



# Combining field work with isotopic and geochemical laboratory data to reveal tectonic evolution on land and off shore.

## Examples from PEGG at the Department of Geosciences, UiO.

### The Palaeozoic evolution of the Embla Oil Field and the North Sea

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#### Background: North Sea region

The North Sea is positioned on the junction of three continental plates, Avalonia, Baltica and Laurentia, juxtaposed during the Caledonian orogeny. The area has a complex structural and tectono-magmatic post-Caledonian history. The presence of large quantities of hydrocarbons in the North Sea fuels industry interest in research in the region.

The Embla project aims to increase our understanding of the regional and local geological evolution by studying core rocks from the Embla Oil Field on the northern flank of the Mid North Sea High, and by field work on Palaeozoic rocks exposed on Orkney, Scotland, in collaboration with ConocoPhillips.

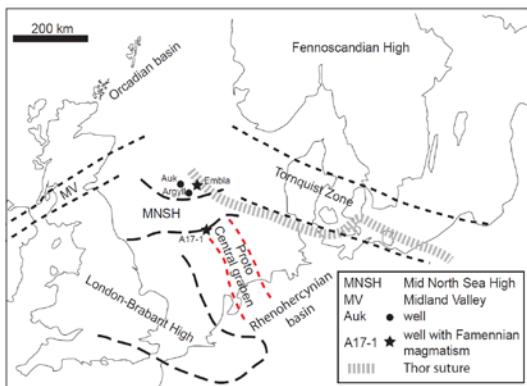


Figure 1. Simplified map of the North Sea area with Palaeozoic structural elements (adapted from Marshall et al. 1996). The Embla Field and well A17-1 lie on opposite flanks of the Mid North Sea High in the extension of the proposed Proto-Central Graben (Ziegler 1990).

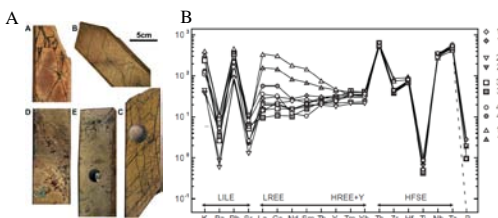


Figure 2A. Quartz porphyries in Embla wells. B) Increasing element mobility with increasing ionic potential (to the left) demonstrate open system alteration; the immobile HFSE constrain the protoliths to intraplate alkali rhyolites, a rock type typically associated with rifting.

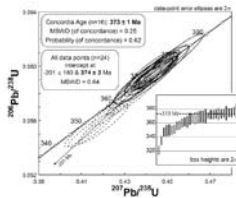


Figure 3. Concordia diagram with LA-MS-ICPMS zircon U-Pb analyses yield an upper intercept at  $374 \pm 3$  Ma. Inset shows  $^{206}\text{Pb}/^{238}\text{U}$  ages. The data represent the first concrete evidence of late Devonian rifting across the MNSH.

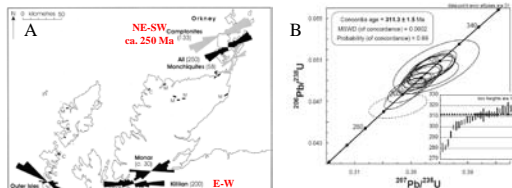


Figure 4A. The Scottish lamprophyre dyke swarms form three groups with distinct strike directions (shown as rose diagrams on map). K-Ar ages are shown in red. Adapted from Upton et al. (2004). B) Re-dating of the Orkney dyke swarm by LA-MS-ICPMS zircon U-Pb analyses yield an age of  $311 \pm 2$  Ma. Inset shows  $^{206}\text{Pb}/^{238}\text{U}$  ages.

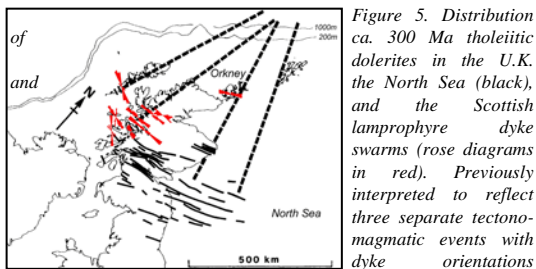


Figure 5. Distribution of ca. 300 Ma tholeiitic dolerites in the U.K. and the North Sea (black), and the Scottish lamprophyre dyke swarms (rose diagrams in red). Previously interpreted to reflect three separate tectono-magmatic events with dyke orientations controlled by basement grains, we interpret the lamprophyre dyke swarms as the 311 Ma early response to Permo-Carboniferous rifting in the North Sea. Adapted from Smythe et al. (1995).

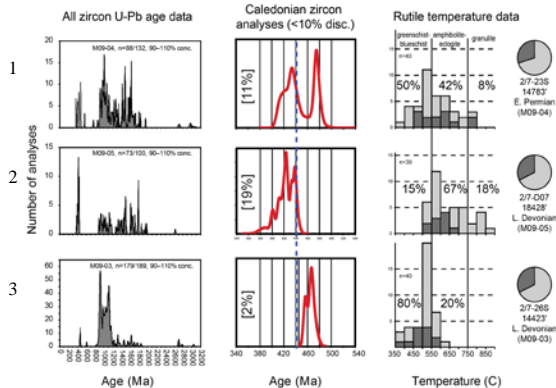


Figure 6. Zircon U-Pb LA-MC-ICPMS age data and rutile trace elements from microprobe analyses at Oslo University can be used to constrain the source (-s) of sediments in the North Sea. Samples nr 2 and 3 represent two groups of late Devonian sediments with different provenance signatures. The signature of nr 3 matches Dalradian sediments in Scotland, and the signature of nr 2 indicates a source region partly sampling the east Greenland Caledonides. Sample nr 1 is an early Permian sediment in the Embla Field that yield ages and rutile temperature data suggestive of erosion and mixing of the late Devonian sediments.

#### References

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