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The Costa Rican Jurassic to Miocene oceanic complexes: Origin, tectonics and relations

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ABSTRACT

The occurrences of oceanic assemblages on the Pacific shore of Costa Rica are part of an intricate group of complexes with different tectonic origins. Although they are dismembered and disrupted, they are the only available inland source of information to decipher the evolution of this active margin. Six main regions are described in this paper: (1) Santa Elena Peninsula, constituted by a supra-subduction zone (Santa Elena Nappe), that is overthrusting an igneous-sedimentary Aptian–Cenomanian sequence (Santa Rosa Accretionary Complex), which includes OIB (Ocean Island Basalts) portions, (2) the Nicoya Complex, which is a Jurassic–Cretaceous chert sediment pile disrupted and detached from its original basement by multiple magmatic events that occurred during the formation of the CLIP (Caribbean Large Igneous Province), (3) the Tortugal area formed by the Tortugal Suite with OIB signature and surrounded by Nicoya Complex outcrops, (4) the Herradura Block composed of the Tulín Formation to Maastrichtian to Lower Eocene OIB accreted oceanic island and the Nicoya Complex as basement, (5) Quepos Block correlated with the Tulín Formation, (6) the Osa-Burica Block composed of the Golfito and Burica Terranes (geochemically and chronologically correlated to the Nicoya Complex), Rincón Block (Early Paleocene to Early Eocene accreted seamounts), and the Miocene Osa-Caño Accretionary Complex. The Santa Rosa Accretionary Complex together with the Tortugal Suite have OIB signatures and possibly without Galapagos hotspot geochemical affinity. These coincidences would be explained by the hypothetical existence of an "autochthonous" Cretaceous basement formed by these two regions together with the rest of the Caribbean. Costa Rican basement is constituted by several CLIP portions and seamounts accreted from the end of Cretaceous in the northwest to the Miocene in the southeast, forming the diverse oceanic occurrences of the Pacific, which are mainly connected to the Galapagos hotspot activity.

1. Introduction

Since the end of the last century, many authors have discussed the origin of oceanic related complexes and their tectonic significance applying the most updated methodologies and technologies to model and hypothesize their genesis, timing and emplacement. Based on this research, large and well-outcropped occurrences of oceanic complexes on the Pacific side of Costa Rica were found to be of great significance for unraveling the geotectonic puzzle of the Caribbean Plate. These oceanic complexes are part of several tectonic blocks, each one with a different geologic and tectonic history. The tectonic blocks are outcropping NW–SE trending, parallel to the present active margin represented by the Middle America Trench, and separating the Cocos and Caribbean plates (Fig. 1A).

In this paper, we redefine the stratigraphic and structural relations of the oceanic complexes of the following areas, from NW to SE: Santa Elena Peninsula, Nicoya Peninsula, Tortugal, Herradura, Quepos, Osa Peninsula and Burica Peninsula using geologic maps and comparative chronostratigraphic columns. We describe the different complexes integrating the information generated through the last 30 years of research and present a comprehensive updated geologic and geochemical overview of the occurrences of oceanic complexes in the region, aiming to understand the true significance of each geotectonic particular component in the geotectonic history of this active margin. This is still an ongoing field of interdisciplinary research and more work needs to be done to better understand the origin and geotectonic history of the Central American convergent margin. This paper represents a comprehensive synthesis and should be used as the starting point for future studies.

1.1. Methodology

The methodology followed in this work consisted of integrating a high number of geochronological and geochemical data. The geochronological synthesis is based on biostratigraphy as well as

