Time Slices Assisting in De-Risking the Traps by Reducing Uncertainties Associated with FaultsGenerated by Transnational Tectonics, Lower Indus Trough, Pakistan

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Summary

3D seismic data which generated three-dimensional (3D) time slices that provide exceptional imaging of the geometry, dimension, and temporal and spatial distribution of stratigraphic and structural features. Seismic fault interpretation is one of the key steps for seismic structure interpretation, which, is a time-consuming task and strongly depends on the experience of interpreters. Seismic attributes such as coherence and variance accelerate the fault interpretation process.

Time slices helped in determining the timing of structure and faults as well. Traps associated with faults need to be assured that faults are sealing and are not breaching or leaking hydrocarbons. Younger faults are linked with mother fault; the older fault can be considered risky at times as can breach the hydrocarbon or is considered as a later event to receive hydrocarbons. Detecting different orientations of faults can help in correlating them with certain tectonic events and hence, age can be estimated.

Considering the timing of maturity and the relationship of younger faults splays with their parents, risk can be associated with traps and can be linked with their timing. It is observed post Tertiary strata have been deformed due to NE-SW oriented faults, associated with post-Eocene tectonics are risky, while NW-SE oriented faults are developed due to relatively older events associated with rifting episodes that can provide potential traps.

Theory / Method / Workflow

The study area is located on the NW corner of Indian plate exhibiting one of the most important region of Pakistan producing hydrocarbons. The study area is located within a syncline surrounded by folded structures like Khairpur, Jacobabad, Mari and Sara, which are supposed to be deformed by high-angle, deep-basement-related faults that extend up to the Base Tertiary unconformity. These have developed flower structures and are strike-slip in nature (Ahmad and Chaudhry, 2002). Generally, the NW-SE oriented wrench faults cut the entire Cretaceous section, changing character from strongly linear and single fault at the top Chiltan to multiple en echelon left stepping segments at the Lower and Upper Goru levels (Sultan and Ilyas, 2010).

Time slices are seismic slicesthat are taken horizontally through original reflectivity 3D seismic volumeshowing the strike of features. Faults are suggested where reflections terminate systematically. Horizontal-time slices are only usefulwhen the geological features of interest and the stratigraphic time lines along which they are developed are horizontal to sub horizontal. A time slice is a quick, convenient way to evaluate changes in amplitude of seismic data. The time slice is the first step toward 3-D interpretation of a 3-D seismic volume. Additionally, a time-slice view of the data is an improvement over vertical sections for the interpretation of depositional systems because it provides the opportunity to see a portion of depositional systems in map view.

Whatever the style of faulting, manual interpretation of faults on vertical seismic sections is traditionally a laborious and time-consuming process. Fault-sensitive attributes, such as coherence, variance are generated to image enhancement, smoothing and sharpening filters aligned parallel and perpendicular to the fault attribute anomaly. Examples of seismic attributes are wavelet shape, frequency, amplitude, phase, and complex trace information contained in transforms of the real trace.

One way to improve the imaging of the paleo-depositional system is to create horizon slices through the 3-D volume. The interpreted reflection (horizon) is an approximation of a paleo-depositional surface. Post-depositional faulting results in shifted but similar reflector patterns across the fault. Syn-depositional faults are somewhat more complicated. A horizon slice that cuts through the 3-D volume along a picked horizon is often the best way to see stratigraphic features. Hence, an attribute mapderived from an interpreted seismic horizon is also necessary to validate the results as depicted from horizon slices.

Results, Observations, Conclusions

Time slices can be used to understand structural contour maps. Some image processing tools also can be used to detect and enhance subtle structural features on time slices. The very obvious offset of the contours almost certainly indicates a fault. The abrupt change of dip probably indicates another fault. The location of these features becomes less clear toward the southeasternpart of time slice.

