A plate model for distributed volcanism in the oceans

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Distributed volcanism in the oceans that is considerably younger than the sea floor on which it erupted has long been considered inconsistent with “normal” sea-floor spreading and thus inexplicable in the framework of plate tectonics. However, as increasingly detailed observations become available from the oceans it has become apparent that their formation and growth is not as simple as the conventional sea-floor spreading process generally envisaged. Continents are broken up by propagating rifts, not by simultaneous splitting of the lithosphere along hundreds or thousands of kilometers. New oceans may also form piece-wise with different segments opening at different times and rifts amalgamating by propagating towards each other.

These complexities at the time of break-up can lead to long-term disequilibrium and complications as the new ocean grows. Features develop such as irregular age, distribution and quantity of volcanic products, both at and subsequent to break-up, widely distributed continental fragments being transported into the new ocean, spreading ridges that propagate, die, migrate laterally, jump or bifurcate forming oceanic microplates, and persistent disequilibrium along the generalized zone of ongoing oceanic-crust formation. “Mid-ocean ridges” are then not so, because they do not remain at the mid-point of the new ocean.

A consequence of these complications is magmatism where the oceanic crust is put into extension, resulting in distributed volcanism occurring at various times and places as the new ocean grows. A complicated pattern of vertical motions is also expected, including sagging, flexing and tilting in the oceans and at the continent-ocean boundary zones, plus tectonic reactivations and complex plate boundary configurations including multiple triple junctions.

We will illustrate this new schema for the development of new oceans taking the example of the North Atlantic. This ocean has been studied intensively for almost a century because of its key roles in early continental drift theory and development of the plate tectonics paradigm, the existence of Iceland whose composition and origin has long been controversial, and the current importance of the region as a source of hydrocarbons. Other regions that are less well studied but also contain the features predicted by the new schema include the Rio Grande Rise/Walvis Ridge region of the South Atlantic, and the Seychelles-Mauritius region in the Indian Ocean.

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