Geophysical Research Abstracts
Vol. 15, EGU2013-3434, 2013
EGU General Assembly 2013
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Cenozoic Transient Convective Uplift of the North Atlantic European Margin

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Given that the Rayleigh number of the convecting mantle is 10^6 to 10^8, instabilities should occur over a range of length and time scales (100–1000 km, 0.1–100 Myr). Tomographic measurements of seismic wave velocities in the mantle, long wavelength gravity observations, surface elevation and the geochemical signature of volcanism can be used to reveal the existence of convective upwellings. Beneath the North Atlantic Ocean, there is evidence to suggest that the region has been affected, for the last 60 Myr, by the presence of an upwelling plume, which is currently centred beneath Iceland. Short-lived (i.e. $<$ 1 Myr) variations in temperature of 10–100 °C are inferred from the pattern of bathymetry and short wavelength gravity south of Iceland, where a series of V-shaped ridges occur. These temperature variations should give rise to an associated variation in dynamic support of the overlying plate and result in vertical motion of the surface over timescales of $<$ 1 Myr.

Interpretation of 3D seismic reflection data from the Faroe Shetland Basin, a Cenozoic sedimentary basin located 200 km north of the British Isles, has revealed a spectacular terrestrial unconformity dated at $\sim$55 Ma, today buried under up to 2 km of sediment in water depths of up to 1km. The existence of this unconformity indicates that the basin underwent up to 1 km of uplift in 1 Myr followed by subsidence of 1 km in 1 Myr. There is also evidence for magmatic and volcanic activity in the basin at these times. These vertical motions can be attributed to the passage of a thermal plume transient beneath the basin. Inversion of longitudinal river profiles which drained this sub-aerial landscape allows a detailed history of uplift to be calculated. This uplift history reveals that the basin was uplifted in three stages with maximum uplift rates of 3 km Myr^{-1}. Therefore, the plume transient must have had a complicated thermal and/or chemical structure. Evidence for heterogeneity in the mantle over these short scales has not been observed in the sedimentary record before, however, it is supported by the composite nature of the V-shaped ridges. The presence of $\sim$58 Ma, $\sim$55 Ma and $\sim$50 Ma unconformities within the Faroe Shetland Basin suggests that this basin was affected by the passage of multiple plume transients during Paleogene times.