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Fracture characterisation using frequency-dependent shear-wave splitting analysis of azimuthal anisotropy: application to fluid flow pathways at the Scanner Pockmark area, North Sea

Adam Robinson¹, Gaye Bayracki^{1,2}, Calum MacDonald³, Ben Callow¹, Giuseppe Provenzano¹, Timothy Minshull¹, Mark Chapman³, Timothy Henstock¹, and Jonathan Bull¹

¹Ocean and Earth Science, University of Southampton, National Oceanography Centre Southampton, SO14 3ZH, U.K

²National Oceanography Centre Southampton, Southampton, SO14 3ZH, U.K.

³School of Geosciences, University of Edinburgh, EH9 3JW, U.K.

Scanner pockmark, located in the Witch Ground Graben region of the North Sea, is a ~900 m by 450 m, ~22 m-deep elliptical seafloor depression at which vigorous and persistent methane venting is observed. Previous studies here have indicated the presence of chimney structures which extend to depths of several hundred meters, and which may represent the pathways along which upwards fluid migration occurs. A proposed geometry for the crack networks associated with such chimney structures comprises a background pattern outside the chimney with unconnected vertical fractures preferentially aligned with the regional stress field, and a more connected, possibly concentric fracture system within the chimney. The measurement of seismic anisotropy using shear-wave splitting (SWS) allows the presence, orientation and density of subsurface fracture networks to be determined. If the proposed model for the fracture structure of a chimney feature is correct, we would expect, therefore, to be able to observe variations in the anisotropy measured inside and outside of the chimney.

Here we test this hypothesis, using observations of SWS recorded on ocean bottom seismographs (OBS), with the arrivals generated using two different air gun seismic sources with a frequency range of ~10-200 Hz. We apply a layer-stripping approach based on observations of SWS events and shallow subsurface structures mapped using additional geophysical data to progressively determine and correct for the orientations of anisotropy for individual layers. The resulting patterns are then interpreted in the context of the chimney structure as mapped using other geophysical data. By comparing observations both at the Scanner pockmark and at a nearby reference site, we aim to further contribute to the understanding of the structures and their role in governing fluid migration. Our interpretation will additionally be informed by combining the field observations with analogue laboratory measurements and new and existing rock physics models.

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