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Modelling the role of magmatic intrusions in the post-breakup thermal evolution of Volcanic Passive Margins

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Passive margins are produced by continental breakup and subsequent seafloor spreading, leaving a transition from continental to oceanic crust. Magmatism is associated with many passive margins and produces diagnostic criteria that include 1) abundant breakup related magmatism resulting in a thick igneous crust, 2) a high velocity zone in the lower crust and 3) seaward dipping reflectors (SDRs) in seismic studies. These Volcanic Passive Margins (VPMs) represent around 75% of the Atlantic passive margins, but beyond this high level description, these magma-rich settings remain poorly understood and present numerous challenges to petroleum exploration.

In VPMs the extent to which the volume, timing, location and emplacement history of magma has played a role in controlling heat flow and thermal evolution during margin development remains poorly constrained. Reasons for this include; 1) paucity of direct heat flow and thermal gradient measurements at adequate depth ranges across the margins, 2) poor onshore exposure 3) highly eroded flood basalts and 4) poor seismic imaging beneath thick offshore basalt sequences. As a result, accurately modelling the thermal history of the basins located on VPMs is challenging, despite the obvious importance for determining the maturation history of potential source rocks in these settings.

Magmatism appears to have affected the thermal history of the Vøring Basin on the Norwegian VPM, in contrast the effects on the Faeroe-Shetland Basin was minimal. The more localised effects in the Faeroe-Shetland Basin compared to Vøring Basin may be explained by the fact that the main reservoir sandstones appear to be synchronous with thermal uplift along the basin margin and pulsed volcanism, indicating that the bulk of the magmatism occurred at the basin extremities in the Faeroe-Shetland Basin, where its effect on source maturation was lessened. Our hypothesis is that source maturation occurs as a result of regional temperature and pressure increases, and the effects of even a large singular magmatic event are small beyond the immediate vicinity, therefore quantifying cumulative regional heat flow is of utmost importance.

The apparently complex relationships between source rock maturation and magmatism are not limited to the north-east Atlantic margins. Other VPMs of interest include the regions between West Greenland and Eastern Canada (Labrador Sea, Davis Strait and Baffin Bay), East Greenland, NW Australia, Western India and segments of the Western African and Eastern South American margins.

This project utilises 1D numerical modelling of magmatic intrusions into a sedimentary column to gain an understanding into the thermal influence of post-breakup magmatic activity on source rock maturation in representative VPMs. Considerations include the timing, periodicity of intrusions, thickness, spacing and background heat in the basin.