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The morphology, structure and geodynamic setting of extinct oceanic spreading centers

Sarah MacLeod, Simon Williams, Kara Matthews, Dietmar Müller, and Xiaodong Qin
EarthByte Group, School of Geosciences, University of Sydney, Australia (dietmar.muller@sydney.edu.au)

Numerous extinct spreading centers are found within the world's ocean basins, recording instances of spreading cessation or migration that provide valuable insights into the dynamics of changing plate boundary configurations through time. This study presents the first comprehensive review of all known extinct ridges and investigates their characteristics, regional distribution and tectonic settings as recorded in preserved oceanic crust. The axial morphology, gravity signal and crustal thickness of extinct ridges are evaluated by generating across-axis profiles through global datasets for individual ridge segments, and using gravity inversion to obtain crustal thickness estimates. We also compile spreading-rates, time of cessation and duration of spreading prior to spreading cessation. These data together with the relationship of extinct ridges to hotspots at their time of extinction is used to assess geodynamic influences on the lifespan and activity of mid-ocean ridges. While extinct ridges are found to be extremely variable in character along axis both within and between individual segments, most have relatively subdued axial morphology, expressed by bathymetric relief of around 900 m, with a large-standard deviation of 600 m. Negative gravity anomalies with a mean of 36 mGal are dominant at extinct ridge axes. Axial valleys of extinct ridges, usually flanked by ridges, have an average width of 36 km, with standard deviation (SD) of 14 km. The mean axial crustal thickness of extinct ridges is $\sim$6.5 km (SD 3.5 km), and extinct ridge axes are on average 1.3 km (SD 2.2 km) thinner than the rift flanks. Axial crustal thickness displays a strong dependence on the distance from hotspots at the time of extinction. Ridges in close proximity to hotspots at the time of spreading cessation have anomalously thick crust overall, yet proximity to hotspots is in some cases associated with a deeper axial valley, stronger negative gravity anomaly and larger variation in crustal thickness in the axial region. The characteristics of extinct ridges vary according to their type, in a similar way to the differences observed at active spreading centers. Extinct microplate ridges are predictably shorter-lived and have higher spreading rates before cessation. Back-arc basin ridges also have a shorter lifespan and thinner crust relative to large-scale mid-ocean ridges and microplate ridges. There is strong evidence for an interaction between hotspots and spreading centers prior to their cessation and many were found to be within 500 km of a hotspot at the time of their cessation. A strong relationship is found between the length of time that spreading ridges persist before extinction and distance they are from a hotspot. Ridges have longer durations of spreading at greater distances from hotspots, which provides good evidence for the theory of ridge 'capture' by focused upwellings at long-lived hotspots. Our analysis leads to the discovery of several previously unidentified structures in the south of the West Philippine Basin that likely represent extinct ridges and a possible extinct ridge in the western South Atlantic.