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Sedimentary Record of Arc-Continent Collision Along Mesozoic SW North America (Siuna Belt, Nicaragua)

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- The Siuna Belt of northern Nicaragua exposes the suture zone between the Siuna Intraoceanic Arc and the continental Chortis Block
- Rocks within the suture zone suggest that the Siuna Island Arc represents an exotic arc that accreted to the Chortis Block approximately 134-131 Ma
- Postcollisional extension led to the rifting of the Chortis Block

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Abstract The western margin of the Caribbean Plate is a typical example where oceanic and continental terranes have amalgamated by subduction, collision, and strike-slip processes. The boundaries between these blocks, as well as their tectonostratigraphic records, are generally covered by younger deposits and dense tropical vegetation, which may hamper reconstructing the accretionary evolution of the convergent margin. In that context, the study of overlap sedimentary assemblages represents an important tool to constrain the accretion timing of terranes. In northern Central America, the geology of the suture zone between the Chortis Block and the exotic Siuna Intraoceanic Arc indicates that the two terranes were assembled together during a Hauterivian arc-continent collision (approximately 134–131 Ma). The exotic origin of the intraoceanic arc is based on the nature of metamorphic blocks within and the kinematics of the Siuna Serpentinite Mélange. The short duration of the collision event is suggested by coeval exhumation of the Siuna Serpentinite Mélange and Chortis-derived coarse sedimentation (El Amparo Formation) along the suture zone, rapidly followed by onset of pelagic sedimentation (Rio Matis Formation). Although the collision appears to have been short lived and preserved only in the suture zone, postcollisional extension affected intra-arc to back-arc settings of the Chortis Block and led to the formation of kilometer-thick extensional basins. We envisage that the convergent margin inboard of SW Mexico—represented by the fringing Guerrero Intraoceanic Arc and the Mixteca continental terrane—underwent similar postcollisional extension, whereas the western margin of the proto-Caribbean oceanic realm experienced onset of WSW dipping subduction beneath the accreted Siuna Intraoceanic Arc.

1. Introduction

Suture zones between intraoceanic arcs and continents are the inevitable result of plate tectonics and the witness of fundamental processes such as the growth/destruction of Earth's crust, exhumation of deeply subducted oceanic and continental material, and Earth's surface vertical motions. Recognition and dating of ancient arc-arc or arc-continent collision zones is a fundamental prerequisite in order to reconstruct Earth's crust history (e.g., Cawood et al., 2009). Disparate, scattered remnants of accreted intraoceanic arcs seem to be the rule as processes that can remove them from Earth's surface (subduction and burial) appear to be more efficient that those favoring their preservation (accretion; e.g., Stern & Scholl, 2010). Consequently, this complicates the recognition of once continuous, plate boundary-wide intraoceanic arc systems (Hébert et al., 2012). Moreover, arc collision events are accompanied by processes such as volcanic arc cessation, mélange formation/exhumation, shortening, and rock/surface uplift (Draut et al., 2008). The identification of past arc collision events may be ambiguous or overlooked in the case when the above processes cannot be tied to any exposed terrane, that is, the response of the passive or convergent margin to arc collision is preserved but not the colliding arc itself (Hall & Wilson, 2000).

Several processes decrease the preservation potential of intraoceanic arcs at different stages of their evolution. (1) Nonsteady subduction erosion can affect intraoceanic arcs in two ways: (a) tectonic erosion during the lifespan of an intraoceanic arc, with the removal of tens of kilometers of forearc crust (e.g., Azuero/Golfito Arc in Costa Rica, Buchs et al., 2011; Talkeetna Arc in Alaska, Clift et al., 2005; European Variscides, Oncken, 1998) and (b) tectonic erosion of an intraoceanic arc once it is accreted to a convergent margin (Clift et al., 2009). (2) Intraoceanic arcs may be underplated or subducted during arc-arc collision events (Hall & Wilson, 2000; Tetreault & Buiter, 2012, 2014; Yamamoto et al., 2009). (3) Chemical and mechanical weathering of igneous rocks, especially in tropical climates, may impede the study of intraoceanic arc records (Hall & Smyth, 2008; Hastie et al., 2007). (4) In long-lived convergent margins, thick volcanic piles may prevent the direct observation of older autochthonous or allochthonous volcanic formations and ophiolitic remnants (Andjić et al., 2018, 2019).

