A complex history for the Caribbean oceanic plateau: Petrology, geochemistry and geochronology of the Beata Ridge

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The Caribbean province is an area where the thickness of oceanic crust is between 8 and more than 20 km, well in excess that of 'normal' oceanic crust. This has led to the conclusion, supported by geochemical studies and tectonic reconstructions, that much of the Caribbean plate formed as an oceanic plateau in the eastern Pacific. Most authors accept that the Caribbean plateau formed through melting of the Galapagos plume head. Through eastward movement of the Farallon plate, part of this plateau was entrained between the two American plates while the southern part collided with northern South America. At least two major phases have been recognized in the plateau building. The first, volumetrically most important event was around 90-88 Ma, and the second around 76 Ma. New petrological, geochemical and geochronological data from the Beata topographic ridge, south of Hispaniola, highlight the complexity of the Caribbean plateau construction and may require a revision of this model.

The Beata ridge is an area of particularly thick crust (up to 20 km) between the Dominican and Haitian sub-basins. The ridge is 2000 to 5000 m deep and is bounded to the west by a normal fault. In this study we focus on the magmatic samples recovered by submersible during the Nautica-Beata cruise.

The ridge is mainly composed by gabbros and dolerites, with minor diorite and rare pillow basalt. The gabbros and dolerites contain euhedral plagioclase (An_{54-62}) and clinopyroxene (Wo_{37-40} En_{44-47} Fs_{13-19}) grains with a variable but minor amount of olivine and/or orthopyroxene relicts, ilmenite and acicular apatite. The presence of orthopyroxene and the early crystallisation of plagioclase indicate a tholeiitic affinity. Textures that vary significantly, from coarse-grained gabbros to very fine-grained dolerites, reflect differences in cooling rates and suggest a subsurface, hypabyssal environment. The rare basaltic flows contain phenocrysts of weathered olivine, plagioclase (An_{50-61}) and clinopyroxene (Wo_{44-47} En_{40-44} Fs_{12-16}) in a matrix of plagioclase microlites (An_{50-55}), clinopyroxene microcrysts (Wo_{45-46} En_{37-40} Fs_{15-16}) and a glassy, vesicular mesostasis. The early crystallisation of olivine, an absence of orthopyroxene and the late crystallisation of plagioclase suggest an alkaline affinity.

The major element compositions of gabbros and dolerites plot on simple trends that correspond to fractional crystallisation of olivine, clinopyroxene and plagioclase (MgO 5–11%; Al_2O_3 12–17%; CaO 8–15%). Trace-element ratios are close to chondritic [$(Nb/Zr)_N$ 0.85–1.1] and rare-earth-element patterns are almost flat [$(La/Yb)_N$ 0.63–1.02]. The source was isotopically depleted [ε_{Nd} +7.4 to +9.5]. The basalts have higher trace-element ratios and enriched rare earth element patterns [$(Nb/Zr)_N$ 3.45; $(La/Yb)_N$ 28–30]. Their source was less depleted than that of the gabbros and dolerites [ε_{Nd} +5].

Several samples were dated by the $^{39}Ar/^{40}Ar$ incremental heating method, either on whole rocks or separated plagioclases. Six samples have ages between 84 to 70 Ma and these correspond with previous dates within the province. But others are surprisingly young, with ages at 62, 56 and 50 Ma. There is no apparent order to the ages: all are found in different rock types and from one end of the ridge to the other. Within the younger age group, consistent results were obtained for both whole rocks and plagioclases. In contrast, within the older age group, whole-rocks and plagioclase gave conflicting ages. For this reason, we consider that the young ages are not due to thermal resetting but probably represent a true magmatic event. In contrast, the ages for older

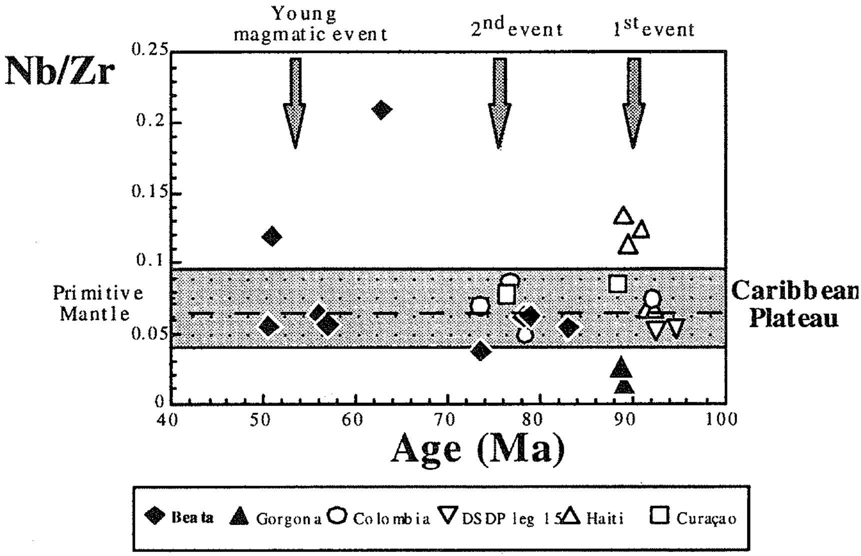

FIG. 1.

samples may have been disturbed by later intrusions. A single basalt sample was dated at 62 My.

The entire gabbro-dolerite group is chemically very homogeneous with a geochemical signature typical of oceanic plateau tholeiites and consistent with a plume origin. Moreover, they are chemically very similar to basalts and picrites from other parts of the Caribbean province (Haiti, Curacao, Gorgona, Colombia). These observations provide convincing evidence that the Beata ridge is closely related to the formation of the Caribbean oceanic plateau, but they also pose difficulties for the interpretation of the wide range of ages. Whereas older samples are compatible with previous model of the plateau building, the ages ranging from 56 to 50 My are the youngest ever reported within the province.

We have considered three interpretations of the younger events: (1) Local extension may have triggered further melting in the mantle beneath the plateau. This hypothesis implies, however, large extension rates and the preservation, for more than 30 m.y., of material hot enough to produce basaltic magma. (2) The Galapagos plume may have had two heads. The arrival of the first was the cause of the main plateau building event, 88–90 My ago; the second led to the formation of younger Beata magmas. However, on the basis of recent plate reconstructions, the plateau would have been far from the Galapagos hotspot, 50 My ago. (3) Two different plumes may have contributed to the construction of the Caribbean plateau. The main plateau building event, 88–90 My ago, may be related to melting in a plume head associated with the hot spot now at Sala y Gomez. The younger Beata magmas erupted in a second event, 50 My ago, when the plateau passed over the Galapagos hotspot. This hypothesis could explain the discrepancy between dates from the different part of the plateau. Moreover it is consistent with reconstructions of the Farallon plate movement and palaeomagnetic study of Gorgona island. However, to distinguish between the various possibilities remains difficult in the light of uncertainties surrounding the positions and movements of tectonic plates during the Cretaceous.