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Lateral segmentation of the Lofoten-Vesterålen Margin, Northern Norway: insights from 3-D digital geological models

R.W. Wilson (1), J. Imber (1), K.J.W McCaffrey(1,2), R.E. Holdsworth (1,2), R.R. Jones (1,2), A. Welbon (3) & D. Roberts (4)

(1) Reactivation Research Group, Department of Earth Sciences, University of Durham, Durham, UK, (2) Geospatial Research Ltd., University of Durham, Durham, UK, (3) Statoil ASA, Norway, (4) Geological Survey of Norway, N-7491 Trondheim, Norway. (robert.wilson@durham.ac.uk)

It is well documented that transfer zones are commonly associated with complex fault patterns on extensional margins. In this study we show that in many cases it is also the bounding structures within margin segments – and their orientation relative to the regional extension vector – that control fault complexity along segmented continental margins.

The Norwegian Continental Margin is divided into four segments (the Møre, Vøring, Lofoten-Vesterålen and West Barents Sea margins) by three NW-trending crustal lineaments (Jan Mayen, Bivrost and Senja Fracture Zones). These lineaments define major changes in the overall structure of the margin, and are often characterized by complex fault zones. Lateral segmentation can also be seen *within* each margin segment in the form of changes in fault polarity, ridge trend, or structural complexity. At this smaller scale, the margin segments themselves are often characterized by complex fault patterns. These variations may reflect differences in obliquity of the segment bounding fault relative to the regional extension vector. Here we investigate this hypothesis along the Lofoten-Vesterålen archipelago (LVA), a basement high showing distinct lateral variations in trend.

The LVA provides a unique opportunity on the Norwegian Margin to study structural variations in both offshore sediments and onshore crystalline basement. Regional lineament patterns, mapped from Landsat imagery, show NNE-SSW and ENE-WSW

preferred orientations, with subsidiary NW-SE, NE-SW and E-W trends. Analysis of these lineament patterns using GIS reveals that the LVA can be sub-divided laterally into a series of distinct lineament domains (North-Lofoten, South-Lofoten, and Inner- & Outer-Vesterålen domains). These domains are coincident with changes in ridge trend, and with previously documented variations in regional gravity and magnetics, denudation ages and offshore fault patterns.

Detailed field mapping and offshore seismic studies have been carried out in the North Lofoten domain (NLD). The NLD is highly oblique to the regional structural trend. Digital field mapping reveals similar fault orientations to lineament studies. Faulting is dominated by dip-slip and oblique-slip movements associated with WNW to NNW extension, confirmed by palaeostress inversion. We propose two possible end-member hypotheses to explain the development of these structures: 1) a *quadrimodal fault model* and 2) a *two phase fault model*. In the former all faults develop simultaneously within a 3D strain field, while in the latter, faults form during two separate events (WNW extension followed by NNW extension). Cross-cutting relationships indicate that the dominant NNE- and ENE-trending faults were active at same time; however the NNE faults show late strike-slip reactivation. These relationships, together with observations of regional onshore and offshore structural patterns, suggest that the faults developed in a 3D strain field during oblique (WNW to NW) extension. Minor fault reactivation during subsequent NNW extension is also likely.