# PS Structural Analysis of Upper Cretaceous Carbonate Using Curvature Attributes, Campeche Sound, Gulf of Mexico*

**Antonio Cervantes Velazquez[1], Matthew J. Pranter[1], and Kurt J. Marfurt[1]**

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[1]ConocoPhillips School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma, United States (antonio.cervantes.velazquez-1@ou.edu)

## Abstract

Campeche Sound, located offshore of eastern Mexico on the continental shelf of the Gulf of Mexico, is the most important petroliferous region in Mexico. Including the giant Upper Cretaceous Carbonate reservoir Cantarell and Ku-Zaap-Maloob oil fields, Campeche Sound production represents close to 80% of the national production of Mexico. At the beginning of Upper Cretaceous, a lowering in sea level, combined with preexisting high relief of the platform margin, is the likely cause of carbonate slope sedimentation in seen in the 3D seismic data volume where the reservoir rock consists mainly of facies of carbonate debris flows deposited on the Yucatan Slope alternating with pelagic deposits. The debris flows consist of heterogeneous carbonate clasts in a carbonate matrix. The formation is diagenetically altered through dolomitization, dissolution, and fracturing. Near the convergence of the North America, Caribbean, and Cocos plates, the study is structurally complex, with significant compression and strike-slip faulting during Late Oligocene to Miocene. The traps include east-west oriented anticlinal structures that are bounded by reverse and thrust faults. The stratigraphic and structural framework of the carbonate reservoirs was interpreted based on 3-D seismic and well data and used to create a 3-D grid for reservoir modeling. For this field, faults are a major control on secondary porosity distribution; therefore, an accurate and detailed fault interpretation is essential for porosity modeling. To enhance our structural interpretation, we applied edge-preserving, structure-oriented filter to the seismic survey, compute coherence, and then enhanced the faults using a modern Laplacian of a Gaussian filter, which also measured fault dip and azimuth. These 3D structural images were then integrated to generate a more precise 3-D model framework.

## References Cited

Chopra, S., and K.J. Marfurt, 2007, Volumetric curvature attributes add value to 3D seismic data interpretation: The Leading Edge, v. 26/7, p. 856, doi:10.1190/1.2756864.

Murillo-Muñetón, G., J.M. Grajales-Nishimura, E. Cedillo-Pardo, J. García-Hernández, and S. García-Hernández, 2002, Stratigraphic Architecture and Sedimentology of the Main Oil-ProducingStratigraphic Interval at the Cantarell Oil Field: The K/T Boundary Sedimentary Succession: Proceedings of the SPE International Petroleum Conference and Exhibition of Mexico, p. 643–649.

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Mewbourne College of Earth and Energy
ConocoPhillips School of Geology and Geophysics
ConocoPhillips

Antonio Cervantes Velazquez (antonio.cervantes.velazquez-1@ou.edu), Matthew J. Pranter, Kurt J. Marfurt

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## Geologic Setting

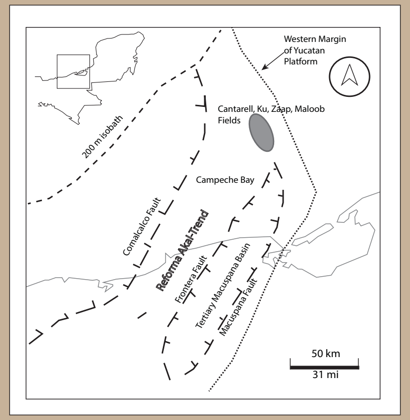


**Figure 1**. Location map of the Submarine Campeche Foldbelt which contained large Gulf of Mexico producing fields such as Cantarell and Ku, Maloob, Zaap. The field objective of the project is contained in this area too (After Murillo-Muñeton, et al., 2002).

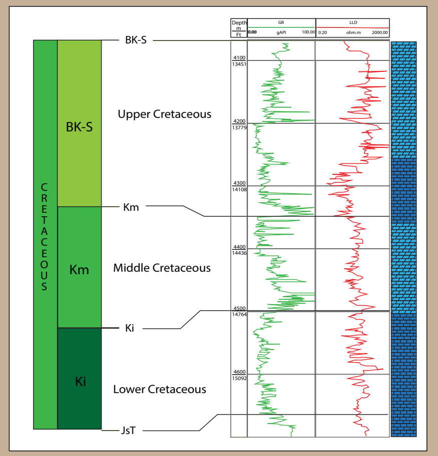


**Figure 2**. Stratigraphy and well type log for study area. Reservoir rock to characterize to this study is from Lower Cretaceous to Upper Cretaceous. Generally more intense dolomitization is present in Breccias of the Upper Cretaceous zone.

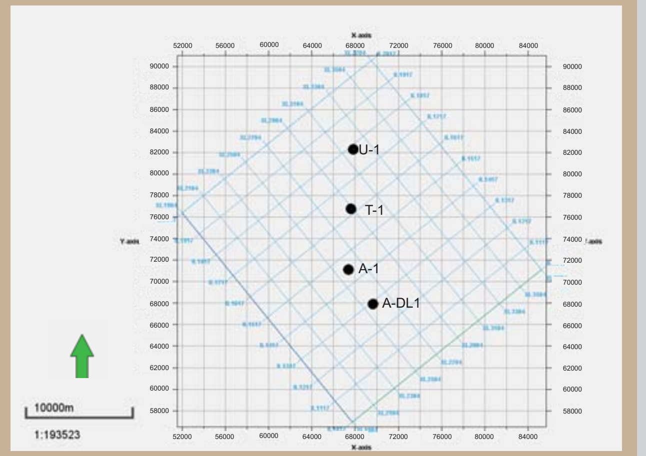


**Figure 3**. Basemap of the study area. Information to characterize this reservoir includes a seismic survey and the data from four exploration wells. These data includes well logs, core description, and core studies.

