Intra-ocean Ridge Jumps, Oceanic Plateaus & Upper Mantle Inheritance

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Ridge jumps within oceanic lithosphere, often associated with enhanced magmatism and the formation of oceanic plateaus, are common and appear to be a fundamental geodynamic process adding complexity to plate tectonics and ocean basin development. Numerous examples globally. The Indian Ocean shows multiple ridge jumps including those between the Conrad Rise, Crozet Plateau and the Madagascar Plateau, between Seychelles and India, and between Kerguelen Plateau and Broken Ridge. The South Atlantic shows examples associated with the separation of Southern Brazil and Namibia leading to the formation separation of the Rio Grande High and Walvis Ridge.

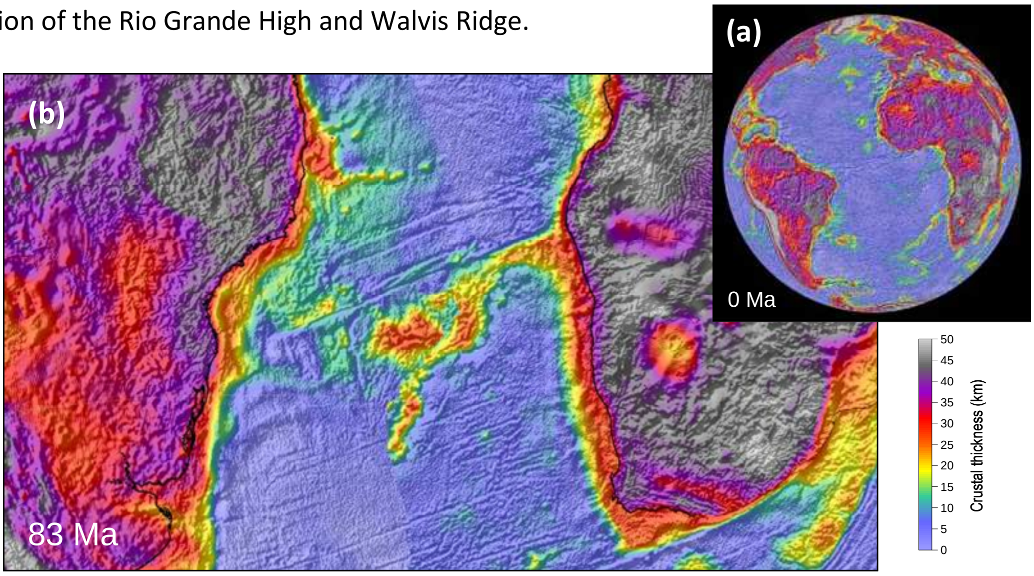

Figure 1 (a) Present day crustal thickness from gravity inversion for the Atlantic Ocean. (b) Crustal thickness restored to 83 Ma using GPlates 1.5.

Gravity anomaly inversion of satellite derived free-air gravity incorporating a lithosphere thermal gravity anomaly correction[1,2] now provides a useful and reliable methodology for the global mapping of oceanic crustal thickness. The resulting maps of crustal thickness may be used to determine the distribution of oceanic lithosphere, micro-continents and oceanic plateaus. Using crustal thickness and continental lithosphere thinning factor maps with superimposed shaded-relief free-air gravity anomaly, we can improve the determination of pre-breakup rifted margin conjugacy and sea-floor spreading trajectory during ocean basin formation. This mapping shows micro-continents, oceanic plateaus and ridge jumps consistent with a complex evolution of ocean basin development.

Examples include:

Rio Grande Rise and Walvis Ridge. Their evolution shows multiple ocean ridge jumps into pre-existing oceanic lithosphere with hot spot magmatism generating 30 km thick oceanic crust. Recent sampling[3] has shown that the Rio Grande Rise contains some continental material of Proterozoic age. Plate restoration to 83 Ma of crustal thickness derived from gravity inversion for the S Atlantic shows the Rio Grande Rise and Walvis Ridge forming a single feature analogous to Iceland (Fig. 1).

Conrad Rise, Crozet Plateau, Madagascar Plateau and SWIR. The evolution of the SW Indian Ocean shows sequential ridge jumps between Antarctica, Conrad Rise, Crozet Plateau and Madagascar Plateau leading to the present-day South West Indian Ridge. Ocean ridge jumps into pre-existing oceanic lithosphere are magma rich generating oceanic plateaus (Fig. 2).

