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Volcanic passive margin of Norway

Is analogue modelling helpful?

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Continental break-up above an anomalously hot mantle may lead to the development of volcanic margins. These margins are characterized by thick seaward dipping lava flow sequences, central intrusive complexes associated with dyke swarms parallel to the coast, and high seismic velocity bodies in the lower crust attributable to magma underplating.

In the case of the Norwegian volcanic margin, deep seismic evidences suggest that the geometry, the segmentation, and many sub-basins of the Norway margins are most probably strongly controlled by the presence of low viscosity discontinuities in the lower crust and sub-Moho mantle, resulting from Caledonian tectonic history, rather than by the direction of regional extension. These tectonic discontinuities are not necessarily oriented perpendicular to the current stretching direction. According to their angle of obliquity, various configurations of oblique rifting and/or strain partitioning can develop.

Where discontinuities are located in the sub-Moho mantle, the response of the overlying crust depends on coupling between the lithospheric mantle and the upper brittle crust through the ductile lower crust. These discontinuities define low-strength zones that would localize tectonic strain and locate continental break-up.

We present, here, a set of scaled experiments designed to study how such localised rheological heterogeneities have a mechanical effect on continental break-up. Models are constructed using 2 layers of sand and 2 layers of silicone putties representing the brittle and ductile layers of the crust and mantle respectively. Zones of low resistance are simulated by low-viscosity silicone putty emplaced within the brittle material.

Expression of the deformation depends of the depth at which low viscosity bodies are emplacing in the model. “Sub-Moho” emplacements interrupt the high strength “mantle” and contribute to a strong strain localization. “Lower crust” emplacement locally decreases the ductile strength, of this layer, and consequently modifies the coupling between the “upper brittle crust” and the high strength “mantle”. Moreover, “volcanic flows” at the surface contribute to temporarily increase the thickness, thus the strength, of the upper crust. Here again, brittle-ductile coupling at lithosphere scale is affected.