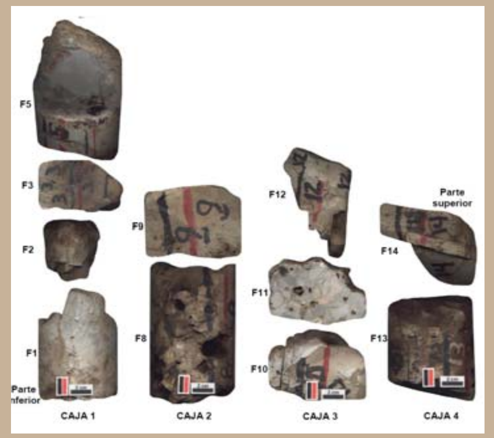


**Figure 4**. Core fragments from the reservoir rock. The samples exhibit fracture and vugs with heavy oil stain.

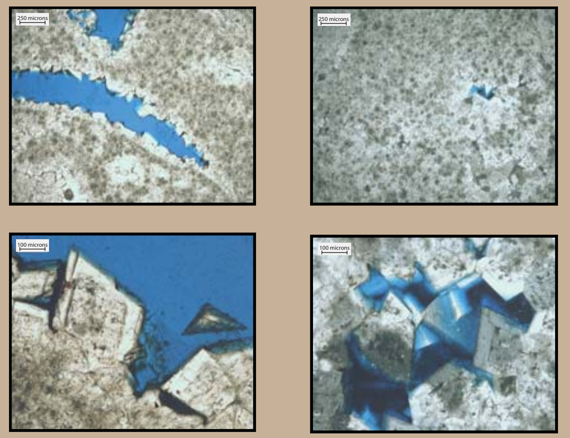


**Figure 5**. Microphotographs from cores showing dolomite with intercrystalline and vug porosity.

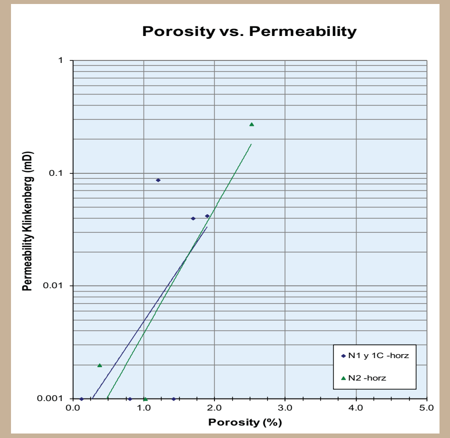
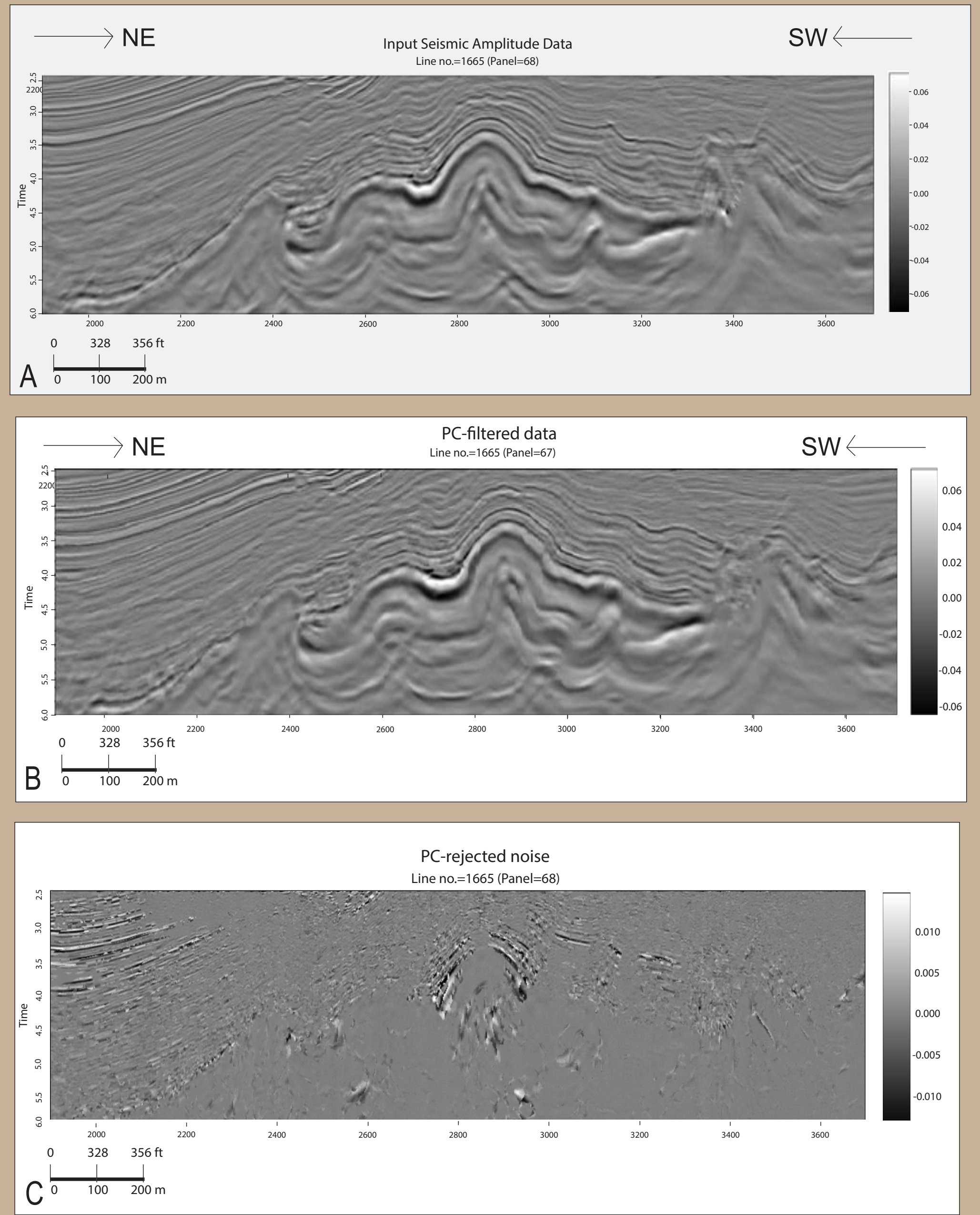



