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Paleo-depth of hydrothermal venting along the Mid-Norwegian volcanic margin during Paleogene continental breakup

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Volcanic rifted margins commonly form in association with the emplacement of Large Igneous Provinces. The intense associated volcanic activity coincides with shifts in the global carbon cycle and rapid climate change during several key geological periods and crises. The Mid-Norwegian and NE-Greenland conjugate rifted margins formed after late Paleocene to early Eocene continental breakup in association with the emplacement of the North Atlantic Igneous Province (NAIP). The NAIP and early opening of the North Atlantic occurred contemporaneous to a rapid 5-6 °C global warming episode known as the Paleocene Eocene Thermal Maximum (PETM). The rapid global warming documented during the PETM is hypothesized to result from the release of thermogenic gases into the atmosphere through thousands of hydrothermal vents. The gases were generated by contact metamorphism of carbon-rich sediments during the extensive sill emplacement from the NAIP. The potential climatic impact of these hydrothermally released greenhouse gases is dependent on the water depth at which they were released. Unless it is released in a shallow marine environment most methane, known for its significantly greater global warming potential compared to carbon dioxide, will be oxidized and dissolved in the ocean before it reaches the atmosphere.

First results of IODP Expedition 396 conducted on the Mid-Norwegian volcanic margin have documented the shallow marine to potentially sub-aerial setting of at least one of the hydrothermal vents (i.e. Modgunn vent). However, a comprehensive regional assessment of the water depth at which hydrothermal venting occurred remains necessary to validate the overall impact on paleoclimate and the PETM. To do so, we apply 3D flexural-backstripping and decompaction to remove the loading effects of sedimentary sequences and determine the sediment-corrected bathymetry down to the top Palaeocene surface at which most of the vents are mapped. Reverse subsidence cannot be directly modelled without knowing the detailed distribution of syn- and post-rift thermal subsidence from Cretaceous and Paleocene rifting as well

as any mantle plume dynamic uplift during NAIP emplacement. Because these tectonic and geodynamic components of subsidence cannot be deterministically predicted at the required accuracy, we use local palaeobathymetric constraints from seismic observations and drilled biostratigraphic data, combined with our flexural backstripping and decompaction results to calibrate palaeobathymetric variations of the Paleocene venting surface at the time of the PETM.

Our results predict that hydrothermal venting occurred within a range of palaeo-water depths showing the complex palaeo-structure of the top Paleocene surface. Key post-Paleocene tectonic influences such as a well-documented Miocene doming episode influence the margin history, and hence, at this location, our palaeobathymetric results represent shallowest estimates and must be interpreted with caution. However, most of the vents (>80%) restore to bathymetries shallower than 500 meters, i.e., in sub-aerial to shallow marine conditions. Our work aims to confirm and extend initial results of IODP Expedition 396 from the Modgunn vent. Shallow water-depth hydrothermal venting most likely occurred during magma-rich continental breakup and NAIP emplacement; a large part of the released hydrogenic gas could have directly contributed to the global warming recorded by the PETM.