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Global Mapping of Oceanic and Continental Shelf Crustal Thickness and Ocean-Continent Transition Structure

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The 3D mapping of crustal thickness for continental shelves and oceanic crust, and the determination of ocean-continent transition (OCT) structure and continent-ocean boundary (COB) location, represents a substantial challenge. Geophysical inversion of satellite derived free-air gravity anomaly data incorporating a lithosphere thermal anomaly correction (Chappell & Kusznir, 2008) now provides a useful and reliable methodology for mapping crustal thickness in the marine domain. Using this we have produced the first comprehensive maps of global crustal thickness for oceanic and continental shelf regions.
Maps of crustal thickness and continental lithosphere thinning factor from gravity inversion may be used to determine the distribution of oceanic lithosphere, micro-continents and oceanic plateaux including for the inaccessible polar regions (e.g. Arctic Ocean, Alvey et al.,2008). The gravity inversion method provides a prediction of continent-ocean boundary location which is independent of ocean magnetic anomaly and isochron interpretation.
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. By restoring crustal thickness & continental lithosphere thinning to their initial post-breakup configuration we show the geometry and segmentation of the rifted continental margins at their time of breakup, together with the location of highly-stretched failed breakup basins and rifted micro-continents.
For detailed analysis to constrain OCT structure, margin type (i.e. magma poor, “normal” or magma rich) and COB location, a suite of quantitative analytical methods may be used which include:
(i) Crustal cross-sections showing Moho depth and crustal basement thickness from gravity inversion.
(ii) Residual depth anomaly (RDA) analysis which is used to investigate OCT bathymetric anomalies with respect to expected oceanic values. This includes flexural backstripping to produce bathymetry corrected for sediment loading.
(iii) Subsidence analysis which is used to determine the distribution of continental lithosphere thinning.
(iv) Joint inversion of time-domain deep seismic reflection and gravity anomaly data which is used to determine lateral variations in crustal basement density and velocity across the OCT, and to validate deep seismic reflection interpretations of Moho depth.
The combined interpretation of these independent quantitative measurements is used to determine crustal thickness and composition across the ocean-continent-transition. This integrated approach has been validated on the Iberian margin where ODP drilling provides ground-truth of ocean-continent-transition crustal structure, continent-ocean-boundary location and magmatic type.