**Figure 6**. Porosity vs. Permeability plot, the distribution of the permeability is broad and depend on the connectivity and the porosity types.

## Data set



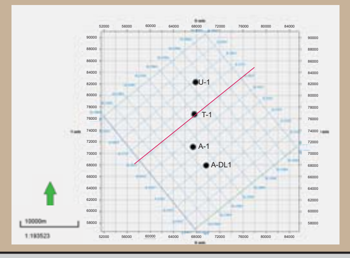



**Figure 7**. The seismic data used was a 3D WAZ depth migrated survey, originally the survey had a size of 2635 km2 but was cropped to focus on the field area (557.5 $km^2$). The expected result was after a structure filtering process, then, the structural image will be enhanced to interpret. The first step was to apply an edge preserving structure oriented filtering, as is proposed by Chopra and Marfurt (2007), was applied in order to try to improve the structural image. This process highlighted subtle structural characteristics that were hard to see in the original data, such as fault planes (Figure A and B). The rejected noise is shown it in the figure C.

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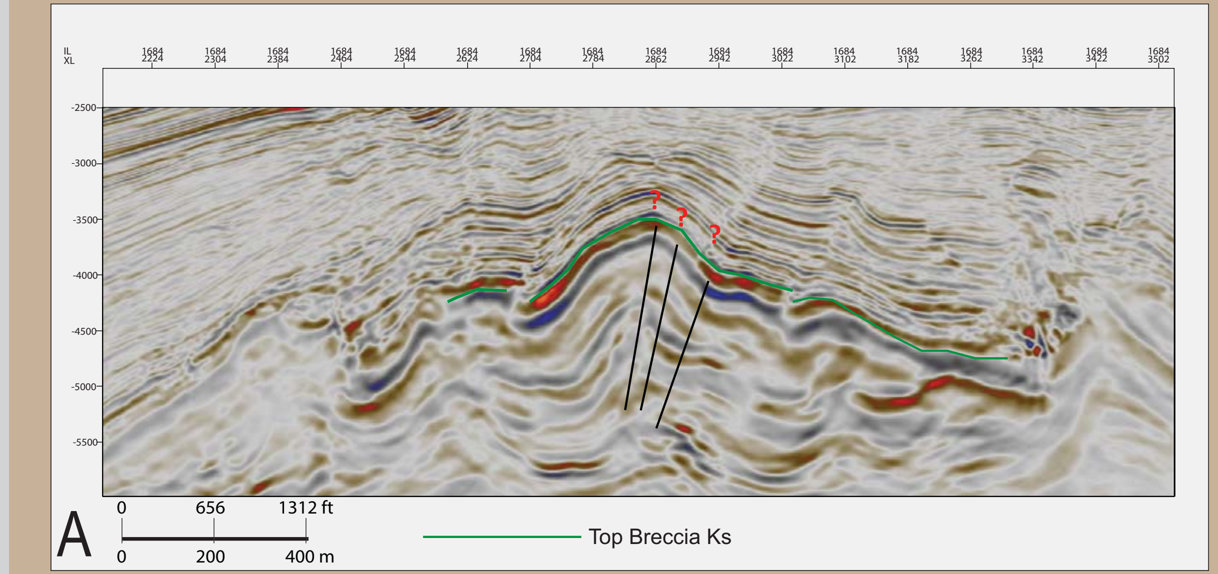
## Methods



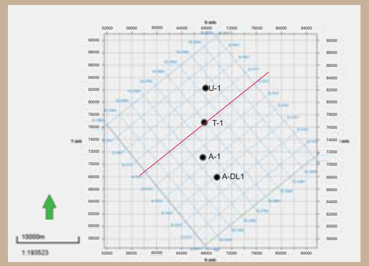



**Figure 8.** In a traditional interpretation workflow, based only on amplitude, it is even possible to see what are the direction and position of the main fault planes, even for an experienced seismic interpreter. The position of the fault plane could have uncertainty, and its spatial continuity can be confusing.

