Structural Styles in the Gullfaks Field, Northern North Sea: Insights from Attribute Assisted Seismic Interpretation

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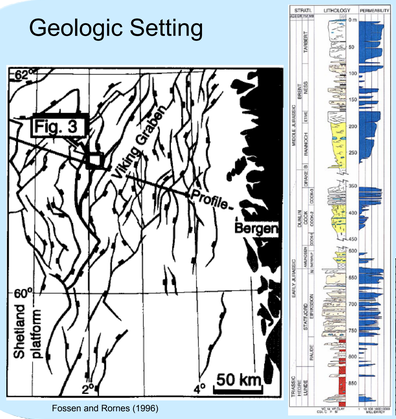
Abstract

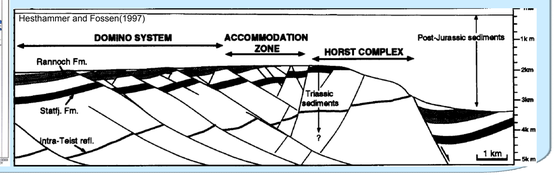
An integrated study of seismic attributes provides useful information in interpreting faults that are close to seismic resolution. Reservoirs with thin bed units separated by impermeable shale or with thicker sandstone units are affected dramatically by faults that decrease permeability. This has posed a serious challenge to produce more accurate and detailed structural maps. For this purpose seismic attribute maps have become the focus of interest of geoscientists in the recent years. With the increase of interest the chances of erroneous interpretation also increase unless the interpreter is extremely careful about the geologic setting and the quality of the seismic data. It has become a common understanding that no single seismic attribute can produce the whole picture, rather an integrated approach involving a combined study of multiple attributes is always preferred. Using independent data like core data, dipmeter data, stratigraphic log correlation and forward modeling alongside seismic attribute study promise to provide a better understanding of geologic structures.

Geologic Setting

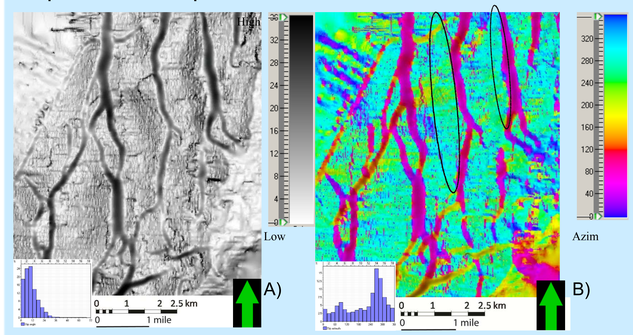


Fossen and Rornes (1996)

The Gullfaks oilfield is located in the western side of the North Sea Rift System, north of the Viking Graben. Most of the reservoir units are within the Late Triassic and Lower-Middle Jurassic sediments. The stratigraphy contains alternating sand and shales of the Lunde and the Stratfjord Formations, partly marine Dunlin Group and deltaic Brent Group. Structurally the field can be separated in to three compartments; a western domino style fault block geometry, a deeply eroded eastern horst complex of elevated sub-horizontal layers and steep faults and a transitional accommodation zone in the middle. The Middle Jurassic Ness Formation is the strongest reflection surface in this area and most of the interpretation in this study is along this horizon.

