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Thermogenic degassing of methane during the PETM: Geochemical and palynological constrains from a borehole in the Norwegian Sea

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Emplacement of voluminous magmatic sills in sedimentary basins around the NE Atlantic led to widespread thermogenic gas generation in contact aureoles. Kilometer-sized degassing pipes and craters, termed hydrothermal vent complexes, are identified on seismic data and believed to have played a key role in releasing methane to the atmosphere and thus triggering of the Paleocene-Eocene Thermal Maximum (PETM). However, the link between pipe degassing and the PETM is questioned due to lack of accurate time constraints on degassing and crater formation. We present new geochemical and palynological data from a 3521 m deep petroleum exploration well, 6607/12-1, drilled through the center of a hydrothermal vent complex in the Vøring basin, the Norwegian Sea. We have undertaken a comprehensive sampling and analytical program of the cuttings from the well to study the age, formation and implications of the hydrothermal vent complex from this unique locality. Based on our results, we have divided the hydrothermal vent complex in four main zones: 1) a high temperature lower conduit (3521-2100 m), 2) an upper conduit (2100-1725 m), 3) crater deposits (1725-1590 m), and 4) seep carbonates (1510-1380 m). The crater is identified as a 2 km wide semi-circular eye-structure on the seismic data, characterized by low seismic velocities (Vp < 1.8 km/s) and high neutron porosities (>45%). The palynomorphs in the upper conduit have a high Thermal Alteration Index, suggesting heating from ascending fluids. At the base of the crater, the PETM dinocyst marker species Apectodinium augustum is present, thermally altered at the base but immature up-section. This can be explained by ejecta deposits at the base or by a final stage of hydrothermal activity. Carbon isotope analyses on palynomorph fractions shows that the PETM negative carbon isotope excursion (CIE) is present in the 1745-1665 m interval. The core of the PETM CIE is preserved at 1745-1720 m and the recovery stage from 1720-1665 m. The new data shows that the hydrothermal vent complex was formed during the early stage of the PETM and thus corroborates the hypothesis that continued thermogenic degassing was a key player in carbon cycle perturbations that characterize the PETM.