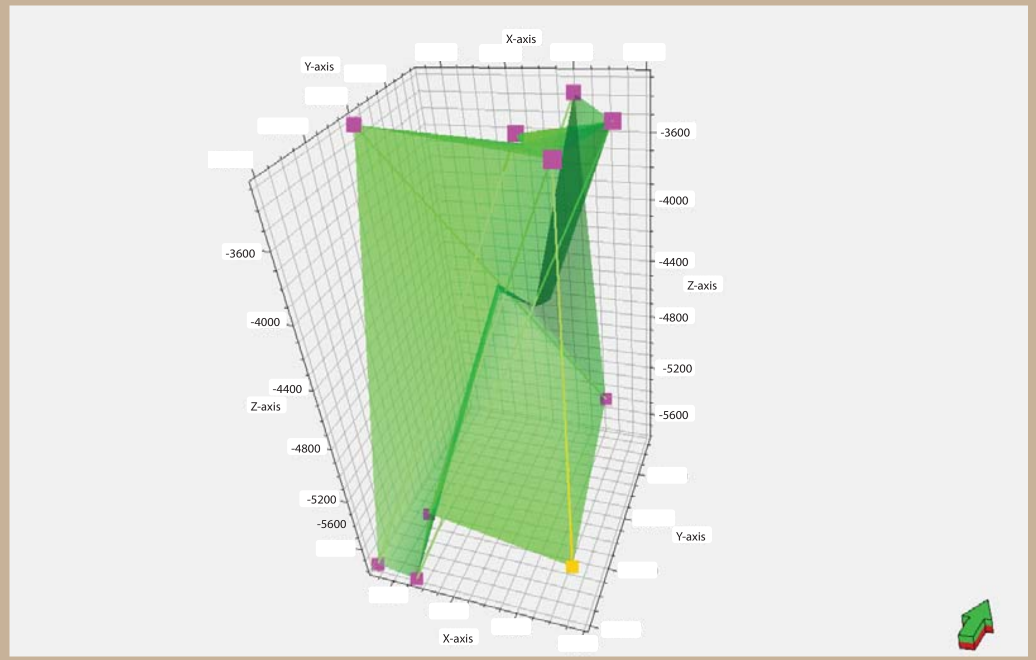
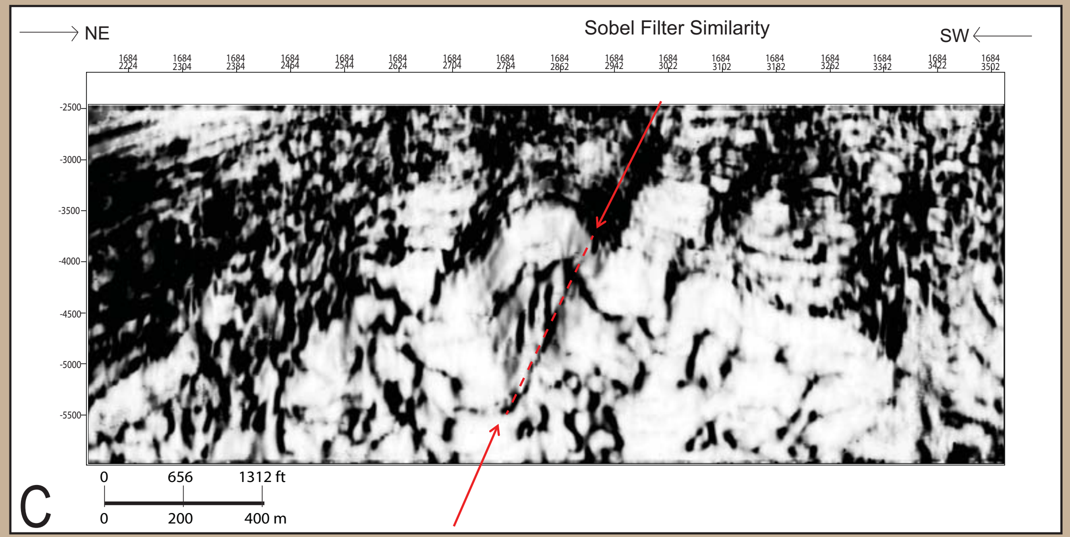


**Figura 9.** In consequence, the resulting interpreted fault plane, varies easily from line to line, producing a zig-zag fault plane. These zig-zag fault planes are not useful to model into a 3D



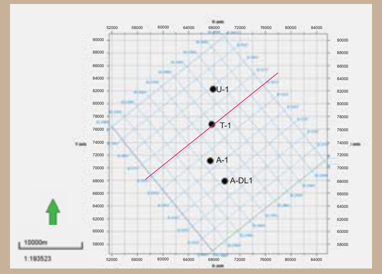



**Figure 10.** Using attributes related to curvature, such as coherence, similarity or Sobel filter, as proposed by Chopra and Marfurt (2007) and using a filtrated data, the fault planes are easier to identify. The minor fault planes, that initially could be confusing to interpret are now easy to interpret and follow from line to line