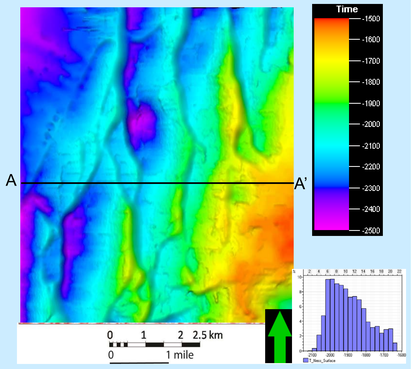


Dip/Azimuth map of the Middle Jurassic Ness Formation



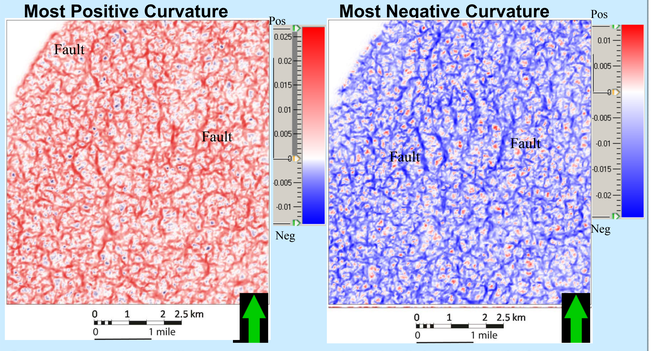
A) Dip map B) Azimuth map. The faults are highlighted well in both these maps. Note the seismic noise near foot walls partly due to acquisition.

Relief Map of the Ness Formation



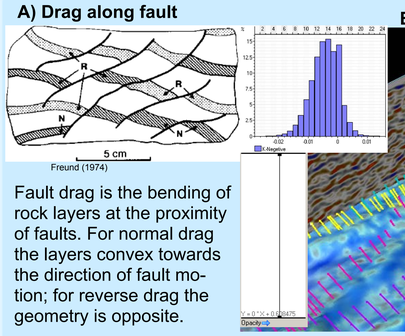
The faults stand out easily as lineaments in the relief map

Curvature maps of The Middle Jurassic Ness Formation

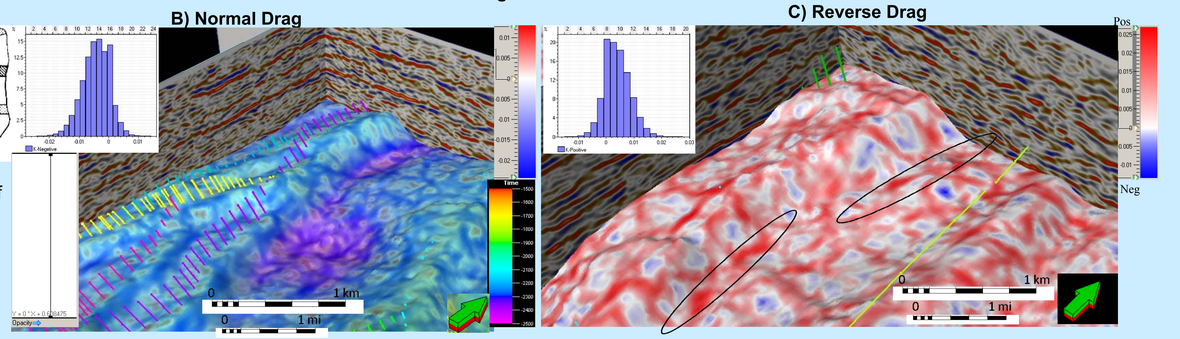


Geometric attributes like curvature somewhat highlights the main fault zones in the area but looks extremely noisy to provide any meaningful prediction of the surface geometry of the faults in the map view.

Fault Drag

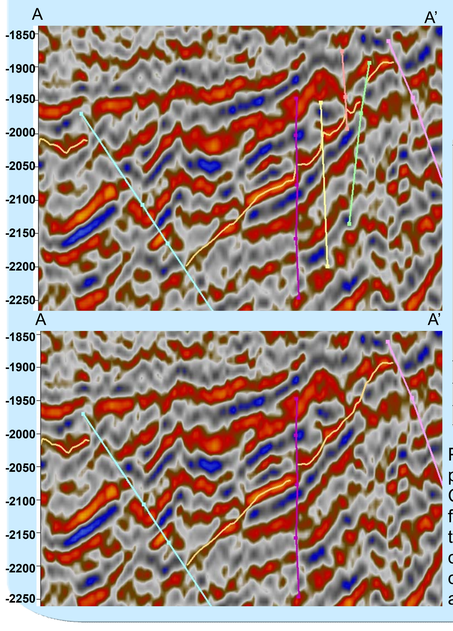


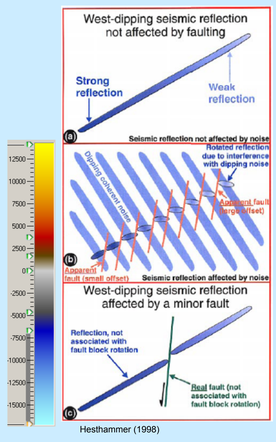
Fault drag is the bending of rock layers at the proximity of faults. For normal drag the layers convex towards the direction of fault motion; for reverse drag the geometry is opposite.