The pre Top Lower Goru Formations are compartmentalized mostly by multiple episodes of rifting of Indian plate during Cretaceous and generated NW-SE oriented faults. Contrarily, post-Tertiary formations are mostly deformed due to transtentional forces and generated NE-SW oriented faults as splays of older NW-SE faults connected with Top Jurassic surface. The NE-SW oriented faults are distributed randomly, indicating generation of the new faults associated with post Eocene uplift and Inversion.

Time slice independentlycannot be categorical, as it doesn't show the full scenario regarding fault plan interpretation. Time slices don't show dipping direction of faults neither separation of various faults aligned in same direction. Hence, interpretation required to draw and correlatedfaults on vertical seismic sections inparallel with time slices.

The time slicesat Top Jurassic and Lower Cretaceous level using coherence attribute show that the western part is mostly covered by fault having strike NW-SE. While eastern part is mostly noisy at Cretaceous level showsfew faults striking at NE-SW orientation with one regional, NW-SE orienting fault. The time slice at Base Tertiary level alsoshows that faults are trending NE-SW are distributed in en-echelon arrangement (Fig. 01), which suggests the involvement of strike-slip element, and hence confirms the deformation is related with transtentional activity. It also shows intensity of faults get minimum as we go into the shallow zone i.e Post Eocene sediments.

It is also analyzed that sources facies within Early Cretaceous are considered to be entered in maturity window during Late Cretaceous and generated maximum of its potential by end of Eocene. So, it is interpreted thatpost tertiary structures were available to receive hydrocarbon before the source facies generated maximum of its potential and younger structuration, associated with NE-SW faults linked post Eocene tectonism, can be considered risky.

Novel/Additive Information

Understanding of hydrocarbon entrapment within the fault bounded trap geometry is always being anuncertain. However, using the 3D time slices through attributes may help in understanding and mapping the possible age, distribution and geometry of fault patterns in defining the trap integrity. Using the workflow adopted during the analysis, uncertainties related with the orientation of faults can be addressed.

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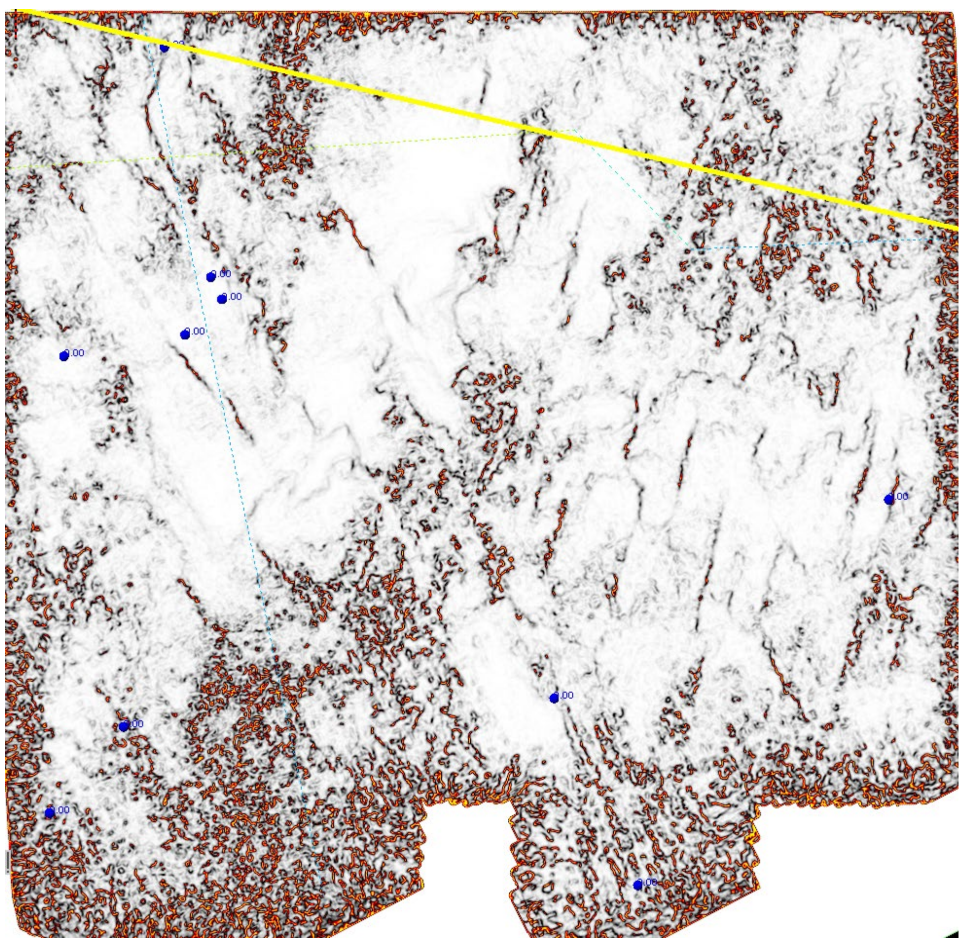

