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Seismic Visualization of subtle fault/fracture zones in Carbonate reservoirs: two case studies (Fahud - Oman and Waterton - Canada)

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One of the key elements in unravelling the structural geometry of carbonate reservoirs is the analysis of seismic data. This poster is compiled primarily to give an insight in the visualization techniques used to highlight fault/fracture patterns. Secondly a work around is given to solve the problems encountered with data management between the different software packages used in the studies. The two case studies discussed are both part of separate multi-disciplinary asset studies carried out in the Shell International Carbonate Development team in Rijswijk. The first study (carried out in the first half 2000) focussed on the Upper Cretaceous Natih E reservoir of the Fahud oil field in Oman. The shallow onshore seismic data suffered from severe noise and quality loss due to amongst others soft overburden. The second study, which is still under evaluation, is carried out on the pre-stacked imaged seismic data in the foothills of the Rocky Mountains in Alberta. The North Waterton gas reservoirs are situated in the thrusted Lower Carboniferous to Devonian sequence. Due to the large terrain effects the seismic acquisition and processing is a tedious job with results that are difficult to interpret.

The goal of both studies is to get an insight in the structural patterns present in the reservoir sections. The first step in data evaluation is to apply noise filter tool to enhance the data quality and run open market and Shell proprietary algorithms for recognition of irregularities in the seismic data. Interpretation of near top reservoir on a zero crossing (in stead of peak or through) is also critical for the success of attribute mapping. Interpretation of the subtle fault/fracture zones is carried out on horizon parallel time-slices and with the optical stacking option in VoxelGeo (Oman) and on the attribute maps (edge, amplitude and rms average of StratAmp of different seismic volumes) directly (Canada). The interpreted lineaments are, with the aids of various tools (Zycor, gOcad, ULA) exported in the correct format for use in structural, static and dynamic modelling packages. In both projects a different route for data management is used, whereas the gOcad route appears to be the least time consuming. Figure 1 shows the workflow as used in the Fahud project.