Among the key markers of arc-continent collision zones, exhumed high-pressure serpentinite-matrix mélanges provide precious information on subduction initiation/duration/termination as well as the nature and age of plates involved during convergence episodes (Agard et al., 2009; Escuder-Viruete et al., 2013; Harlow et al., 2004; Krebs et al., 2008; Shervais et al., 2011). Overlap or molasse sedimentary rocks overlying exhumed ophiolitic mélanges provide equally important information on the timing of tectonic events and the nature of the terranes involved in arc collision zones (Nokleberg et al., 2000). The combined study of exhumed ophiolitic mélanges and overlap assemblages is especially relevant in the cases where the colliding objects have subsequently been removed from Earth's surface by tectonic/physical processes or laterally displaced many tens or hundreds of kilometers (Aitchison et al., 2011; Hildebrand, 2013; Johnston, 2001, 2008).

The Siuna Belt of inland Nicaragua is one such place where the lack of exposure and detailed knowledge of Cretaceous arc-related units represents a major gap in the reconstruction of the Circum-Caribbean terranes in general, and the enigmatic history of arc-continent collision in Central America in particular. In this paper we present new sedimentary constraints on the early evolution of the only known exposure of the suture zone that separates two of the largest terranes in Central America, that is, the Siuna Intraoceanic Arc and the continental Chortis Block. This paper complements our recent study of the evolution of the Siuna Serpentinite Mélange (SSM; Escuder-Viruete et al., 2019) and provides new constraints on the exhumation timing of the mélange along the suture zone between the two blocks, as well as the postcollisional evolution of the convergent margin. We also propose a model for the Early Cretaceous evolution of the margins of SW North America and the western proto-Caribbean, some key steps of which may be explained by the collision of the Siuna Intraoceanic Arc.

2. Northern Central America: A Collage of Continental and Oceanic Terranes

Representing the western margin of the Caribbean Plate, the isthmus of Central America consists of a complex geological collage of predominantly Mesozoic-Cenozoic oceanic assemblages of suprasubduction and intraplate affinities with subordinate continental terranes restricted to its northern part (Rogers et al., 2007; Baumgartner et al., 2008; Buchs et al., 2011; Figure 1). The geology of northern Central America is characterized by a core of continental crust, the Chortis Block, with which oceanic terranes were tectonically juxtaposed by collision and strike-slip processes during the Cretaceous-Cenozoic (Mann et al., 2007; Pindell et al., 2012). Based on a multidisciplinary data set, Rogers, Mann, and Emmet (2007) established that the Chortis Block comprised two distinct terranes; the Central Chortis Terrane consists of greenschist- to amphibolite-grade continental rocks of Precambrian-Paleozoic age, whereas the Eastern Chortis Terrane displays Jurassic nonmetamorphic to greenschist-grade (meta)sedimentary rocks of continental provenance (Agua Fria Formation; Figure 2). The Chortis terranes are covered by a Cretaceous sedimentary-volcanic overlap succession formed in extensional basins (Gordon, 1990, 1993; Rogers et al., 2007; Rogers et al., 2007). Prior to the Cenozoic, the Chortis Block was possibly located in the prolongation of Mixteca/Xolapa terranes of SW Mexico, as suggested by a wide range of geological similarities and the paleomagnetic history of the Chortis Block (Rogers, Mann, & Emmet, 2007; Sierra-Rojas et al., 2016; Molina Garza et al., 2017; Figure 2b).

To the NW, the Central Chortis Terrane is bordered by the Guatemala Suture Zone, which marks the transform boundary between the Caribbean Plate and the North American Plate (Donnelly et al., 1990; Flores et al., 2015; Figure 1). The Guatemala Suture Zone displays several belts of oceanic and continental high-pressure rocks that were emplaced during at least two Cretaceous collision events and later juxtaposed by Cenozoic strike-slip motion along the Motagua-Cayman fault system (Flores et al., 2013; Harlow et al., 2004; Pindell et al., 2012; Ratschbacher et al., 2009; Torres-de León et al., 2012). To the southwest, the Chortis continental terranes are possibly bordered by accreted oceanic terranes, as suggested by the

