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Geochemical components in a Cretaceous island arc: The Th/La–$(Ce/Ce^*)_{Nd}$ diagram and implications for subduction initiation in the inter-American region

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ABSTRACT

Tectonic models of the evolution of the inter-American region show that induced subduction initiation/polarity reversal is required in order to isolate the Caribbean as a separate plate. However, the timing and mechanism of this subduction initiation/reversal are still controversial. In order to shed light on this issue we investigate the geochemistry of arc-derived, ~80 Ma, basic to acidic igneous rocks from the Main Ridge Formation (MRF) in central Jamaica. The affinity of the mantle component in the MRF arc rocks can help increase our understanding of the initiation of any new subduction zone in the inter-American region. Trace element geochemistry demonstrates that the MRF mantle source component was N-MORB-like. Conversely, younger circum-Caribbean arc rocks (≤75 Ma) have a more enriched plume-like mantle component. Unfortunately, when considering the slab component, some of the most useful trace elements that can be used to identify the affinity of a slab flux in arc lavas (e.g., Ba) have been mobilised by subsolidus alteration processes in the MRF. Consequently, the immobile element Th/La–$(Ce/Ce^*)_{Nd}$ discrimination diagram is proposed as a method of determining the affinity of slab components from altered igneous rocks. This diagram identifies sedimentary slab components that have potentially contaminated an arc source region, e.g., continental detritus, volcanic detritus, hydrogenous Fe–Mn oxides, fish debris-rich clay and hydrothermal sediments. In this study, the Th/La–$(Ce/Ce^*)_{Nd}$ diagram suggests that the slab component in most of the MRF samples has a composition similar to continental detritus/GLOSS II. Additionally, several MRF samples are derived from a source region that has been fluxed with a subduction component, in part, composed of fish debris and hydrothermal sediments. These results help constrain the timing and mechanism of Cretaceous subduction initiation in the inter-American region. The geochemical components recognised in the MRF rocks support a Turonian–Campanian (93.5–70.6 Ma) model of intra-Caribbean induced subduction polarity reversal that resulted from the collision of the Caribbean oceanic plateau with an inter-American arc system (the Great Arc of the Caribbean).

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1. Introduction

The tectonic processes responsible for generating volcanic island arcs are now relatively well understood (e.g. Elliott, 2003; Pearce and Stern, 2006). Nevertheless, subduction initiation mechanisms are controversial for both present-day and older arc systems (e.g. Dilek and Thy, 2009; Hall et al., 2003; Ishizuka et al., 2006; Pearce and Robinson, 2010). The two models advocated for generating a convergent margin include the induced (forced) or spontaneous (self-nucleation) hypotheses (e.g. Hall et al., 2003; Stern, 2004). Spontaneous subduction zones form when gravitationally unstable old and cold oceanic plates founder into the underlying asthenosphere along a pre-existing transform fault or fracture zone (Stern and Bloomer, 1992). Induced subduction zones are generated when existing plate convergence causes compression and ultimately plate rupture and/or subduction at a zone of lithospheric weakness (Hall et al., 2003; Stern, 2004). Subduction polarity reversal and subduction backstep (transference) are cases of induced convergent zones and both examples can be found in the western Pacific (e.g. Niu et al., 2003; Stern, 2004).

To understand the importance of these different modes of subduction initiation it is of benefit to investigate instances in the geological past that require new subduction systems to develop in order to explain the current plate tectonic framework on the Earth today

