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Evidence from 3D seismic tomography for hydrate accumulation in a fluid-escape chimney in the Nyegga area on the Vøring plateau.

Andreia Plaza-Faverola (1,2), Graham Westbrook (3), Stephan Ker (2), Russell Exley (3,4), Audrey Gailler (3,5), Tim Minshull (6), and Karine Broto (7)

(1) Institute for Geology, University of Tromsø, Norway (andreia.a.faverola@uit.no), (2) Département Géosciences Marines, Ifremer, Plouzané, France., (3) School of Geography, Earth & Environmental Sciences, University of Birmingham, United Kingdom, (4) Fugro Multi Client Services (UK), Wallingford, Oxfordshire, United Kingdom, (5) Université Européenne de Bretagne, Brest, CNRS UMR6538, IUEM, Plouzané, France, (6) National Oceanography Centre Southampton, University of Southampton, United Kingdom, (7) IFP, Rueil-Malmaison, France

Vertical fluid-migration features in continental margins, so-called gas chimneys (fluid-escape chimneys), have become an important target of investigation because of their potential as major routes for the escape of methane to the ocean. One of these chimneys, associated with a pockmark in the seafloor at the Nyegga region, offshore Norway, was investigated with a 3D high-resolution seismic experiment. Reflection travel-times recorded by sixteen ocean bottom seismic recorders, located around the pockmark with a separation of approximately 100-m, were used for tomographic inversion to provide a detailed 3D P-wave velocity model. The chimney is about 500 m in diameter at its base. It is defined by stratal deformation, by Vp increasing towards its centre and by localized seismic attenuation. The tomography experiment shows that P-wave velocity within the hydrate stability zone inside the chimney is up to 300 m/s higher than Vp of the host sediment, which ranges from 1490 to 1700 m/s. The highest anomalous velocities appear in a zone of about 150 m above the top of a gas-rich layer. Unless carbonate has been preserved in layers at hundreds of meters beneath the present seafloor, the depth extent of the anomalous velocity zone makes it more likely to be explained by the occurrence of gas hydrates in the flanks and interior of the chimney. On the basis that a predominantly fracture-filling model is appropriate for the formation of hydrate in low-permeability sediment, the maximum hydrate concentration in the chimney is estimated to be 11% -27 % by total volume, depending on how host sediment properties are affected by hydrate formation. The doming of the strata penetrated by the chimney appears to be associated with the growth of hydrate. The chimney is inferred to have originated as a vigorous gas vent system, but at present it is likely to be dominated by the slow dissociation of hydrate in upwardly migrating pore-water.