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Hydrothermal vent complexes acting as preferential fluid migration pathway: a comparative study of the NE Atlantic and Indonesia

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Hydrothermal vent complexes are common in volcanic sedimentary basins world-wide. The vent complexes have commonly formed in sedimentary basins affected by large igneous provinces due to widespread sill emplacement into organic-rich shales, which caused devolatilization in sill aureoles. The activity of these vents could have contributed to trigger drastic climate changes and extinction events through the Earth history. Continental break-up of the NE Atlantic during the Paleocene to earliest Eocene led to the formation of thousands of hydrothermal vent complexes ultimately leading to the rapid climate changes of the Paleocene-Eocene Thermal Maximum (PETM). Thousands of these hydrothermal vents are scattered within the Møre and Vøring basins where sills and connected vertical conduits are identified respectively as high amplitude reflections and chaotic reflection zones. The north east Java sedimentary basin comprises potential modern analogues for fluid flow-related structures triggered by hydrothermal activity. The spectacular Lusi eruption, ongoing in north east Java since 2006, represents a unique modern analogue of the hydrothermal vent complexes from the geological past. Lusi is fueled by magmatic intrusions and hydrothermal fluids migrating from 4.5 km depth from the neighboring Arjuno-Welirang volcanic complex. Less than 10 km away from Lusi is the buried Porong structure. This kilometers-scaled vent is interpreted as the evidence of a similar palaeo hydrothermal vent activity characterizing the area. Here we present a comparative study of these vent complexes based on 2D and 3D seismic data offshore Norway and onshore Indonesia. The key features that characterize these hydrothermal vent systems are analyzed and compared within a broad context to investigate the mechanisms of fluids migration. The analyzed hydrothermal vents are characterized by distinctive eye-shaped geometries in the upper part, consisting of craters or depressions with mound-like geometries above. The conduits between the sills and the vents are characterized by disrupted seismic reflections and surrounded by inward dipping reflections. The shallow amplitude anomalies are interpreted to be caused by gas due to their vertically clustered geometries, the ‘soft’ nature of some of the anomalies, and the widespread occurrence of gas in the basin. Mounds suggest that sediments were later remobilized due to fluid flow. These features occur directly above the vents, suggesting that fluids migrated preferentially through the underlying hydrothermal vent complexes. The interpreted fluid flow features show the importance of hydrothermal vent complexes for fluid overpressure development in basins and for potential migration of hydrocarbons from deep structures to shallow reservoirs. The shallow seismic anomalies furthermore suggest that the vent complexes have been reused for focused fluid flow for millions of years after their initial formation.