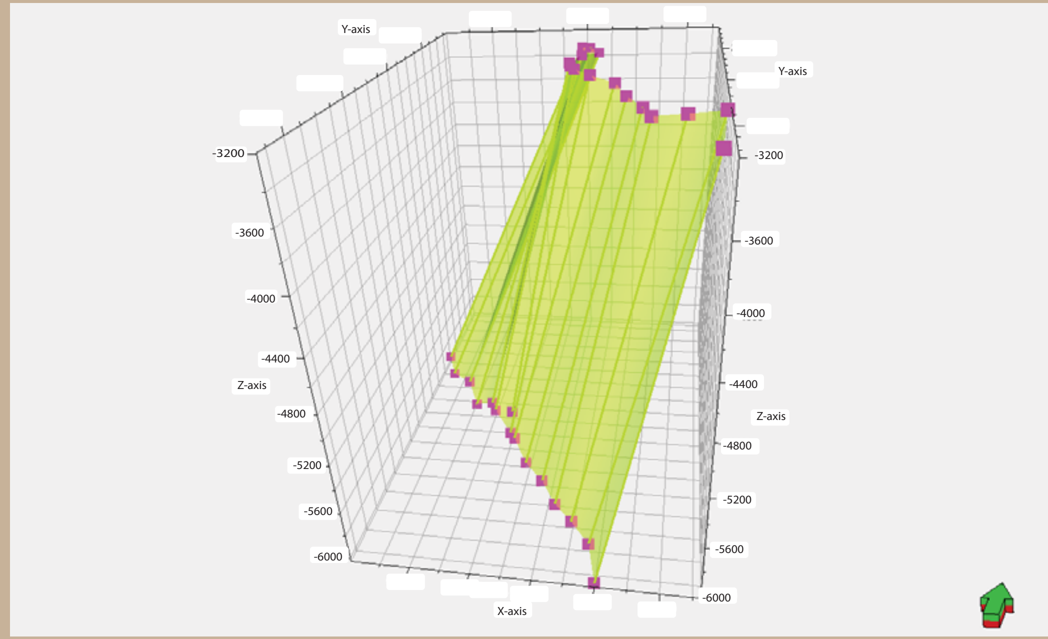


**Figure 11.** The result is an interpreted fault plane can vary significantly from line to line, with a better consistency in its interpretation and a minor uncertainty in its direction. These fault planes, interpreted using this technique are easier to model into a 3D geological grid.