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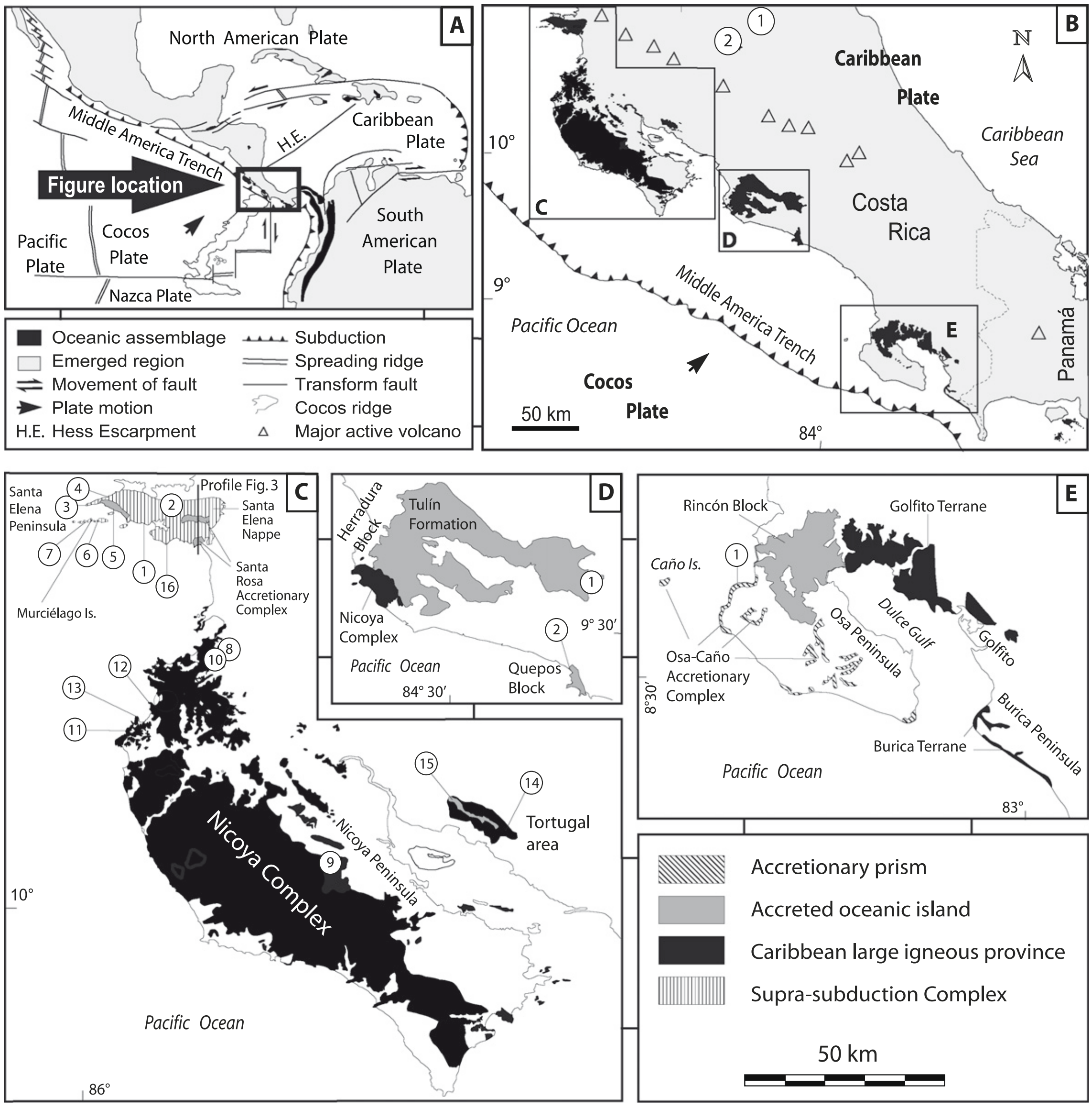

Fig. 1. (A) Present day tectonic setting of the Caribbean region, showing the occurrences of oceanic complexes in the region based on Dengo (1985), DeMets et al. (1990) Donnelly (1994), Meschede and Frisch (1994), Tournon et al. (1995), Ranero and von Huene (2000), Ranero et al. (2003) (B) Location of the oceanic complexes of Costa Rica mentioned in this paper. Geologic sketched maps of the oceanic complexes of Santa Elena - Nicoya peninsulas (C) Herradura-Quepos (D) and Osa-Burica (E) The numbers in circles correspond to localities mentioned in the text.

$^{40}Ar/^{39}Ar$ dates from Sinton et al. (1997), Hauff et al. (2000) and Hoernle et al. (2002). Some K/Ar radioisotopic data from Bellon and Tournon (1978), Tournon (1984) and Berrangé et al. (1989) were also used, especially in areas that lack $^{40}Ar/^{39}Ar$ ages. The compiled geochronological database includes geochemical analyses from Sinton et al. (1997), Beccaluva et al. (1999), Arias (2000), Hauff et al. (2000) and Hoernle et al. (2002), which are available upon request. These data were plotted and interpreted in chondrite-normalized REE (Rare Earth Elements), Pb isotopes ($^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$) and HFSE (High Field Strength Elements, e.g. Ti, Zr, Nb) ratio diagrams.

2. Geologic and geotectonic setting

Costa Rica is located on a geotectonically complicated triple junction, where the Middle American Trench separates Cocos and Caribbean plates and the Panama Fracture Zone separates the Cocos and Nazca plates (Fig. 1A). At the Middle America Trench, the Cocos plate subducts beneath the Caribbean Plate at an average rate of 88 mm/yr (DeMets, 1995) and extends north for more than 1000 km (Seely et al., 1974). The subduction of the Cocos Ridge below Costa Rica has caused wide diversity in the subduction processes, varying from smooth subduction in front of Nicoya Peninsula to rough subduction where the Cocos Ridge collide with the Middle American Trench (Gardner et al., 1992; Vannucchi et al., 2001). Offshore of the Nicoya Peninsula, the trench retreated 50 km during the last 16 Ma, in comparison to Osa trench which has retreated just 20 km (Vannucchi et al., 2001; Vannucchi et al., 2006).

Underthrusting has been suggested offshore Nicoya Peninsula (Seely et al., 1974). The subduction is also accompanied by coexisting erosion and accretion (von Huene and Scholl, 1991; Clift and Vannucchi, 2004), probably acting alternatively in time (Vannucchi et al., 2006). However, the presence of large oceanic provinces along the Pacific coast of Costa Rica means that the accretionary processes have been more dominant than tectonic erosion (Denyer