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Vestiges of the proto-Caribbean seaway: Origin of the San Souci Volcanic Group, Trinidad

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ABSTRACT

Outcrops of volcanic–hypabyssal rocks in Trinidad document the opening of the proto-Caribbean seaway during Jurassic–Cretaceous break-up of the Americas. The San Souci Group on the northern coast of Trinidad comprises the San Souci Volcanic Formation (SSVF) and passive margin sediments of the ~130–125 Ma Toco Formation. The Group was trapped at the leading edge of the Pacific-derived Caribbean Plate during the Cretaceous–Palaeogene, colliding with the para-autochthonous margin of Trinidad during the Oligocene–Miocene. In-situ U–Pb ion probe dating of micro-zircons from a mafic volcanic breccia reveal the SSVF crystallised at 135.0 ± 7.3 Ma. The age of the SSVF is within error of the age of the Toco Formation. Assuming a conformable contact, geodynamic models indicate a likely origin for the SSVF on the passive margin close to the northern tip of South America. Immobile element and Nd–Hf radiogenic isotope signatures of the mafic rocks indicate the SSVF was formed by ≪10% partial melting of a heterogeneous spinel peridotite source with no subduction or continental lithospheric mantle component. Felsic breccias within the SSVF are more enriched in incompatible elements, with isotope signatures that are less radiogenic than the mafic rocks of the SSVF. The felsic rocks may be derived from re-melting of mafic crust. Although geochemical comparisons are drawn here with proto-Caribbean igneous outcrops in Venezuela and elsewhere in the Caribbean more work is needed to elucidate the development of the proto-Caribbean seaway and its rifted margins. In particular, ion probe dating of micro-zircons may yield valuable insights into magmatism and metamorphism in the Caribbean, and in altered basaltic terranes more generally.

1. Introduction

Rifting of the supercontinent Pangaea and the opening of the Central Atlantic during the Mesozoic represents both a classic example of continental break-up and passive margin development, and an enduring enigma in assessing the role of mantle plumes in such a process (e.g., Callegaro et al., 2013; Hill, 1993; McHone, 2000). One branch of the Pangaea break-up story that has hitherto received little attention is the rifting of North and South America from the latest Triassic onwards (e.g., Bartok, 1993; Ostos et al., 2005). This rifting generated both the Gulf of Mexico and the proto-Caribbean seaway (Pindell and Dewey, 1982), and lasted until the onset of N–S convergence between the Americas in the Late Cretaceous (Müller et al., 1999). The Pacific-derived Caribbean Plate has over-ridden much of the proto-Caribbean since the Cretaceous. Only fragments of proto-Caribbean crust which have been either accreted to the Caribbean Plate or thrust onto South America remain, from which the tectono-magmatic evolution of the proto-Caribbean oceanic crust have to be pieced together. Many of these 'fragments' in South America have hitherto received little attention.

During the Late Jurassic–Early Cretaceous, the proto-Caribbean seaway was fringed on its western margin by east-dipping subduction of the Farallon Plate, generating the 'inter-American Arc' (e.g., Pindell and Dewey, 1982). During the Early–Late Cretaceous (see Hastie and Kerr, 2010; Pindell et al., 2011; Hastie et al., 2013; Escuder Viruete

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et al., 2014, for recent debate), east-dipping subduction beneath the inter-American Arc ceased and was superseded by SW-dipping subduction of proto-Caribbean oceanic crust. Proto-Caribbean subduction gave rise to the 'Great Arc of the Caribbean' (sensu Burke, 1988), a composite of several island arc systems of debated origin and complexity (Neill et al., 2011; Wright and Wyld, 2011). This arc system includes much of the present-day Greater Antilles, Aves Ridge, and Netherlands-Venezuelan Antilles as well as Tobago and allocthonous terranes in Venezuela, and marked the leading edge of the Pacific-derived Caribbean Plate from the Cretaceous to the Palaeocene. These subduction systems shut down following roll-back of the proto-Caribbean slab and were superseded by growth of the Palaeocene–Eocene to present-day Lesser Antilles Arc system.

The central region of the Caribbean Plate consists of 7–20 km thick crust of the Late Cretaceous mantle plume-derived Caribbean Oceanic Plateau (see review in Kerr et al., 2003). Due to continued Atlantic spreading and Andean–Cordilleran subduction, the Pacific-derived Caribbean Plate has moved east relative to the Americas from the Cretaceous to the present, with much of the proto-Caribbean oceanic crust being subducted beneath the 'Great Arc' system. Therefore, models of how and when North and South America broke apart remain to be tested properly, and the role of igneous processes in continental break-up in this region is still uncertain as we have little proto-Caribbean crust to work with.

Fortunately, a few fragments of Mesozoic proto-Caribbean crust and lithospheric mantle escaped subduction, having been either accreted to the present-day Greater or Lesser Antilles (e.g., Jolly et al., 2008; Marchesi et al., 2011; Neill et al., 2010) or been thrust onto northern South America (Kerr et al., 2009; Ostos and Sisson, 2005; Wadge and Macdonald, 1985) (Fig. 1). Nevertheless, a further problem remains in studying such proto-Caribbean outcrops in that many of these contain altered mafic rocks which are inherently difficult to interpret geochemically and to date accurately due to mobilisation of major and trace elements. In this paper, we present new ion microprobe U–Pb zircon geochronology along with immobile element and Nd–Hf radiogenic isotope data from the San Souci Volcanic Formation of northeast Trinidad (Fig. 2), the easternmost exposure of igneous rocks on the Caribbean coast of South America. We use the new data to re-assess the timing and source of magmatism at San Souci and its relationship to both the break-up of the Americas and later Caribbean tectonics. Furthermore, this work demonstrates the potential for accurate dating of altered fine-grained Phanerozoic mafic rocks.

