Geophysical Research Abstracts
Vol. 12, EGU2010-10764, 2010
EGU General Assembly 2010

Paleogene uplift of the UK and surrounding continental shelf: The case for magmatic underplating

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Recent work has made an evidential case for the involvement of tectonic shortening in the uplift of the UK during the Paleogene which appears to contradict earlier studies which emphasised the role of magmatic underplating associated with the volcanic activity at the surface.
Magmatic underplating is an attractive explanation for epeirogenic uplift, particularly along magmatic continental margins, because the intrusion and cooling of magma in the lithosphere lowers its overall density. This must result in uplift, or the suppression of subsidence in regions where extension is occurring. Its effects are also permanent. However, one of the major issues with underplating is unequivocally demonstrating its presence and age when it is postulated to be largely trapped at the density barrier at the base of the crust. Two recent studies and ongoing work using wide-angle seismic data and local earthquake tomography from the UK have been used to address both these issues. Firstly, a compilation and 3-D extrapolation of wide-angle data has been used to identify an area of anomalously high seismic p-wave velocities in the lower crust beneath North Wales and NW England. This region has all the characteristics of the areas of postulated magmatic underplate along the North-East Atlantic margins and lies beneath known Paleogene volcanic rocks in North Wales. The wide-angle model for the crust has been validated by 3-D modelling of the gravity anomaly. The distribution of the wide-angle seismic data limits knowledge of its distribution in 3-D. This has been addressed through the application of 3-D local earthquake tomography which has been used to build a high (10 x 10 x 2 km) resolution model of the crust and uppermost mantle beneath England and Wales. This model reveals the full irregular intrusive shape and extent of the high velocity rocks in the lower crust. Crucially, it shows that the underplate crosses known Caledonian terrane boundaries and is therefore younger than these features. It also correlates closely with areas of Cenozoic exhumation. In combination with the evidence from surface geology the seismic data suggests modification of the crust by high density, high seismic velocity rock, for which the most consistent explanation is solidified mafic magma. The high density of this material, as derived from the 3-D gravity modelling, limits the amount of uplift and hence exhumation this underplating can be responsible for. The underplate cannot be the sole cause of the widespread exhumation of up to 2 km as previously suggested but could be responsible for the discrepancy between the amount of exhumation demonstrated by the studies of tectonics and the overall distribution of exhumation constrained as Paleogene in age. Unless it can been demonstrated that the underplate is of variable age it cannot be invoked to explain Neogene or younger uplift and alternative explanations for this must be tested by observation.