Geophysical Research Abstracts, Vol. 7, 03646, 2005
SRef-ID: 1607-7962/gra/EGU05-A-03646

Late Miocene Magmatic Underplating of Oceanic Crust at the Outer Vøring Margin, Norway, Euromargins 2003 OBS Experiment

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The Vøring margin off mid-Norway is a volcanic passive margin where large volumes of igneous rocks were emplaced during the breakup of the Norwegian-Greenland Sea during the earliest Eocene, also underplating the continental crust. In 2003, an ocean bottom seismometer/hydrophone survey was acquired on the Vøring and Lofoten margins. One profile crosses the Vøring Plateau and continues to a bathymetric high northeast of the East Jan Mayen Fracture Zone (EJMFZ). The P-wave data were modeled by a combined forward ray-tracing and inversion procedure, giving a 2D velocity model. The model shows a rapid transition from continental to oceanic crust (COT) located under the zone of seaward dipping reflectors, similar to earlier results. Maximum igneous crustal thickness was found to be 17.5 km, 5 km less than found by previous studies nearby. From the COT the igneous crustal thickness decreases from 17.5 to 9 km over a distance of 90 km, indicating abating magmatism over $\sim$3.5 m.y. after continental breakup. West of that, the bathymetric high is supported by increased (12-15 km) crustal thickness. P-wave velocity is well constrained to be 7-7.25 km s^{-1} in the lower crust under the high, indicating a gabbroic composition. The sedimentary pattern over the high seen on recent multi-channel reflection seismic profiles shows that the high is not a primary feature, but was created through later uplift. As no compression can be seen, the only viable explanation is an increase in crustal thickness by later magmatic underplating. The inversion is related to a prominent unconformity that can be followed over a 400 km long and 200 km wide area NNE of the high, up to oceanic crust of Middle Eocene age. While the deep ocean unconformity cannot be followed onto the margin due to lack of the appropriate sedimentary layers, a Middle Miocene unconformity followed by Late Miocene compression and domal formation on the shelf suggest that the underplating event affected the margin as well. Thus, a possible dual underplating history at the outer Vøring margin challenges the hypothesis that ridge-push forces is the main source for compression and inversion on the shelf, which has implications for the hydrocarbon exploration of the area. A model based on interaction between the Aegir Ridge and the Iceland hot-spot is proposed to explain the observed Late Miocene magmatic underplating. V-shaped lineations seen in the satellite gravity field around the Aegir Ridge SSW of the bathymetric high indicate NE migrating asthenosphere zones with increased melt production under the Aegir Ridge. Due to low magnetic track coverage, the EJMFZ was reinterpreted from the satellite gravity field. Using this to re-evaluate the spreading history of the Norway Basin, the revised synthetic flowlines show that the V-shaped lineations are reasonably symmetric with respect to spreading direction, even if they are not symmetric with respect to the ridge trend. Estimated asthenospheric transport velocities along the Aegir Ridge range typically from 0.23 to 0.39 cm/a for the Paleogene. Partially melted asthenosphere created by decompression melting under the Aegir Ridge was transported northeastwards when spreading in the Norway Basin ceased, and released through episodic ascent northeast of the EJMFZ. There is, however, a need to speed up the transport in the Neogene (to 2-2.5 cm/a) to cover the distance during the available time, which is comparable to observations on the Kolbeinsey Ridge north of Iceland for the same time period.