubiquitous metamorphic recrystallization, tectonically overlies the much less deformed and variably recrystallized rocks of the El Altar zone. The presence of ferri-winchite and high-Si phengite, first reported in this paper, in the peak metamorphic assemblage of rocks of the Ozama shear zone (actinolite + phengite + chlorite + epidote + quartz + albite ± ferri-winchite ± stilpnomelane) point to subduction-related metamorphism. Pseudosection calculations and intersection of isopleths indicate peak metamorphic conditions of ~8.2 kbar at 380 °C. These figures are consistent with metamorphism in the greenschist/blueschist facies transition, burial depths of ~25–29 km and a thermal gradient of ~13–16 °C/km. Our new data dispute previous models pointing to metamorphism of Maimón rocks under a steep thermal gradient related to burial under a hot peridotite slice. Instead, we contextualize the metamorphism of the Maimón Formation in a subduction scenario in which a coherent slice of the (warm) Early Cretaceous forearc was engulfed due to intra-arc complexities and regional-scale-driven tectonic processes operating in the late Early Cretaceous. Integration of our findings with previous studies on metamorphic complexes in Hispaniola suggests that a major tectonic event affecting the whole arc system took place at c. 120–110 Ma.

1. Introduction

Intra-oceanic island arc systems represent locus of intense magmatism and seismic activity coupled to major metamorphic and tectonic processes framed in a rapidly evolving setting relative to other geological systems (Gerya, 2011; Gerya et al., 2002; Ichikawa et al., 2016; Maresch and Gerya, 2005). Despite having a simple crustal structure when compared to arcs developed on continental crust (e.g., Jicha and Jagoutz, 2015; Stern, 2010), intra-oceanic arcs ordinarily embrace complex, condensed in time and space, tectonic processes that may couple extension and compression along a single arc involving the trench, forearc, volcanic-magmatic arc and back-arc (Hawkins et al., 1984). Formed in dynamic subduction systems, these arcs are the loci for the development of high-pressure, low-temperature (HP/LT) metamorphism, whose study offers a priceless information on the evolution of convergent plate margins (e.g., Agard et al., 2009). In the Greater Antilles, in the northern margin of the Caribbean plate, several of these HP-LT metamorphic complexes have been studied in Cuba (e.g., Blanco-Quintero et al., 2010; Boiteau et al., 1972; Garcia-Casco et al., 2002, 2006, 2008a, 2008b; Millán, 1996; Schneider et al., 2004; Stanek et al., 2006) and Jamaica (e.g., West et al., 2014; Willner et al., 2016). In Hispaniola (Haiti and Dominican Republic), HP/LT metamorphic complexes include Samaná (Escuder-Viruete et al., 2011) and Río San Juan (Escuder-Viruete and Pérez-Estaún, 2013; Escuder-Viruete et al., 2013a, 2013b; Krebs et al., 2008, 2011). Subduction/exhumation and associated prograde/retrograde metamorphism recorded on these Antillean complexes are dated as Cretaceous. In Cuba, serpentinite-matrix mélanges record subduction of MOR-

* Corresponding author at: Departament de Mineralogia, Petrologia i Geologia Aplicada, Universitat de Barcelona, C/ Martí i Franquès s/n, 08028 Barcelona, Catalunya, Spain.
E-mail address: lisardtorro@hotmail.com (L. Torró).

http://dx.doi.org/10.1016/j.lithos.2016.10.026
0024-4937/

derived material since the Early Cretaceous (e.g., Blanco-Quintero et al., 2011; Garcia-Casco et al., 2002, 2006; Lázaro et al., 2009). In the Río San Juan metamorphic complex, oceanic crust including MOR- and island-arc-derived materials begun to subduct in the Early Cretaceous (Escuder-Viruete et al., 2013b); therefore, initial intra-arc complexities during the first stages of subduction in the Hispaniola segment of the Caribbean island arc must be pondered on any model regarding initial subduction geometry below the primitive, Hauterivian-Albian Caribbean island arc (cf. Lidiak and Anderson, 2015; Pindell et al., 2012).

Uplift and unroofing after Neogene tectonics bountifully expose deformed and metamorphosed Early Cretaceous basement rocks along the Median Belt in Cordillera Central (sensu Lewis and Draper, 1990) of Hispaniola. Therefore, the Median Belt renders an exceptional opportunity to study deformation and metamorphic processes that affected geologic units during the first stages of the tectonic evolution of the Caribbean Island Arc. The study of the metamorphic units (including the Maimón and Amina Formations and the Río Verde and Duarte complexes) and the conspicuously complex structure has led to the construction of regional-scale tectonic models on the early evolution of the Caribbean island arc. Such models include, for example, the proposal of a paired metamorphic belt in Hispaniola unlike the rest of the Greater Antilles (Nagle, 1974) and an Aptian/Albian subduction polarity reversal event under the primitive arc (e.g., Draper and Gutiérrez-Alonso, 1997; Draper and Lewis, 1991; Draper et al., 1996; Lebrón and Perfit, 1994; Lewis et al., 2002).

