# The Curaçao lava formation: samples of the oldest and most primitive magmas from the Galapagos plume

**J.M. Hergt** *School of Earth Sciences, University of Melbourne, Parkville, VIC., Australia*

**M. Storey** *Division of Geography and Geology, West London Institute, College of Brunel University, Middlesex, TW7 5DU, England.*

**G. Marriner** *Dept. Geology, Royal Holloway and Bedford New College, Egham, TW20 OEX, England.*

**J. Tarney** *Dept. Geology, University of Leicester, LE1 7RH.*

Curaçao Island is located in the southern Caribbean close to the northwestern coast of Venezuela. The oldest sequence exposed on the island is the Curaçao Lava Formation (CLF) which consists of approximately 5 km of basaltic rocks dominated by pillow-lavas. In the uppermost half of the sequence the pillow lavas are interrupted by hyaloclastite units and the intrusion of sills and dykes. Beets *et al.*(1984) noted that this 5 km section of magmas shows some evidence for decreasing lava density with height, with picritic and olivine tholeiitic rocks occurring towards the bottom (MgO 8–31 wt%) and the upper half of the sequence dominated by olivine and ol±pl±px tholeiitic magmas (MgO 5–10 wt%). A narrow (only a few metres thick) intercalation of sediment contains ammonites of middle Albian age (Weidmann, 1978) which, despite some confusion with the results of K–Ar dating, suggests that the CLF is approximately 100 Ma old. An angular unconformity separates this formation from an approximately 2 km thick section of pelagic, silica-rich, and clastic sediments (Knip Group) and turbidites (Midden Curaçao Formation). These units contain a minor amount of volcanics apparently of subduction affinity (Beets *et al.*, 1984), however it is the lower, CLF which is of interest to the current study.

Given its location on the Caribbean Plate, and therefore its complicated tectonic setting, it is not immediately obvious what Curaçao Island actually represents. The crust now forming the basement of the Caribbean is believed to have been transported from its site of formation in the Pacific by processes of eastward subduction (e.g., Malfait and Dinkelman, 1972; Burke *et al.*, 1978; Beets *et al.*, 1984; Duncan and Hargraves, 1984). Duncan and Hargraves (1984) re-evaluated the origin of the Caribbean crust using plate reconstructions relative to the hotspot reference frame. Such reconstructions place the Caribbean Plate over the site of the Galapagos hotspot at approximately 100 Ma. Eastward transport caused by the subduction of the Farallon Plate resulted in the collision between the unusually thick (and therefore buoyant) oceanic crust of the Caribbean Plate and the Greater Antilles Arc. This effectively clogged the subduction zone and began to push the entire arc and related crust northeast. It is during this transport and rotation of the crust that islands of the southern Caribbean borderland, including Curaçao Island are thought to have been formed by obduction (Donnelly *et al.*, 1973a; Beets *et al.*, 1984; Sen *et al.*, 1988).

The similarity in chemistry between rocks from the CLF and mid-ocean ridge basalts (MORB) has been noted by numerous authors (e.g., Donnelly *et al.*, 1973a,b; Beets *et al.*, 1982, 1984). Beets *et al.* (1982, 1984) noted that the CLF were closest in composition to T-MORB (transitional MORB) because the chondrite normalized REE data have flat patterns rather than the LREE depleted signatures more commonly observed in MORB. A higher than expected K content was also noted in the CLF rocks.

Despite some overlap in their chemistry however, a number of other features distinguish the CLF rocks from typical MORB. The thickness of the pillow basalt section is much greater than observed at spreading ridges (but similar to that of the Caribbean crust, and oceanic plateaus such as Ontong-Java and Manahiki), there is a significant quantity of highly magnesian compositions (including picrites) in the CLF ranging down to MgO values more typical of MORB, and finally, despite the wide range in MgO contents, the entire suite can be related to a single picritic parent by shallow-level fractional crystallization processes (Beets *et al.*, 1984). The fact that picrites occur has been used to suggest that the magmas were

erupted at the beginning of a thermal perturbation before magma chambers had been established (Beets *et al.*, 1984). In addition, these authors suggest that magmatism was rapid and prolific; perhaps occurring in less than 10 Ma. These features of the CLF are entirely consistent with generation from a starting plume, perhaps the Galapagos plume still active today.

Support for a plume influence on the formation of the Caribbean oceanic crust and subsequent obduction caused by collision has come the geochemical study of basaltic rocks from another of the Caribbean islands. Sen *et al.* (1988) have demonstrated that basalts from the Dumisseau Formation of southern Haiti could indeed find equivalents in the Caribbean seafloor basalts (recovered during DSDP Leg 15) indicating, that at least in the northern Caribbean, obducted crust could be recognized. These authors also noted the similarity between the chemistry of rocks from the Dumisseau Formation and magmas more recently erupted over the Galapagos hotspot.

Owing to the spectacular exposure of fresh and primitive basaltic rocks, samples from the CLF on Curaçao Is. are an ideal choice for further investigation of this problem. While our data confirm the essentially flat nature of the chondrite normalized REE patterns for the picritic rocks, we also point out the low La/Th and La/Nb in our samples (11 and 0.75 respectively) compared with typical MORB. The values we observe in the CLF picrites are actually more typical of ocean island basalts. Certainly, if the CLF magmas were derived from a mantle plume, the degree of melting was high (approximately 30% suggested by Beets *et al.*, 1984) and occurred at a level shallower than the stability field for garnet.

The range in Pb, Sr, and Nd isotopic compositions of the CLF picrites so far measured is limited and variations occur from 19.263–19.453; 15.551–15.567; 38.10–38.18; 0.70312–0.70329; 0.513000–0.513026. These values are similar to those reported for samples from Isabela Island in the Galapagos (more precisely, from Volcan Alcedo, Cerro Azul, and Sierra Negra volcanoes; data from White *et al.*, 1993) and are indistinguishable from values reported for the Dumisseau Formation of southern Haiti (Sen *et al.*, 1988).The link between the CLF and the Galapagos plume is strong, as is the evidence supporting Curaçao Island as an obducted part of the seafloor formed close to the hotspot. The picritic rocks from the CLF therefore provide the oldest and most primitive samples of the plume yet analysed, and are critical to further investigations into the petrogenesis of magmas from the Galapagos Islands.

## References


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