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Slip on serpentine detachments at magma-poor margins

Timothy Reston (1), Gael Lymer (1), Derren Cresswell (1), Carl Stevenson (1), Jonathan Bull (2), Dale Sawyer (3), Julia Morgan (3), Galicia 3D working group (3,4,5)

(1) University of Birmingham, Geography, Earth and Environmental Sciences, Birmingham, United Kingdom (t.j.reston@bham.ac.uk), (2) University of Southampton, Ocean and Earth Science, National Oceanography Centre Southampton, Southampton SO14 3ZH, UK, (3) Rice University, Department of Earth Science, Houston, Texas 77005, USA, (4) Lamont-Doherty Earth Observatory, Columbia University, New York, (5) Institute of Marine Sciences, Barcelona, Spain

At magma-poor margins, the structures formed during rifting are not obscured by thick lavas, allowing detailed analysis of the tectonics of rifting and breakup. At most of these margins, the mantle beneath the thin crust has unusually low velocities, interpreted as a consequence of serpentinization following the embrittlement of the crust during rifting; models for the onset of serpentinization predict the thicknesses of crust that are observed at the landward limit of the serpentinized mantle.

At a handful of margins the top of the serpentinized mantle appears to have acted as a detachment or decollement: faults that bound the overlying crustal blocks root on a bright reflection at the base of these blocks. Examples include the P reflection west of Ireland, the H reflection west of northern Portugal, and the S reflector west of Galicia. Corrugations observed on a 3D volume collected in 2013 above the S reflector strongly support its interpretation as a slip surface.

A remaining question is whether slip on these “serpentine detachments” occurred at low-angle or not: for typical friction coefficients of $\sim$0.7, normal faults should lock-up and be replaced by steeper faults once they have rotated to perhaps 35°, an observation consistent with earthquake data. This angle can be reduced to 20-25° if the fault zone is composed of weak minerals such as serpentine. One possibility is that the detachment is actually composed of segments of faults that were active sequentially in a rolling hinge model. Beneath the centre of the Porcupine basin, the P reflection is sub-horizontal but its western continuation dips beneath the Porcupine bank at 20-25°, consistent with slip on serpentine-weakened rolling hinge system.

West of Galicia, based on the geometrical relationships between late synrift wedges and their bounding faults which root on S, S has been interpreted to have slipped at angles below 20-25°. However, a 3D dataset collected over S in 2013 provides the opportunity to examine in detail the geometries of the synrift and so determine whether these were indeed deposited during slip on the adjacent fault or perhaps during flexural rotation of the footwall during slip on a fault further oceanward. The analysis shows that the relationship between synrift sedimentation and faulting is highly complex and may be consistent with a rolling hinge model, albeit one in which the root zone was active at the low-angles predicted by the presence of weak serpentinites.