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Deformation analysis and unsupervised fault facies classification of normal faults from the Snøhvit field, Barents Sea

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Seismic imaging of faults has been a topic of interest for decades. We apply fault seismic imaging techniques to a near partial stack, depth-converted seismic volume in the Snøhvit field, Barents Sea, Norway. The applied workflow includes data conditioning, analyses of fault throw, dip distortion, seismic attributes, fault enhancement facies and seismic amplitude. Data conditioning includes noise attenuation and amplitude normalization to remove the effects of gas clouds and a thick dolomite unit at the depth range of interest (2-3 km). Three major (> 100 m throw) E-W normal faults are present in the field, the southernmost fault dipping south, and the two northern faults dipping north. Fault throw distribution was generated using horizon interpretations of five Upper Triassic-Lower Cretaceous reflectors (top Fruholmen, top Fuglen, top Knurr, intra-Kolje, and top Kolje) and their fault cutoffs. Fault throw is higher (200-300 m) in the lower top Fruholmen and top Fuglen reflectors, and decreases up-section in the top Knurr to top Kolje reflectors, which are more folded. Dip distortion, a measure of fault-related deformation, shows fault zones ∼100-200 m thick in the lower top Fruholmen and top Fuglen reflectors, which are broader (∼500-600 m) but have less dip distortion in the more folded top Knurr and intra-Kolje reflectors. On the top Kolje reflector, dip distortion is low and barely defines the fault zones. Dip, tensor and semblance volume attributes show a similar fault network although with less detail. A color blend of these three attributes shows the fault structure with increasing detail. Fault enhancement (a measure of fault probability based on the color blend) exhibits the clearest fault bodies. Four middle-to-high range fault enhancement classes define unsupervised fault facies (USFF) that have high fault enhancement values (high deformation) towards the fault centers, and lower values (low deformation) towards the exterior of the fault bodies. Fault enhancement correlates with dip distortion. High fault enhancement values correlate with high fault throw, juxtaposed lithology and Shale Gouge Ratio (SGR). Seismic amplitude variations increase towards the fault, on both the hangingwall and footwall. The top Fuglen and Fruholmen horizons show the most severe increase in amplitude towards the fault plane and a sharp drop in seismic amplitude on the fault plane itself. Although fault throw, juxtaposed lithology and SGR correlate with fault enhancement and the USFF, it is impossible to draw a more direct linkage to lithology without a well transecting the fault plane directly. However, this integrated workflow allows a linkage to be established between fault architecture and seismic characteristics, which can provide a better and more direct input to reservoir models.