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Geochemistry and petrogenesis of Cretaceous oceanic plateau lavas in eastern Jamaica

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Abstract

Basaltic lavas of Turonian to Coniacian age belonging to the Bath–Dunrobin Formation occur with intercalated island arc tuffs in the south of the Blue Mountain inlier, have been interpreted as being derived from the Caribbean oceanic plateau. This study presents new major and trace element and Sr–Pb–Nd–Hf isotopic data for these igneous rocks. The Jamaican rocks are altered by tropical weathering, hydrothermal and metamorphic processes, which have mobilised many of their elements (e.g. K and Ba). Consequently, the basalts and dacitic tuffs have been classified by using immobile trace elements. The trace element and ε_{Hf}(i)–ε_{Nd}(i) geochemistry suggests that the basaltic lavas are derived from a chemically similar source region by variable degrees of partial melting. The Caribbean plateau basalts lie on a mixing line between a depleted plume component and HIMU in Nd–Hf isotopic space. The Pb isotope data also demonstrate that the Jamaican plateau lavas are composed of a larger HIMU component than the other plateau lavas within the Caribbean region. The intercalated island arc tuffs are the first to be found in any oceanic plateau succession in the Caribbean and imply that the Caribbean oceanic plateau at ~90 Ma was relatively close to the subduction zone along South America and the Great Arc of the Antilles.

Keywords: Caribbean; Jamaica; Bath–Dunrobin Formation; Oceanic plateau; Mantle plume; Cretaceous arc

1. Introduction

As a mantle plume collides with the base of the lithosphere decompression melting will rapidly produce large amounts of melt that will eventually form an oceanic plateau or a continental flood basalt (e.g. Campbell and Griffiths, 1990; Campbell, 2007). The volumes of magma produced as a result of this decompression melting can be vast. For example, the Ontong Java oceanic plateau has an estimated melt volume of $44–50 \times 10^6$ km^3 (Eldholm and Coffin, 2000) whereas the estimated original melt volume of the Caribbean oceanic plateau is $\sim 4 \times 10^6$ km^3 (Kerr, 1998).

In the Caribbean region, accreted oceanic plateau sections have been identified on all of the Greater Antilles islands except Jamaica and the U.S. Virgin Islands (Fig. 1) (Kerr et al., 2003; Jolly et al., 2007). This paper describes the geochemistry of the Cretaceous Bath–Dunrobin Formation in the Blue Mountain Inlier, eastern Jamaica (Fig. 2). The geochemistry of these rocks is consistent with the formation of the Bath–

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Dunrobin lavas in the Caribbean oceanic plateau, and so provides further evidence of the Caribbean plate representing, in large part, an oceanic plateau. In addition, for the first time, intercalated island arc tuffs have also been discovered within the Bath–Dunrobin plateau succession. We will show that the occurrence of plateau lavas and tuffs in Jamaica helps support the Pacific model of Caribbean evolution and provides further insights into the origin and evolution of the Caribbean region and other oceanic plateaus.

2. Geological background

2.1. Caribbean regional geology

Present-day subduction zones are found on the eastern and western margins of the Caribbean plate: to the west the Cocos Plate is subducting under the Central American arc to produce the Costa Rica and Panama arc, whereas in the east, Atlantic oceanic crust is subducting in a westerly direction to form the active Lesser Antilles island arc (Fig. 1). In contrast, the northern and southern boundaries of the plate are complex areas of strike slip motion and rifting, with sinistral strike slip motion along the northern boundary and dextral motion along the southern boundary (e.g. Pindell and Barrett, 1990). Although controversial the velocity of the Caribbean plate with respect to North America is ~19 mm/yr to the east (see Jansma et al., 2000 for a review).