Mauritius, Nazareth, Mascarene and Chagos Banks. These are underlain by crust rifted and magmatically thickened ahead of propagating sea-floor spreading. Precambrian age zircons have been found on Mauritius[4].

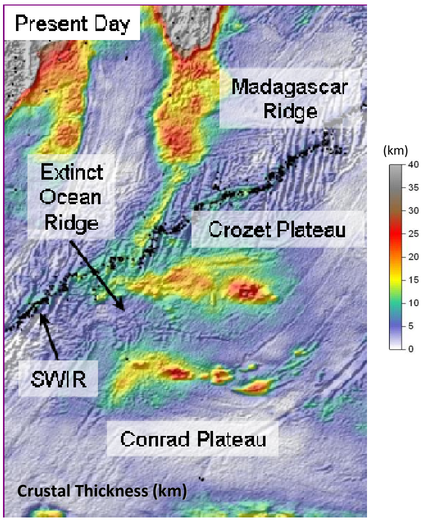

Figure 2 Present day crustal thickness from gravity inversion for the SW Indian Ocean showing magmatically thickened oceanic crust underlying Conrad Rise, Crozet Plateau and Madagascar Ridge. Sea-floor spreading on SWIR developed at ~ 55 Ma. An earlier now-extinct Late Cretaceous oceanic spreading centre can be seen between Conrad Plateau and Crozet Plateau. Early Cretaceous sea-floor spreading was located south of Conrad Rise immediately north of Antarctica.

Canaries and New England Sea Mounts. Plate restoration of the Central Atlantic shows that the intraplate magmatism of the New England Sea Mounts (Late Cretaceous) and the western Canaries (Neogene) align perfectly and also coincide with the northern limit of the West African craton. However this spatial alignment of intraplate magmatism of different ages is not consistent with a mantle plume or hot-spot track source.

Iceland. Crustal thickness mapping shows large crustal thicknesses (> 30 km) under SE Iceland extending offshore to the NE (Fig. 3) and consistent with SE Iceland being underlain by a southward continuation of the Jan Mayen micro-continent and geochemical evidence[5].

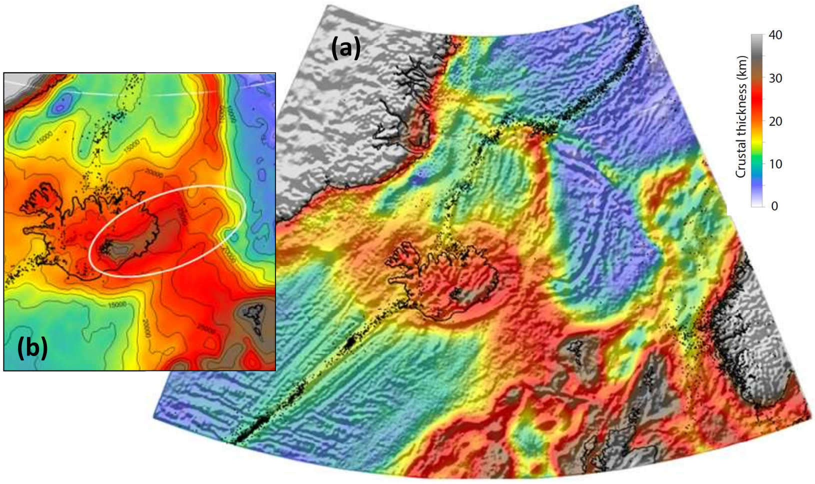

Figure 3 (a) Present day crustal thickness from gravity inversion for the NE Atlantic Ocean. (b) Higher resolution map of crustal thickness for E Iceland.

Important questions include:

(i) Why do some intra-oceanic regions show repeated rift/ridge jumps and hot spot magmatism? Are these plate re-organisations locally or globally driven?

(ii) Are these intra-oceanic regions underlain by lithosphere (or deeper tectosphere) with some continental compositional component?

(iii) Are these intra-ocean ridge jumps attracted by rheological weaknesses controlled by compositional or thermal anomalies (or both)?

(iv) Can these ocean ridge jumps (and hot spots) be explained by upper mantle chemical heterogeneity (water?) and thermal “weather” (+/- a few tens of ^{o}C)?

References

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