Fig. 01 Time Slice within post-Tertiary sediments by using coherence attribute show that the western part is mostly deformed by NW-SE oriented faults. While eastern part is mostly NE-SW orientation faults

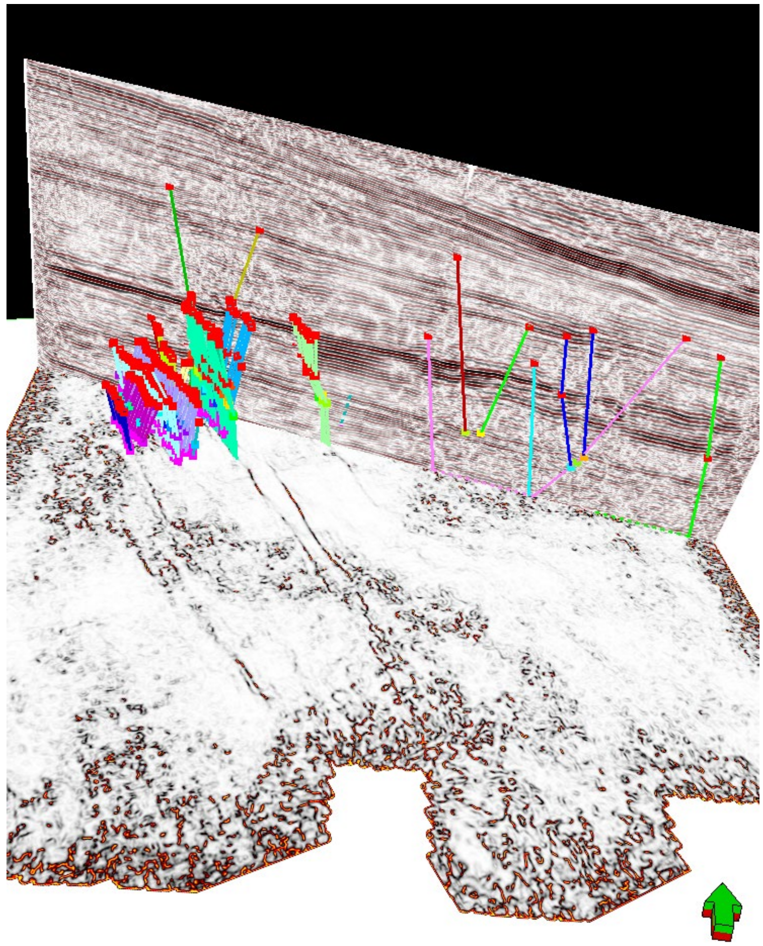

Fig. 02 Time Slice within pre-Tertiary sediments by using coherence attribute show that the western part is mostly deformed by NW-SE oriented faults. While eastern part is mostly undeformed. Image also showing fault sticks marked on cross section following fault plane

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