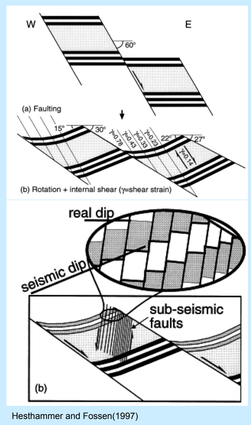
In B) the most negative curvature along the Ness Formation is corendered with the relief map of the same horizon. The similar location of the zones of high values of most negative curvature and the structural low is well prominent. It is proposed in this study that these zones of negative curvature along the hanging wall of the faults are due to normal drag. In C) the most positive curvature shows linear zones in the hanging wall at the proximity of the faults. This is probably due to the reverse drag effect. Similar geometries can be observed in the inlines. Note that a single fault plane can show both normal and reverse drag at different location along the strike.

Seismic Noise





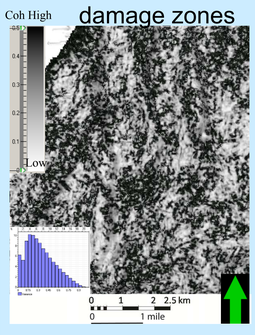
Hesthammer (1998)



Hesthammer and Fossen(1997)

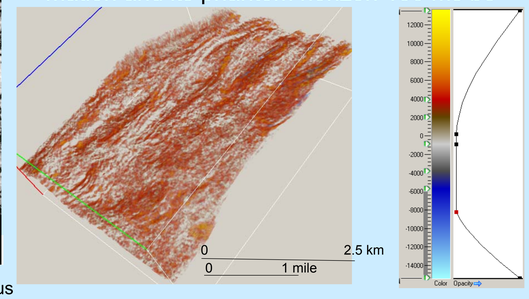
Presence of minor antithetic fault like features close to the foot wall in proximity of the faults is a common observation in seismic section. Core and well log data confirms the presence of only a few of these faults. Structural models suggest that these faults are expected close to the hanging wall or if they are present near the footwall the bedding dip from dip meter would be significantly lower than the seismic dip which is not the case in Gullfaks. Coherent dipping noise associated with block rotation is the probable cause for such anomalies.

Variance map and fault damage zones



The main faults are less obvious in the variance maps. The main faults with larger damage zones are probably not characterized by a consistent discontinuity in local trace to trace coherence. The relief and dip/azimuth maps are highly affected by seismic interpretation and thus the interpreter's inputs regarding the location of the faults will guide the results seen in these maps (Hesthammer, 1998).

3-D perspective visualization of a seismic amplitude volume along the Ness Formation and its phantom horizon 150 ms be-



It is possible to make phantom horizons of interpreted surfaces for an improved understanding of the vertical variation in structural and stratigraphy. Such phantom horizon along with the original interpreted one can be used to produce slabs of seismic volumes of different attributes. A similar amplitude volume is shown in the above figure. Perspective viewing in 3-D of such a slab provides the interpreter with useful information about how the regional structure looks like in a three dimensional space.

Conclusions

- The dip, azimuth and relief maps are most useful in mapping large and small scale faults from seismic data in the Gullfaks oilfield.
- 3-D perspective view of curvature attributes on an interpreted horizon can give useful information about convex up or convex down geometries related to fault drag.
- Using additional data or model always promises a better understanding of the geologic structures and is useful for separating seismic noise from real features.
- In the Gullfaks field a suspected minor fault can be separated from noise related artifacts by the presence or absence of block rotation and position of the feature with respect to its proximity to the footwall.
- In case of major faults with a large damage zone variance maps are not the best to identify faults. It also infers that if the faults are not clearly visible in the seismic data no attribute maps can be used to identify them automatically without the input from the seismic interpreter.

Acknowledgement

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