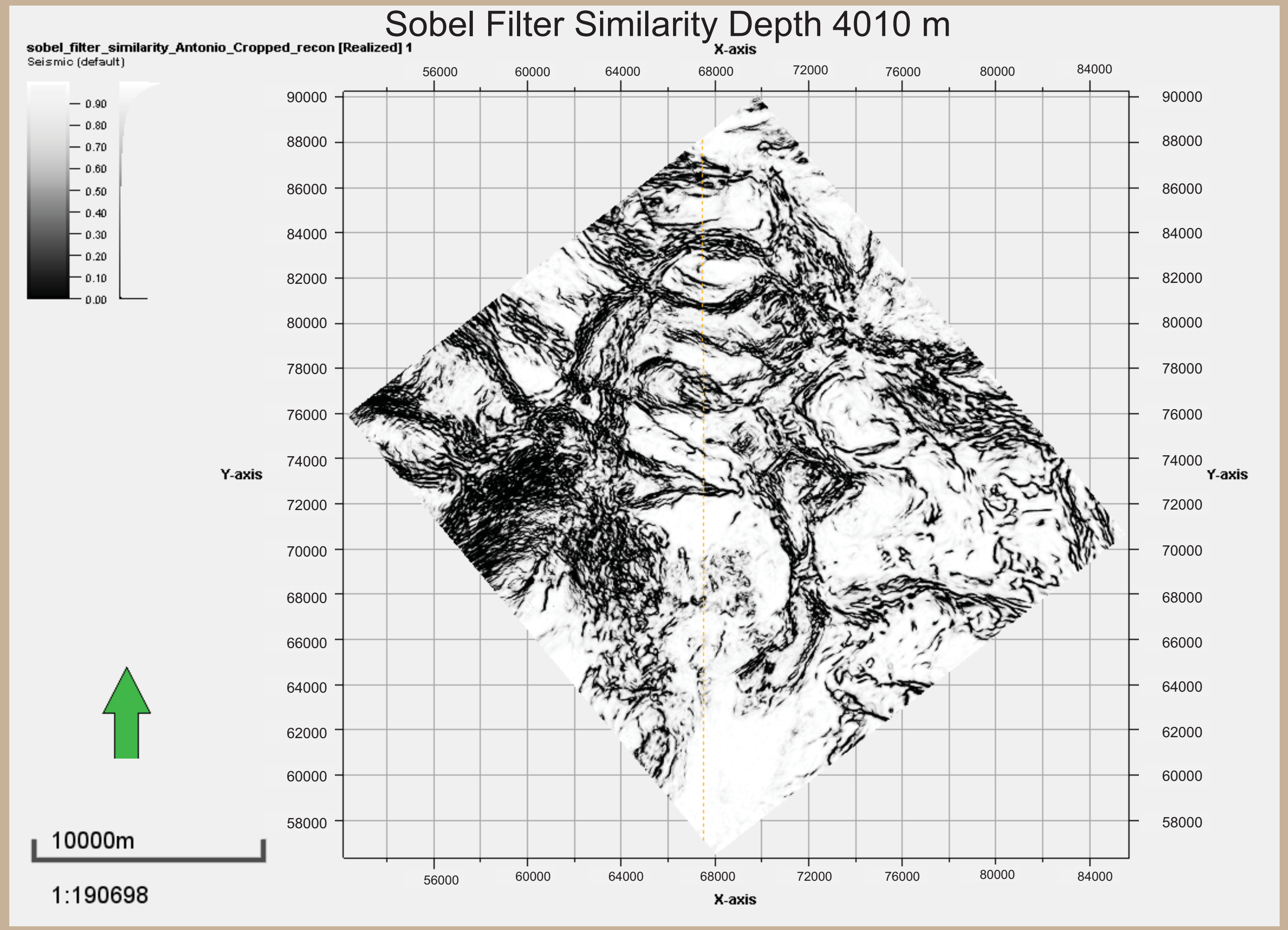



**Figure 12.** The slices generated from the attributes are helpful to identify main faults and possible fracture corridors. It is even possible to identify possible limits that could separate and compartmentalized structures.

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## Results

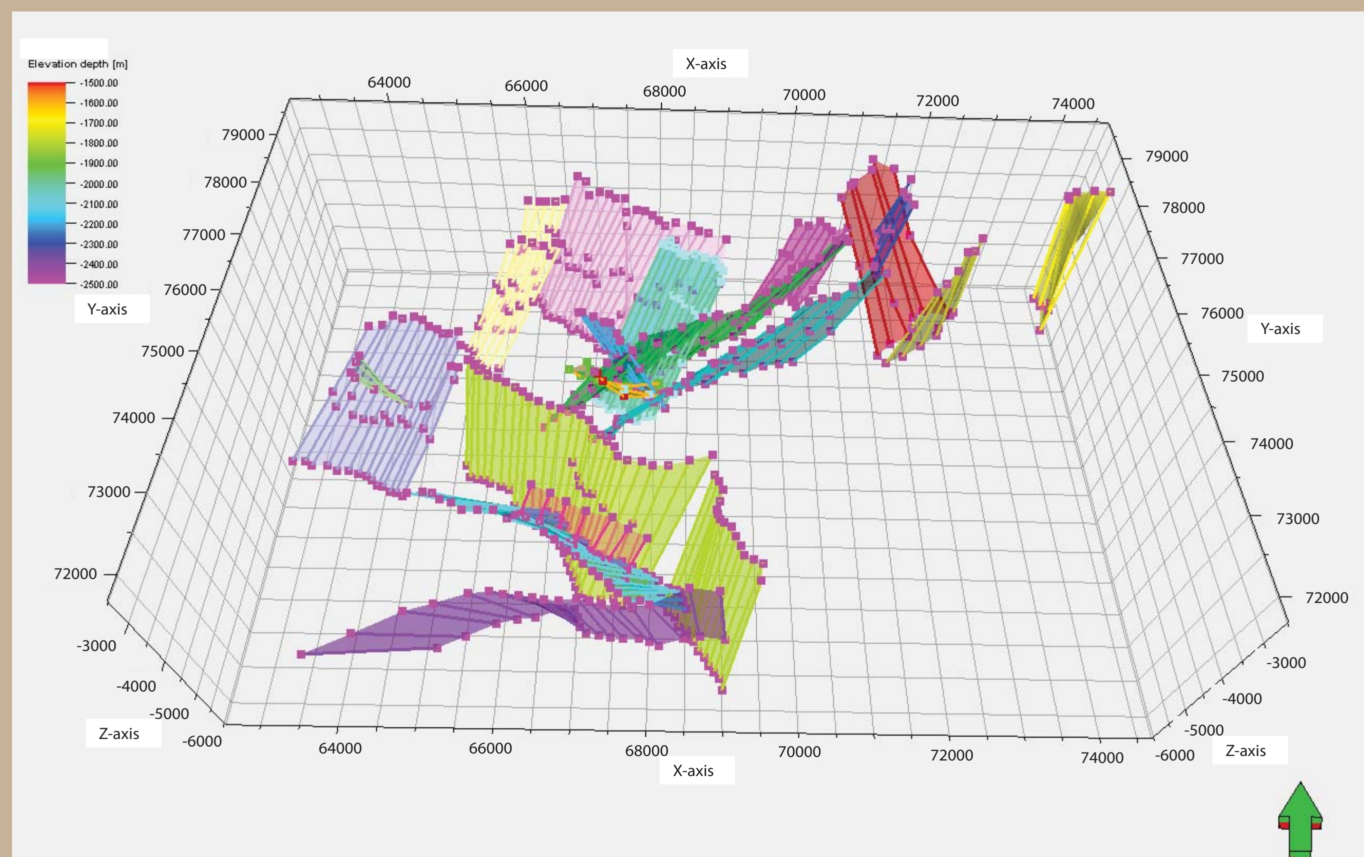


**Figure 13.** The fault planes interpreted with these methods are presented in this figure. The interpreted faults provide a structural framework to understand the structural evolution of the structural traps and for the interpretation of the top and base of the reservoir.

