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The origin of Western Atlantic volcanic archipelagos by Interaction of Edge-Driven Convection and Mantle Plumes

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Intraplate volcanism is a widely studied but poorly understood phenomenon. In particular, Atlantic intra-oceanic volcanism near the African continental margin displays several characteristics that do not fully conform with the predictions of classical plume theory. In this context, it has been suggested that Edge-Driven Convection (EDC) plays a major role in the generation of magmas beneath e.g. the Canaries, Cape Verde or the Cameroon volcanic line. In order to explore the roles of EDC vs. plume in the generation of Atlantic volcano chains, we have conducted a series of numerical models using mantle-convection code CITCOM coupled with a new parameterization for peridotite melting. Our new parameterization has been derived from empiric fitting of melting experiments and pMELTS melting models, and can predict the extent and major-element composition of peridotite melting as a function of p-T path. To better understand plume-EDC interaction, we explore a wide range of model parameters, focusing specifically on the effects of mantle viscosity, plume temperature, plume flux and plume position relative to the edge (i.e. African margin) in steady-state and non-steady-state (transient) models. Our results suggest that EDC can distort plume ascent and imprint characteristic properties on the related volcanism, resulting in irregular age progressions and elongated melting zones. In addition, our models predict that the chemical characteristics of primary magmas depend on mantle upwelling geometry: for example, EDC without a plume, EDC that interacts with relatively cool plumes, or with plumes that rise close to the African margin, is predicted to be associated with alkalic volcanism; while hot plumes that interact (or not) with EDC tend to produce more tholeiitic magmas. Thus, major-element signatures can help to distinguish shallow (EDC) vs. deep (plume) mechanism and even to specify some characteristics of the latter. Although EDC alone is not a suitable mechanism for extensive intraplate magmatism, it can have important effects on plume ascent, reconciling some poorly understood characteristics of eastern Atlantic volcano chains. Finally, transient phenomena (e.g. changing melt volumes due to plume arrival) cannot be ruled out, since the time-spans required for steady-state modeling are larger than the age of the Atlantic ocean.