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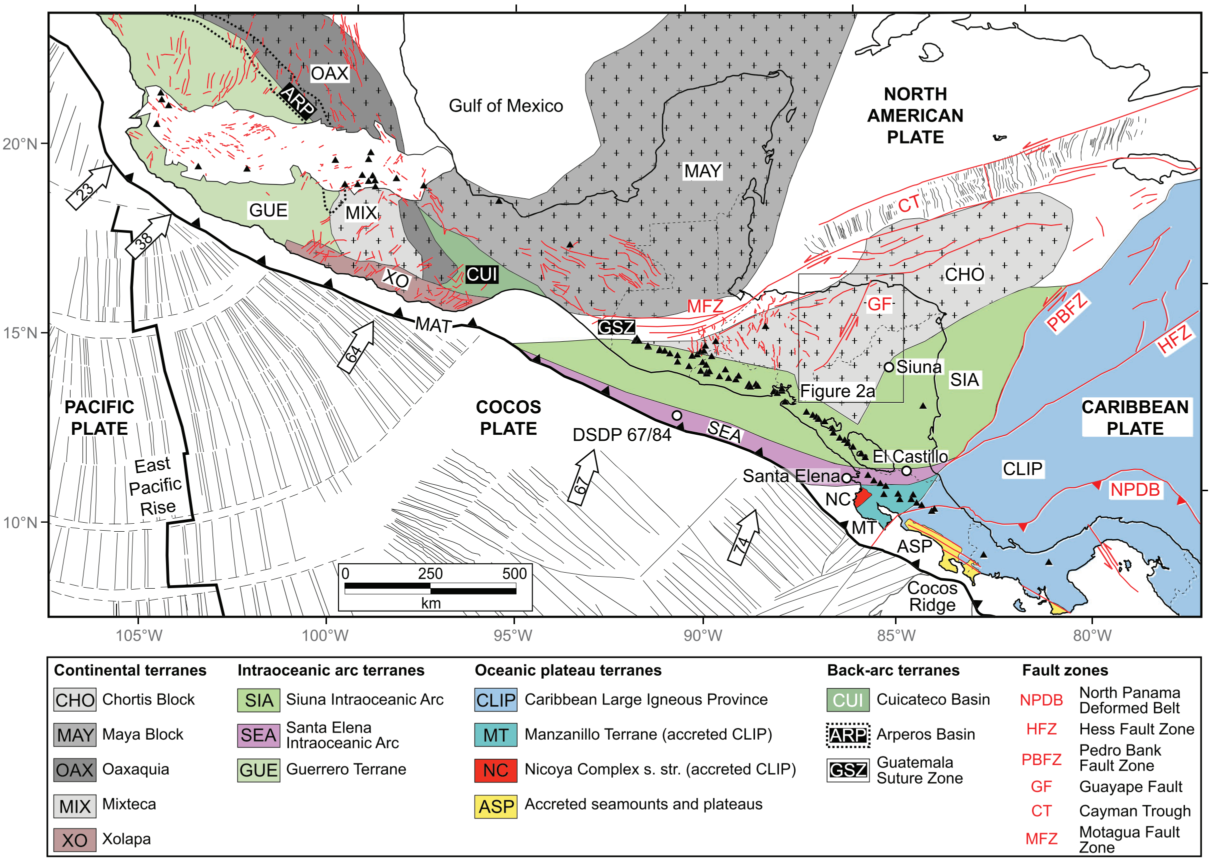
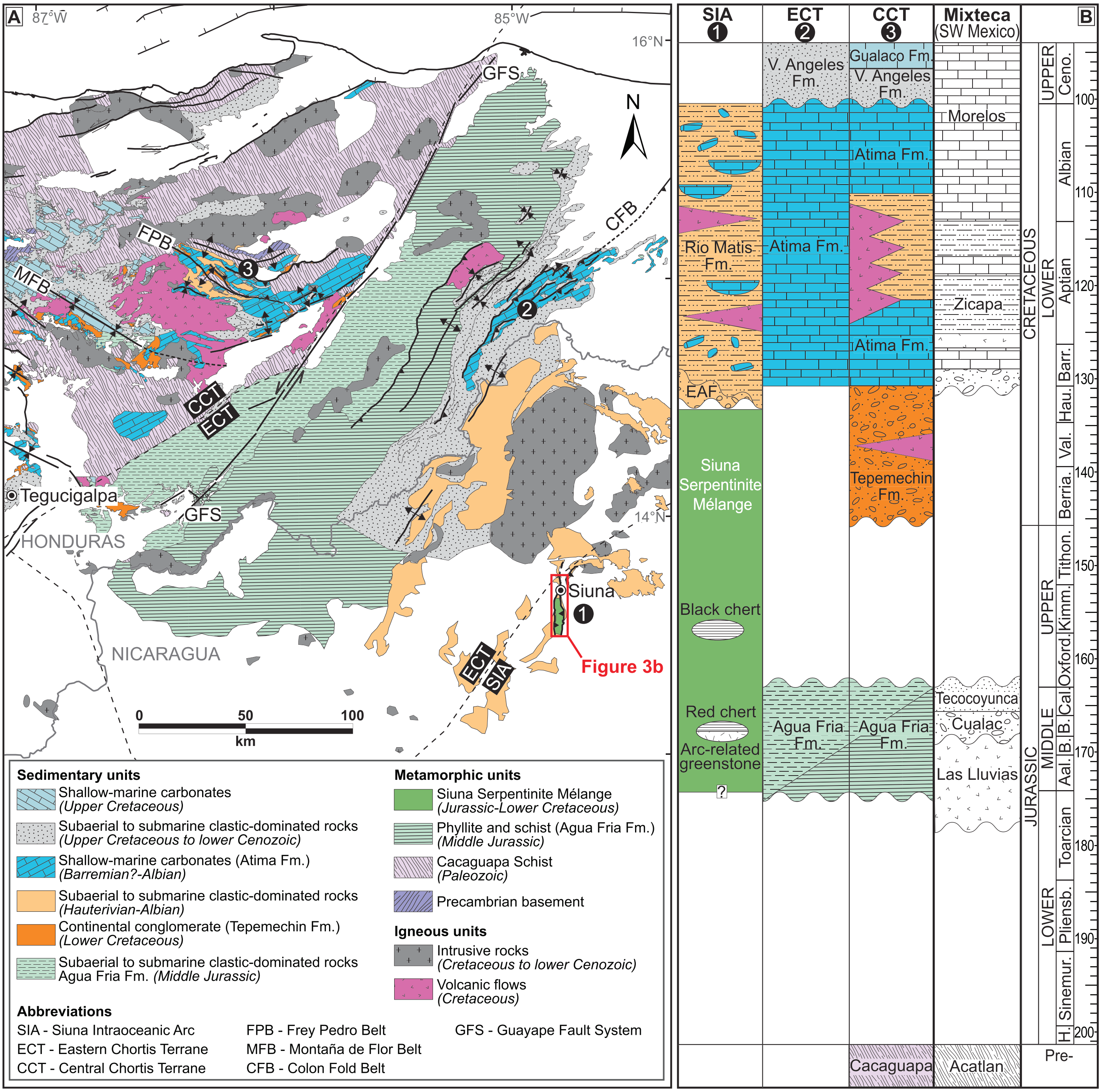