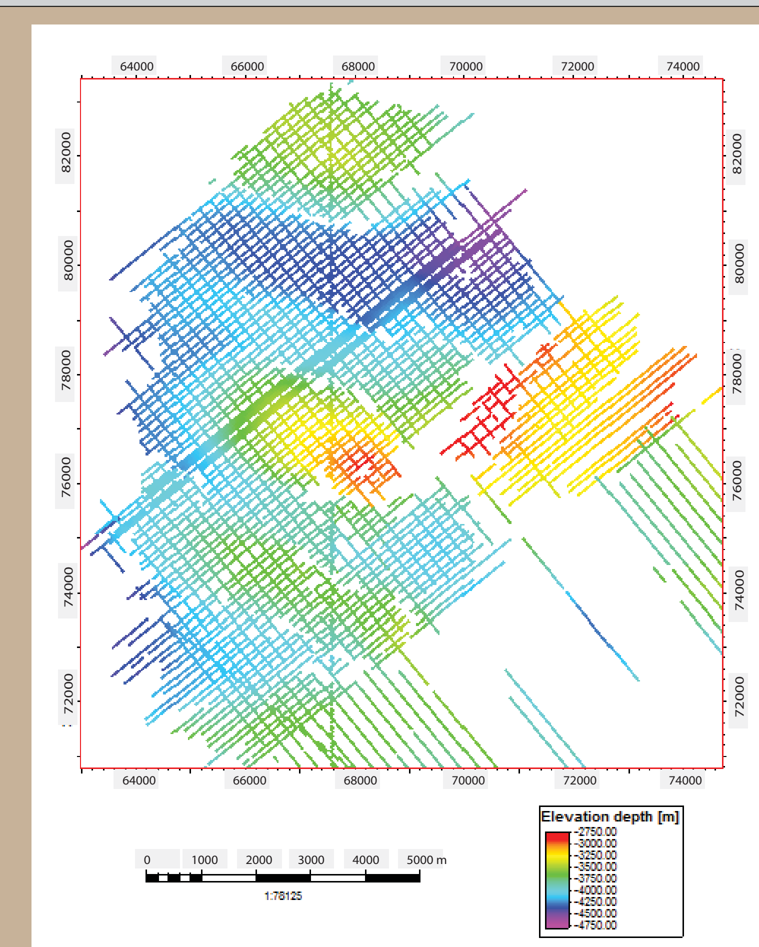


**Figure 14.** The interpretation of the top of the reservoir is covered with a dense interpretation every 10 lines. The structural framework provided by the previous fault interpretation helps to make the interpretation consistent. In a next step, the base of the reservoir will be interpreted too.