It is now widely recognised that the Caribbean plate consists mostly of a Cretaceous oceanic plateau that was formed in the Pacific ~89–93 Ma (see review in Kerr et al., 2003). Today the Caribbean oceanic plateau has a total area of $\sim 6 \times 10^5$ km^2, and underlies most of the Caribbean basin (Fig. 1) (Mauffret and Leroy, 1997). The plateau originally covered a much larger area when it was erupted onto the Farallon plate, which was moving to the northeast to be subducted beneath the North and South American continents (Alvarado et al., 1997; Sinton et al., 1998; Kerr et al., 2003). Unlike the Farallon oceanic crust the upper layers of the oceanic plateau would have been too thick, hot and buoyant to subduct beneath the American or proto-Caribbean subduction zones (Kerr et al., 2003). As a result the southern part of the oceanic plateau collided with the northwestern margin of South America forming significant accreted sequences in Colombia and Ecuador (Spadea and Espinosa, 1996; Kerr et al., 1996a, 2002a,b). The northern part of the oceanic plateau collided with an upper Cretaceous arc (The Great Arc of the Antilles; Burke, 1988) situated at the western entrance of the Proto-Caribbean seaway which had been opening between the American continents since the Jurassic (Duncan and Hargraves, 1984; Burke, 1988; Pindell and Barrett, 1990; Pindell and Kennan, 2001).

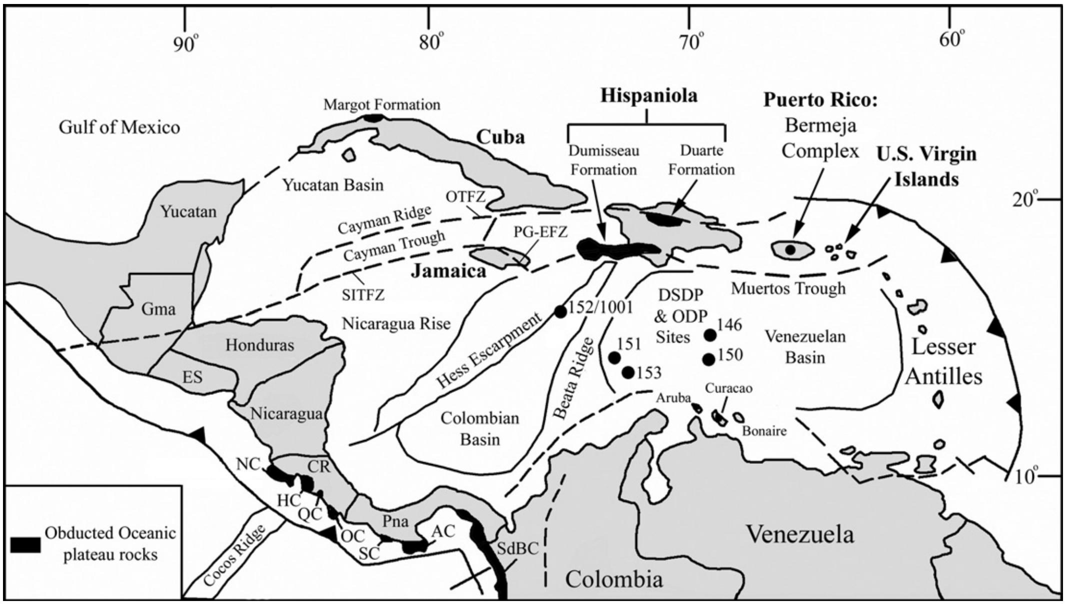

Fig. 1. Map of the Caribbean and Central American region. Guatemala (Gma), El Salvador (ES), Costa Rica (CR), Panama (Pna), Swan Islands Transform Fault Zone (SITFZ), Oriente Transform Fault Zone (OTFZ), Plantain Garden–Enriquillo Fault zone (PG-EFZ), Nicoya Complex (NC), Herradura Complex (HC), Quepos Complex (QC), Osa Complex (OC), Sona Complex (SC), Azuero Complex (AC), Serrania de Baudo Complex (SdBC) (Modified from Sinton et al., 1998).