2. Geological setting and studied samples

2.1. The Caribbean–South American Plate boundary

Northern South America is a tectonically complex transpressive plate boundary between the Caribbean and South American Plates. South America is currently moving to the west at ~20 mm a^{-1} relative to the Caribbean Plate, with much of the motion taken up on the El Pilar–San Sebastian fault system running through Trinidad and Venezuela (Weber et al., 2001) and the offshore North Coast Fault Zone to the north of Trinidad (Figs. 1,2). In pre-Cenozoic times, northern South America was a passive margin of the proto-Caribbean seaway between North and South America, with the future

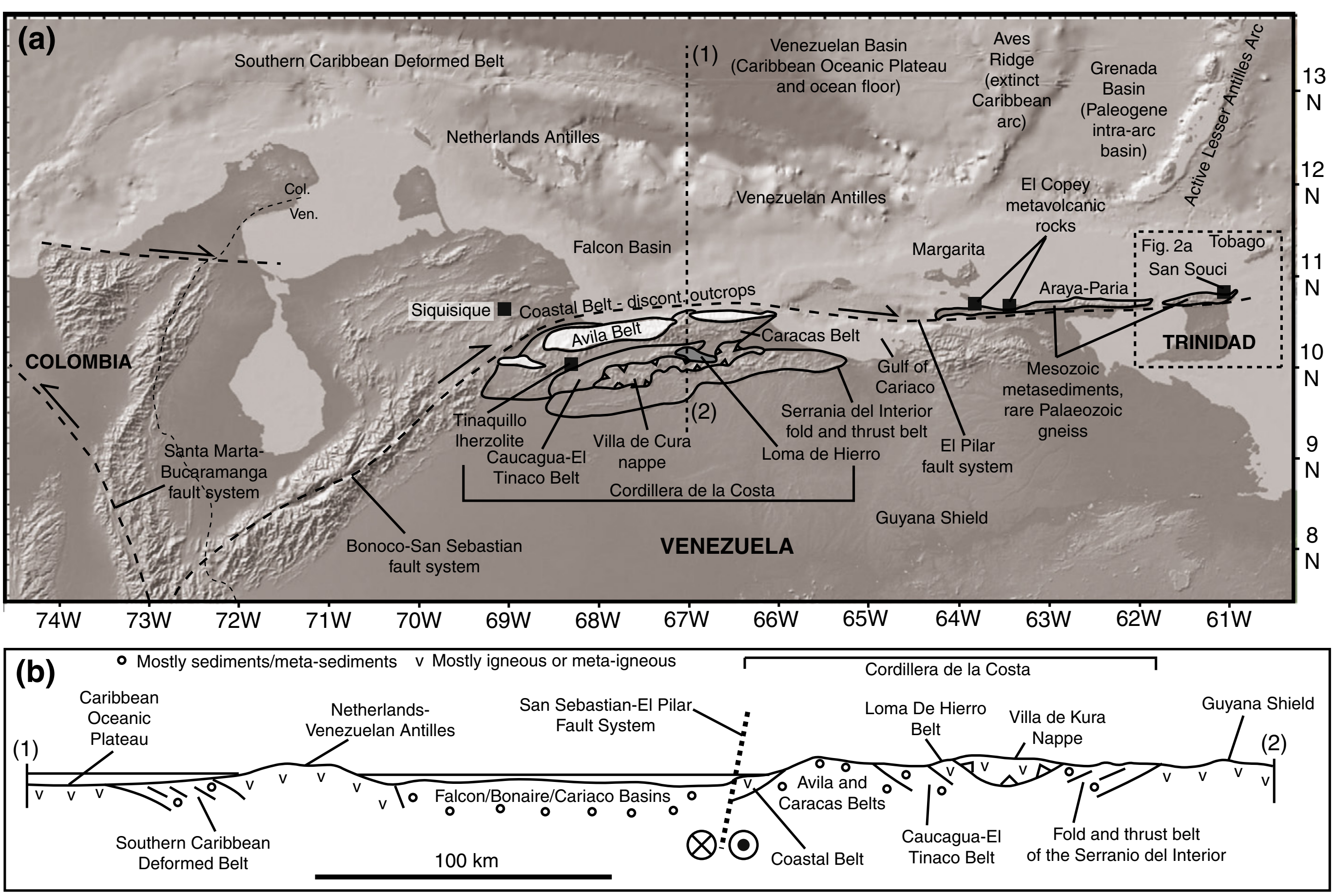

Fig. 1. (a) Map of the Caribbean–South American Plate boundary region showing the units mentioned in the text. Geological units adapted from Urbani and Rodríguez (2004) and Hackley et al. (2005). Background topography map is from www.geomapapp.org (Haxby et al., 2010; Ryan et al., 2009). (b) Geological cross section from north to south through the Caribbean–South American Plate boundary at around 67°W modified from Giunta et al. (2002).