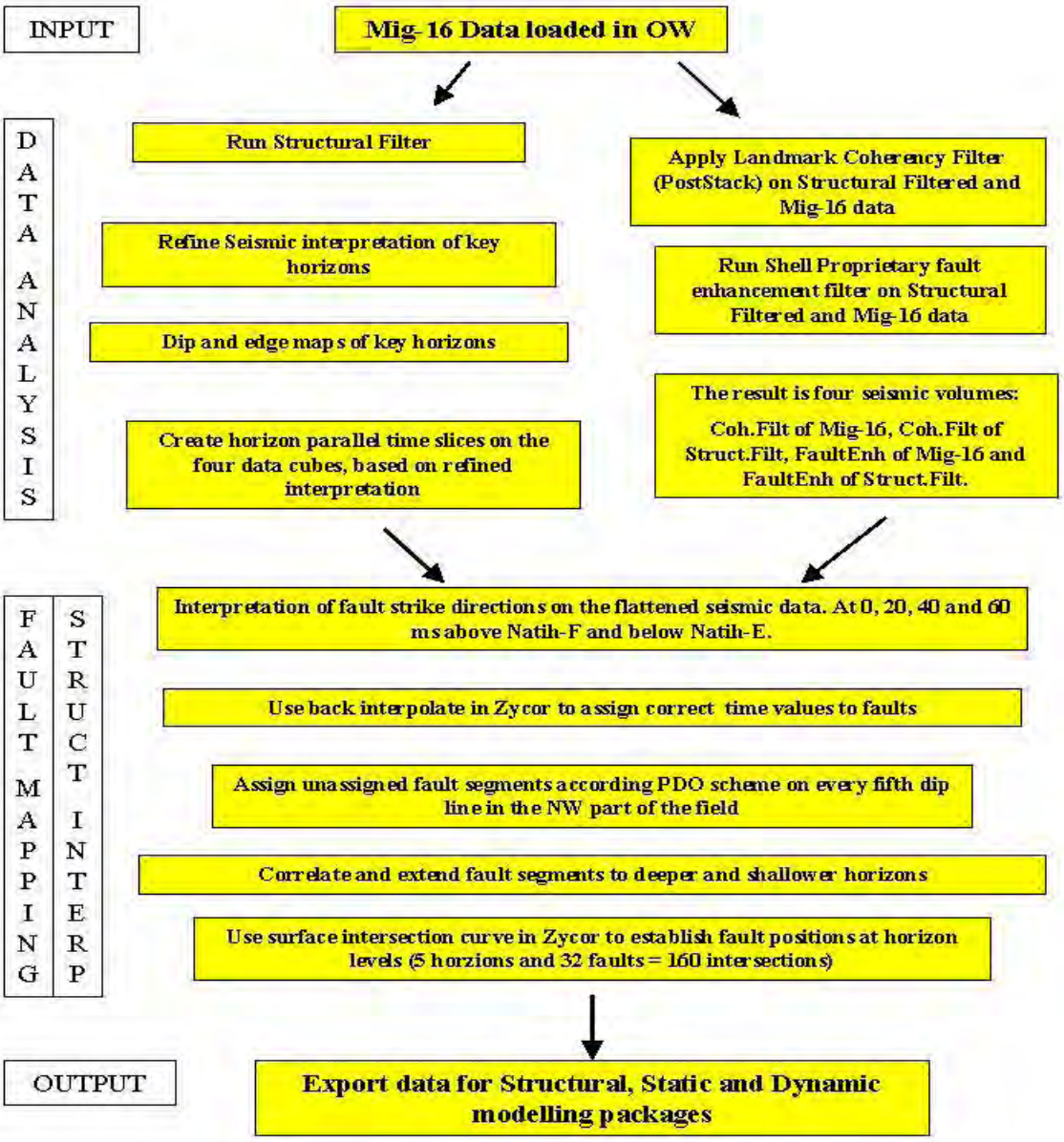

Figure 1: Workflow for Structural Interpretation of the Fahud data.

To get the best out of your seismic data with respect to fault/fracture zones it is recommended to use:

- Structurally oriented filtered data for horizon interpretation (Shell proprietary Optimum Filters combined with OpenWorks: DipScan algorithm)
- At least two attributes derived from seismic (edge, rms average of StratAmp on different seismic volumes, Shell proprietary fault extraction) for fault/fracture interpretation
- GOcad for getting your data in the correct format.

Especially the attribute analysis is a matter of trial and error. No rule of thumb can be used apart from the three general recommendations described above. Figure 2 shows the result of the fracture pattern recognition in Canada.

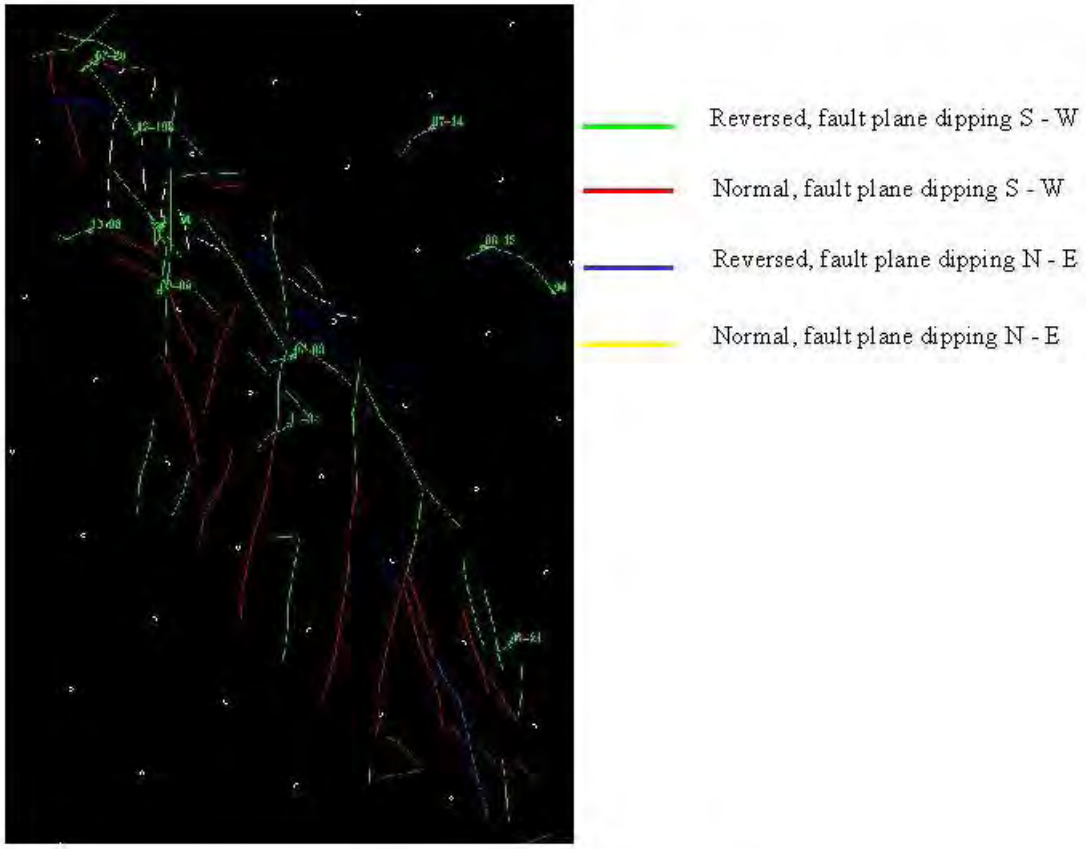

Figure 2: Result of the Structural Pattern Recognition workflow in the Waterton area.

Implementation of the results in the Oman study resulted in a better prediction of the reservoir volume (increase of 1.9 million m^3). And better understanding of the drainage pattern of the Fahud oil field (better targeting of appraisal wells – estimated impact 25% reduction in total well cost – saving 3.7 million USD). The preliminary result of the Canada study is a seismic fault/fracture pattern that is comparable with the outcrop fracture patterns as seen in a field study in Montana. This will result in a better understanding of the structural history of the North Waterton fields and presence of open fractures and fracture zones critical for appraisal well positioning.