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Using shear-wave splitting to assess strong anisotropy in a shale-gas reservoir and its relation to lithology, texture and fractures

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Organic-rich shales represent an important energy resource, however they often have very low permeabilities due to there fine-grained, clay-rich composition, and require fractures to enhance gas production. Both the alignment of phyllosilicate minerals such as clays and the alignment of fractures and cracks are very effective means of producing seismic anisotropy. Thus the detection and characterisation of this anisotropy can be used to infer details about lithology, rock fabric and aligned crack properties within reservoirs, although care must be taken to distinguish their relative effects. We present a study characterising anisotropy using shear-wave splitting from microseismic sources in a highly anisotropic shale gas reservoir. We observe very strong shear-wave splitting (up to 30%) with a predominantly VTI anisotropic symmetry (vertical transverse isotropy), but with some evidence of an HTI (horizontal transverse isotropy) overprint due to a vertical fracture set striking parallel to the maximum compressive stress. We observe clear evidence of a shear-wave triplication due to anisotropy, which to our knowledge is one of only a very few observations of such triplications in field-scale data. We use modal proportions of minerals derived from X-ray fluorescence data combined with realistic textures to estimate the contribution of intrinsic anisotropy. Although much of the VTI anisotropy can be explained by the preferred orientation of clay minerals we find that an additional contribution from horizontal microcracks is required to produce the observed patterns of splitting. This has important implications for fracture treatments, as the geomechanical interplay between stimulated vertical fractures and these horizontal microcracks may be an important mechanism to facilitate gas flow.