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Voluminous Production of Greenhouse Gases in the Vøring Basin Caused by Intrusive Magmatism at the Paleocene-Eocene Boundary: A Case Study of the Utgard High

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A large igneous sill complex was emplaced in the Vøring and Møre basins offshore mid-Norway during the Paleogene. Detailed 2D and 3D seismic mapping shows that the areal extent of the sill complex is greater than 80,000 km2. The sills mainly intrude clastic sedimentary sequences of Cretaceous age. Sub-sill imaging is commonly difficult, but several layers of sills can be interpreted with confidence in most areas. Individual sills have estimated thicknesses between 50 and 150 m. We have mapped more than 700 hydrothermal vent complexes connecting the sill complexes with the paleosurface. In total, more than 2000 hydrothermal vent complexes are present in the basins. One well, 6607/5-2, has sampled thick sills in the basins. It was drilled in 1991 on the Utgard High, and penetrated an upper 92 m thick sill and a lower >42 m thick sill emplaced in Upper Cretaceous sediments. We have done detailed geochemical and geochronological analyzes of cuttings from the well. Zircon U-Pb dating of the two dolerites gives ages of 55.6 $\pm$ 0.3 and 56.3 $\pm$ 0.4 Ma of the upper and lower sill, respectively. Vitrinte reflectance (45 samples) and total organic carbon content (31 samples) measurements show that the sills have heated the host rock into the gas window in a more than 1 km thick interval. These results are consistent with numerical simulations of the temperature history of two simultaneously emplaced sills at the same stratigraphic levels as the Utgard High sills. From the borehole data we find that a large volume of carbon has been lost due to contact metamorphism. Gas data from the drilling show an increase in methane concentration towards the sill contacts, suggesting that the aureole gases are still present in the basin. Petrography shows that muscovite and chlorite are the main metamorphic minerals in the aureoles, with a host rock porosity of 5-15 %. The Utgard High case study shows that huge volumes of carbon gases are potentially formed by contact metamorphism during emplacement of sill intrusions in organic-rich sedimentary basins. The zircon U-Pb ages overlap within errors with the timing of the Paleocene-Eocene Thermal Maximum (PETM). These observations are consistent with the hypothesis that sill intrusions in the northeast Atlantic triggered global warming in the earliest Eocene.