The metamorphic grade undergone by the Maimón Formation has been recurrently classified as of low-pressure greenschist facies on the basis of the petrographic study of its metamorphic mineral assemblages (Bowin, 1960, 1966; Draper and Gutiérrez-Alonso, 1997; Draper and Lewis, 1991; Draper et al., 1996; Escuder-Viruete et al., 2002; Kesler et al., 1991a; Nagle, 1974); nevertheless, these studies largely lacked methodical mineral chemical analysis. In the course of a petrological and geochemical characterization of rocks from this formation, we found unexpected systematic high Si contents in white mica lepidoblasts and presence of the sodium-calcium amphibole ferriwinchite in rocks from the Ozama shear zone, suggestive of moderate pressures of crystallization. This article presents, for the first time, an exhaustive study on the petrology and mineral chemistry of metamorphic assemblages of rocks from the Maimón Formation. We offer isochemical P–T projections (pseudosection) in order to constrain the P–T evolution undergone by the studied rocks and to discuss their meaning by comparison to previous work in the context of subduction-zone thermal gradients. In addition, we assert the influence of the intense pre-metamorphic hydrothermal alteration of the rocks in the subsequent metamorphic assemblages and show that diagnostic high-P assemblages are expected to form only in the less intensely altered rocks. The existence of high-pressure subduction-related mineral assemblages in rocks of the Maimón Formation is not only of local interest, but has major implications for the interpretation of early geodynamic evolution of the Caribbean realm.

2. Geological overview

The island of Hispaniola is a collage of Early Cretaceous to Tertiary arc-, oceanic- and continental margin-derived units which resulted largely from the oblique convergence and underthrusting of the North American (Proto-Caribbean) Plate beneath the Greater Antilles island-arc since c. 135 Ma (Pindell et al., 2012; Rojas-Agramonte et al., 2011). Mesozoic separation of North and South America allowed the progressive west to east insertion into the Proto-Caribbean (Atlantic) realm of the allochthonous (Pacific in origin) Caribbean plate and related arc and oceanic complexes (Boschman et al., 2014; Lidiak and Anderson, 2015 and references therein; Pindell and Kennan, 2009). West-dipping subduction of the Proto-Caribbean caused arc–continent collision in the northern leading edge of the Caribbean in the latest Cretaceous-earliest Tertiary and obduction of ophiolitic complexes onto continental margins in Guatemala, Cuba, Hispaniola and Puerto Rico (Garcia-Casco et al., 2008a; Lewis et al., 2006; Pindell et al., 2012; Solari et al., 2013). In Hispaniola, subduction and related arc-magmatism ceased after the collision with the Bahamas platform in Eocene time (Donnelly et al., 1990; Mann et al., 1991), and the plate margin evolved to the current left-lateral strike-slip tectonics (Mann et al., 2002; Vila et al., 1987).

The Early Cretaceous Maimón Formation is a 9 km wide and about 73 km long NW-SE trending belt that crops out along the Median Belt (Central Cordillera) of the Dominican Republic (Draper and Lewis, 1991; Kesler et al., 1991a). The Median belt is a composite of accreted oceanic units affected by the left-lateral strike-slip Hispaniola (HFZ) and San Juan-Restauración (SJRFZ) fault zones (Fig. 1a)

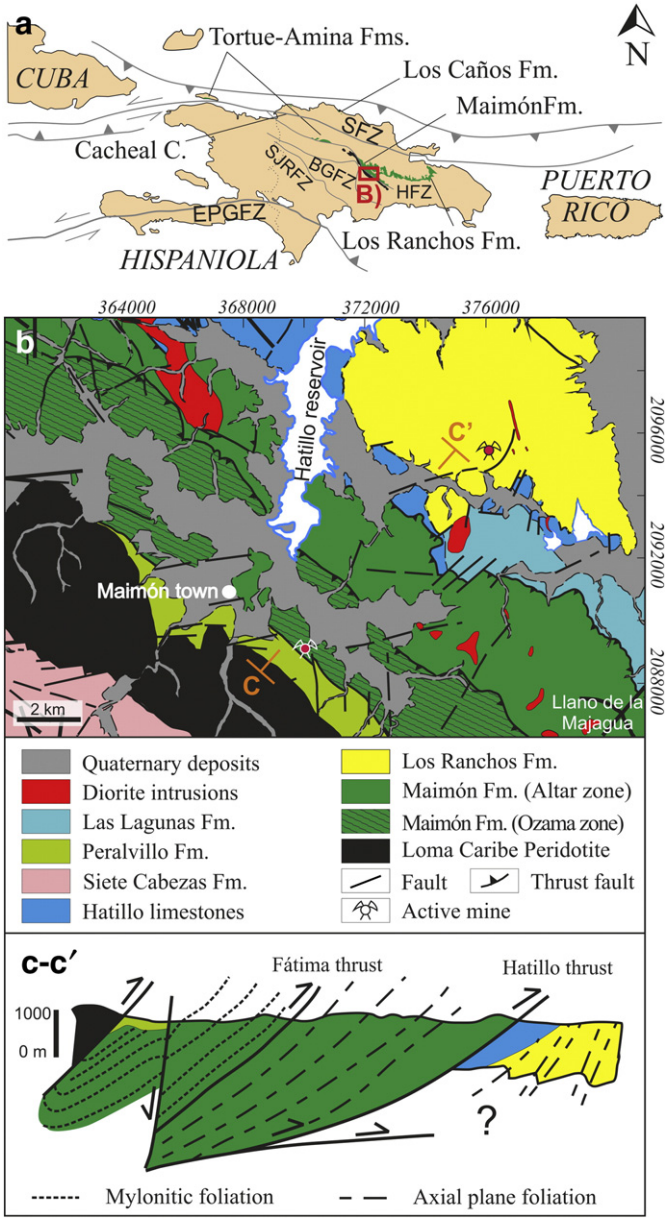

Fig. 1. (a) Location of the PIA series (green), ophiolitic peridotites (black), and major fault zones of Hispaniola; EPGFZ: Enriquillo-Plantain Garden fault zone; SFZ: Septentrional fault zone; HFZ: Hispaniola fault zone; BGFZ: Bonao-La Guácara fault zone; SJRFZ: San Juan-Restauración Fault Zone. (b) Geological map of the Maimón Formation and surrounding units modified from Martín and Draper (1999). (c-c′) Synthetic geologic cross section of the Maimón Formation and surrounding geologic units in the Median belt. (After Draper et al., 1996.)