Figure 1. Plate tectonic map displaying the main terranes of Middle America (modified from Sedlock et al., 1993; Mann et al., 2007; Rogers et al., 2007a; Baumgartner et al., 2008; Centeno-García et al., 2008; Ratschbacher et al., 2009; Flores et al., 2013, 2015; Padilla y Sánchez et al., 2013; Carvajal-Arenas & Mann, 2018; Andjić et al., 2018, 2019; Sanchez et al., 2019). White arrows show the azimuth and rate (mm/year) of oceanic crust convergence relative to North America (after Ferrari et al., 2012) and the Caribbean Plate (after Kobayashi et al., 2014). Triangles represent Quaternary volcanoes (after Rogers et al., 2007a). The black rectangle represents the location of the geological map in Figure 2a. MAT = Middle America Trench.

geochemistry of Quaternary volcanoes and gravity anomalies (Carr et al., 2003; Rogers, Mann, & Emmet, 2007; Figures 1 and 2).

To the southeast, the Eastern Chortis Terrane is bordered by an accreted intraoceanic arc assemblage of Jurassic-Early Cretaceous age, called the Siuna Terrane (Rogers, Mann, & Emmet, 2007; Rogers, Mann, Emmet, & Venable, 2007; Venable, 1994) or the Mesquito Composite Oceanic Terrane (Baumgartner et al., 2008; Flores et al., 2015; Figures 1 and 2). Besides evidence built on field, geological, petrological, and geochemical data (Baumgartner et al., 2008; Escuder-Viruete et al., 2019; Flores et al., 2015), the distinction between the Chortis continental terrane and the Siuna Intraoceanic Arc terrane is further based on their conspicuously different Pb isotope and gravity signatures (Rogers, Mann, & Emmet, 2007; Sundblad et al., 1991; Venable, 1994). The recognition of the exotic Siuna Intraoceanic Arc relies on the geology of the Siuna Belt, which was exposed due to Cenozoic strike-slip fault activity (Escuder-Viruete et al., 2019; Flores et al., 2015). The bulk of the Siuna Intraoceanic Arc is covered by younger sedimentary and volcanic deposits elsewhere (Baumgartner et al., 2008), including offshore eastern Nicaragua (Carvajal-Arenas & Mann, 2018; Sanchez et al., 2019). Based on geological and age similarities, Baumgartner et al. (2008) included the Siuna Intraoceanic Arc in the Mesquito Composite Oceanic Terrane together with other oceanic assemblages, that is, the El Castillo Mélange (S Nicaragua), the Santa Elena Intraoceanic Arc (N Costa Rica), and rocks of DSDP Leg 67/84 (Guatemala forearc; Figure 1). The latter three exposures may be related to a distinct intraoceanic arc that accreted during the mid-Cretaceous, as suggested by the evolution of the Santa Elena Intraoceanic Arc and its similarities with that of the rocks of the DSDP Leg 67/84 (Escuder-Viruete et al., 2015; Escuder-Viruete & Baumgartner, 2014; Geldmacher et al., 2008). In contrast, any bathymetric feature that



A
87°W
85°W
16°N
14°N
N
GFS
CFB
FPB
MFB
CCT
ECT
SIA
Tegucigalpa
HONDURAS
NICARAGUA
Siuna
Figure 3b
0
50
100
km
Sedimentary units
Shallow-marine carbonates (Upper Cretaceous)
Subaerial to submarine clastic-dominated rocks (Upper Cretaceous to lower Cenozoic)
Shallow-marine carbonates (Atima Fm.) (Barremian?-Albian)
Subaerial to submarine clastic-dominated rocks (Hauterivian-Albian)
Continental conglomerate (Tepemechin Fm.) (Lower Cretaceous)
Subaerial to submarine clastic-dominated rocks Agua Fria Fm. (Middle Jurassic)
Metamorphic units
Siuna Serpentinite Mélange (Jurassic-Lower Cretaceous)
Phyllite and schist (Agua Fria Fm.) (Middle Jurassic)
Cacaguapa Schist (Paleozoic)
Precambrian basement
Igneous units
Intrusive rocks (Cretaceous to lower Cenozoic)
Volcanic flows (Cretaceous)
Abbreviations
SIA - Siuna Intraoceanic Arc
ECT - Eastern Chortis Terrane
CCT - Central Chortis Terrane
FPB - Frey Pedro Belt
MFB - Montaña de Flor Belt
CFB - Colon Fold Belt
GFS - Guayape Fault System
B
SIA 1
ECT 2
CCT 3
Mixteca (SW Mexico)
Rio Matis Fm.
EAF
Siuna Serpentinite Mélange
Black chert
Red chert
Arc-related greenstone
?
V. Angeles Fm.
Atima Fm.
Agua Fria Fm.
Gualaco Fm.
Tepemechin Fm.
Cacaguapa
Morelos
Zicapa
Tecocoyunca
Cualac
Las Lluvias
Acatlan
CRETACEOUS
JURASSIC
UPPER
LOWER
MIDDLE
Ceno.
Albian
Aptian
Barr.
Hau.
Val.
Berria.
Tithon.
Kimm.
Oxford.
Cal.
B.
Aal.
Toarcian
Pliensb.
Sinemur.
H.
Pre-
100
110
120
130
140
150
160
170
180
190
200