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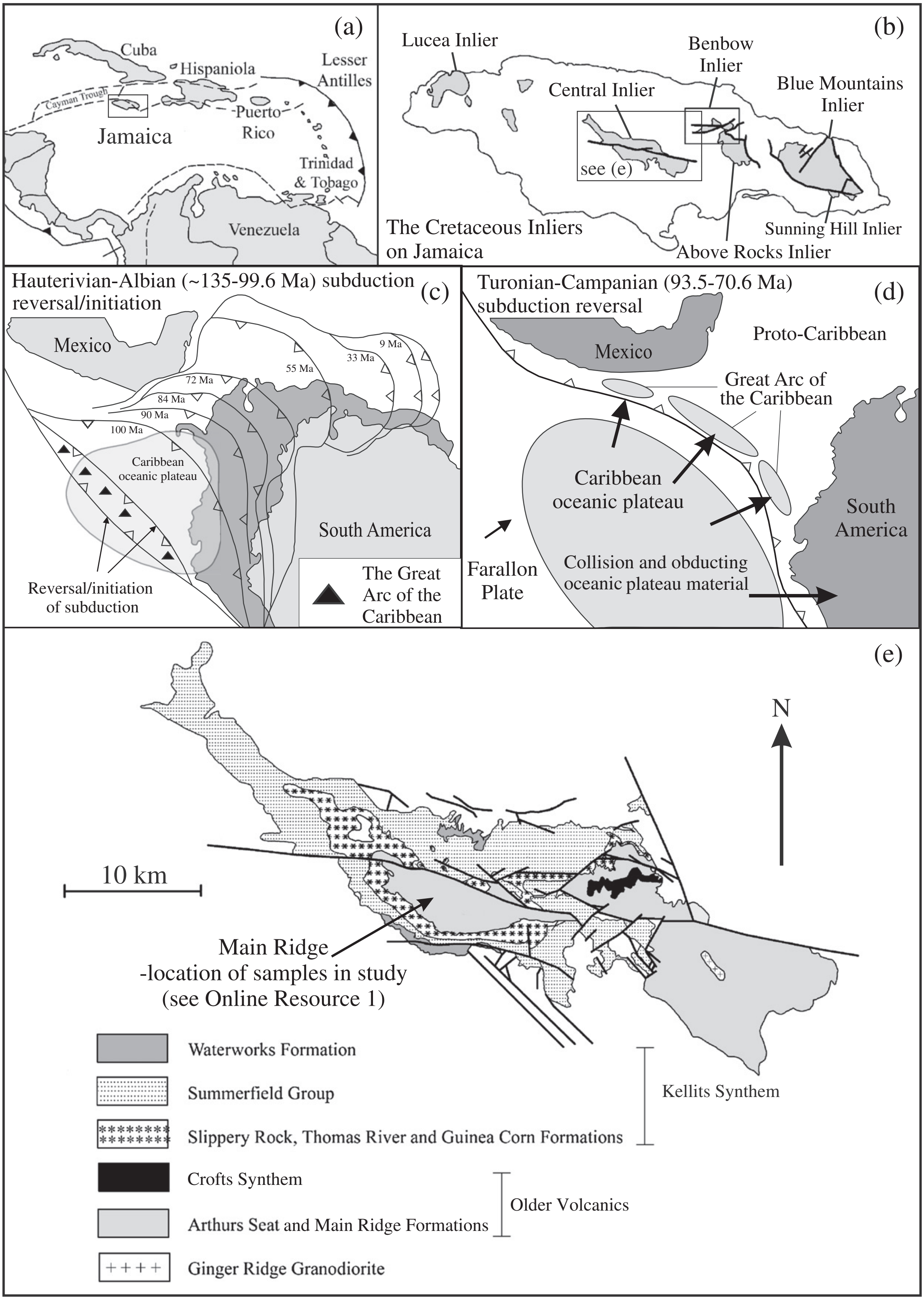

Fig. 1. (a) and (b) represent a map of the Caribbean region and the location of volcano-sedimentary Cretaceous inliers in Jamaica respectively (Modified from Hastie et al., 2010). (c) and (d) are the two main models for the evolution of the Caribbean region. (c) represents the Hauterivian to Albian subduction initiation/reversal model modified from Pindell et al. (2006) and (d) represents the oceanic plateau reversal model modified from Burke (1988) and Kerr et al. (1999). (e) Simple stratigraphic and structural geological map of the Central inlier (modified from Mitchell, 2002).

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