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Azimuthal anisotropy at a natural fluid escape structure in the northern North Sea

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Securely storing the carbon dioxide within depleted oil and gas fields require a good knowledge of the distribution of fluid pathways within the overlying sediments. Shallow and young sediments contain up to 90% porosity, filled by sea water. During burial, the porosity of the sediments decreases. Chimney and pipe structures created by hydro-fracturing are used as pathways for vertical fluid migration. The longevity and the physical properties of these chimney/pipe structures, compared to their surroundings, remain poorly known.

In September 2017, to learn more about the structure and physical properties of gas-bearing sediments and the vertical fluid flow conduits associated with them, we carried out the NERC-funded CHIMNEY broad band seismic experiment (James Cook 152) around the Scanner pockmark in the northern North Sea. The Scanner pockmark is a natural active gas seepage zone located on top of a circular, diffuse seismic anomaly with bright zones indicating the presence of gas. We deployed 25 ocean bottom seismometers (OBS) within and around the Scanner pockmark. These instruments recorded shots from five different sources (Bolt airguns, GI-guns, and two different surface sparkers and a deep-towed sparker sources) offering a wide range of frequencies, along a survey designed to achieve multi-azimuth shot coverage.

Aligned vertical fractures are known to produce azimuthal anisotropy. Seismic anisotropy therefore offers a way of exploring the density and orientations of cracks, which are linked to the stress history and the physical properties of a region. We will first explore the azimuthal anisotropy within the Scanner pockmark and its surroundings using the particle motion of PS converted (C-) waves from GI gun-source recorded by the OBS network of CHIMNEY survey. Our multi-frequency dataset is recorded with a high sampling rate (4 kHz) and allows the identification of far-offset refraction phases as well as reflection phases from shallow sedimentary layers. The velocity of the sedimentary layers and their topography will be explored by a 3D tomographic inversion and the resulting structure will be used to approach the anisotropic parameters of the medium. We expect to observe variations between anisotropic properties of the layered sediments of North Sea and the Scanner pockmark affected by vertical conduits for fluid flow.