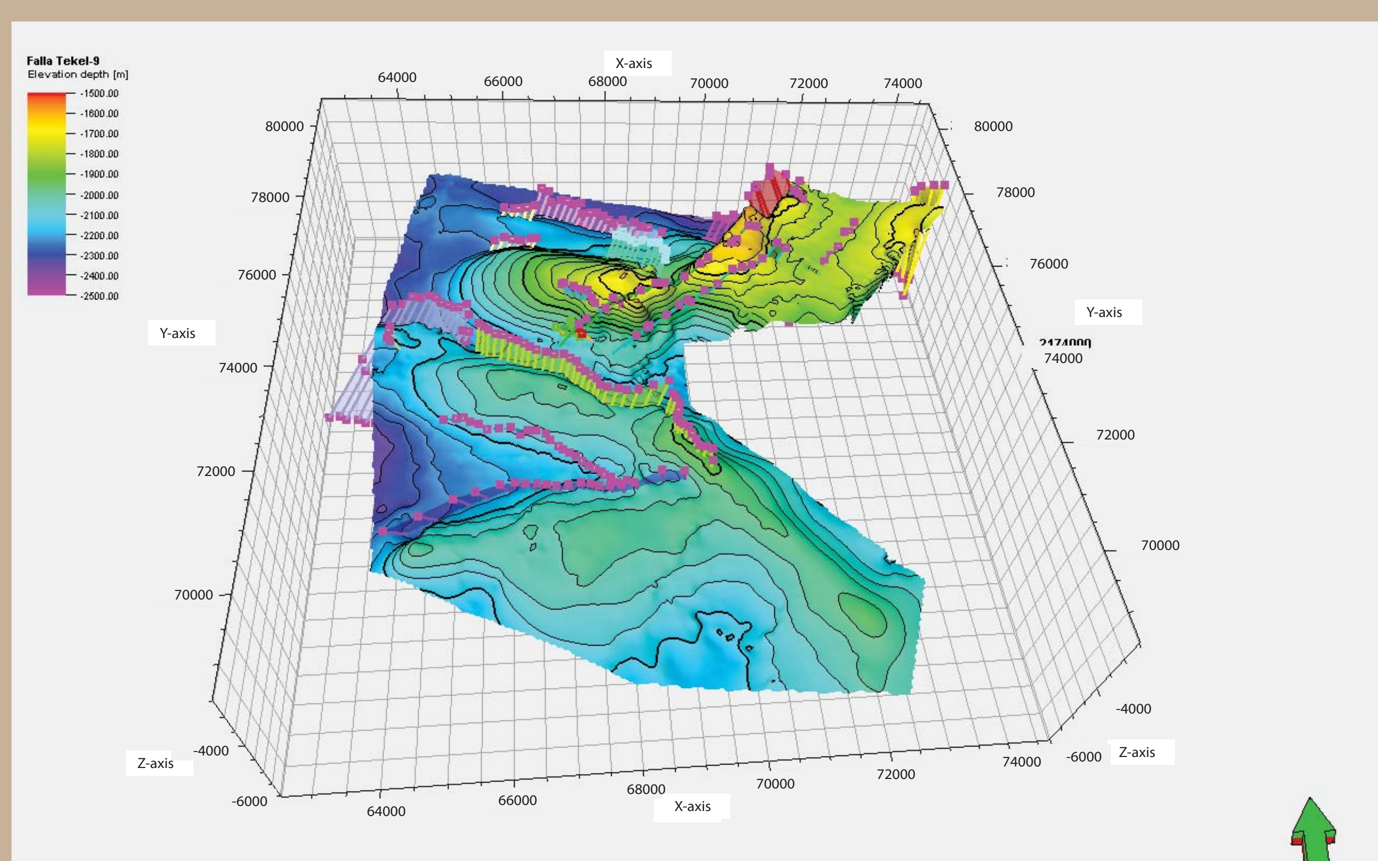


**Figure 15.** Isometric view of a surface generated with the reservoir top interpretation. The interpreted faults are included too. This surface can be used as a quality control measure for the interpretation and the consistency of the fault planes can be verified.

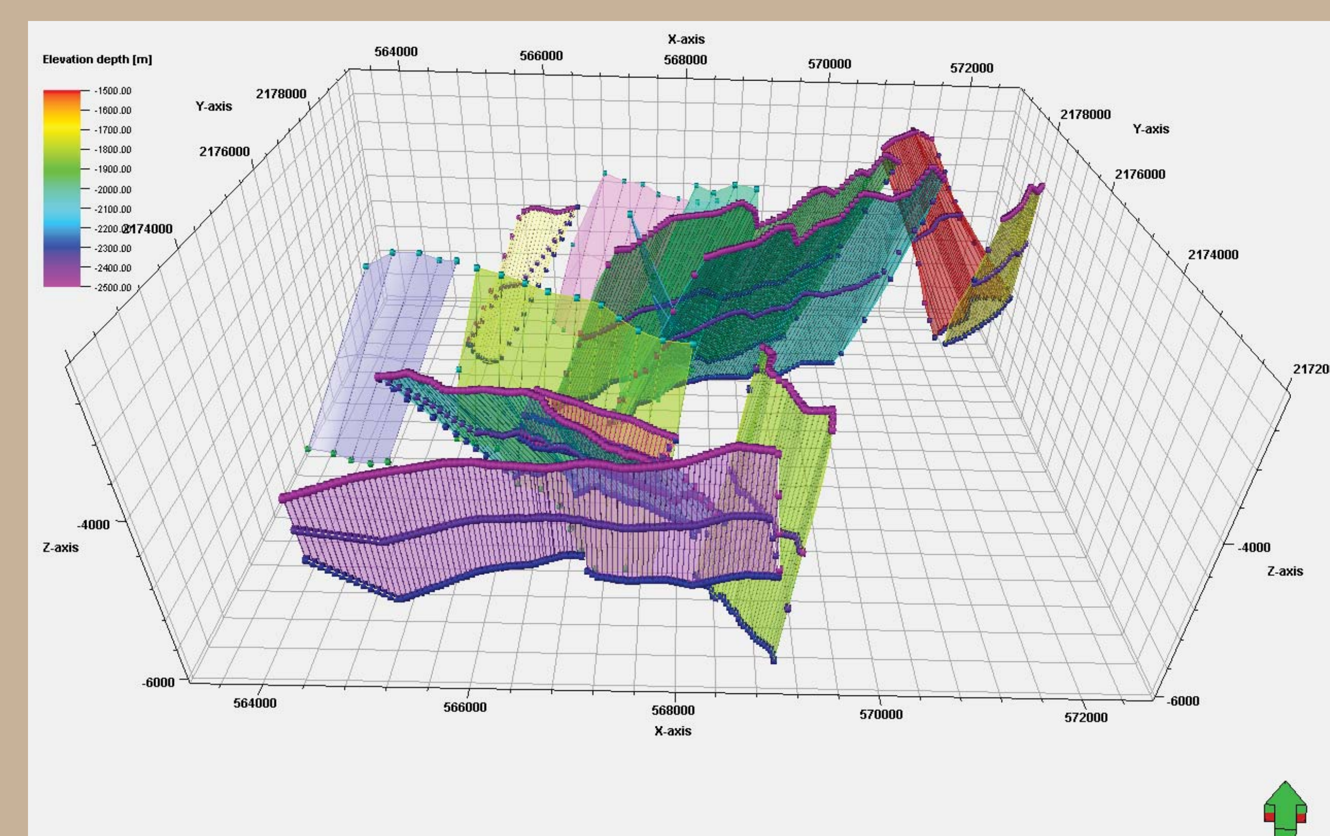


**Figure 16.** The interpreted faults are converted to faults in the fault model. These faults will be part of the 3D grid where the properties will be populated.

## Conclusions

Using a structurally oriented filter can enhance the original seismic data. These filters subtract the remaining noise and preserve the structural characteristics. Using curvature attributes permits the identification of discontinuities that are hard to see using amplitude, such as fault planes and possible fracture trends. These attributes support the seismic interpretation because it is possible to identify the position and continuity of the fault planes. The resulting faults are a structural framework that supports the interpretation of surfaces, such as the top and the base of the reservoirs.

## References

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