BHI 3D visualisation and interpretation in SVS

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New development in fracture modelling software SVS (Simple Visualisation Software) allows 3D visualisation and 3D interpretation of BHI data integrated with all subsurface data.).

A large proportion of PDO's future production resides in fractured reservoirs. In order to support the development of these volumes, a strong effort of fracture characterisation and modelling has been initiated. The key enabler for these studies is the software technology, SVS (Simple Visualisation Software [Ref. 1]) which is being developed by the Carbonate Development Team (CDT). PDO, as lead implementer of the CDT, has taken not only the role of implementation but has a strong role in SVS development and steers strongly the development of SVS according to the study needs. One of the key pillars of any detailed fracture characterisation is the BHI data. To maximise the value of the BHI data, new functionalities have been developed to visualise the image in 3D along with open hole logs, seismic, Eclipse grids etc and also to carry out 3D interpretation of the images. This specific use of BHI data is part of an ongoing focused effort of the PDO study centre for clastic and carbonate reservoirs alike. The main objective of this article is to share with you some of the functionalities to illustrate the value of the data integration.

Loading and basic viewing of BHI data into SVS

The borehole images are loaded as image files. These image files are created from packages such as Recall Review or Geoframe. Then the BHI can be visualised either in a simple 2D window or in a 3D window along the wellbores. Figure 1 illustrates a) an oblique view of a well with BHI, b) a zoomed portion of the image as a flat picture and b-e) the same image displayed around a tube at various rotation angles. It is important to note that while it is more fancy to display the image in 3D around a tube, 50 percent of the image is hidden. The picture file on Figure 1 has been plotted from Recall at 1/20 scale and it provides a sufficient resolution for detailed observation. Similarly to the BHI, core pictures or any type of pictures can be loaded along the borehole at specific depth interval.

Combining BHI and open logs

Once the BHI data is loaded in SVS, any combination with the rest of the dataset is possible. The Figures 2 and 3 illustrate the specific combination of open logs (SH, LDEN, CAL, POR), fracture picks

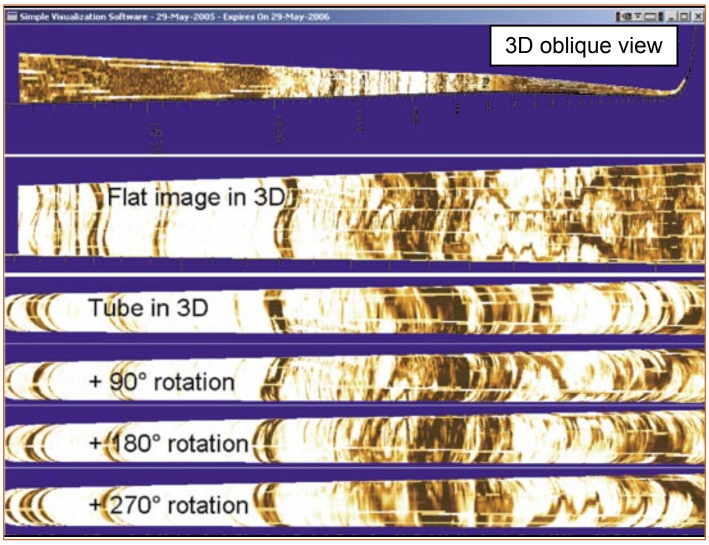

Figure 1: BHI picture displayed in SVS as flat picture (top 2 images) or around a cylinder (bottom 4 images).

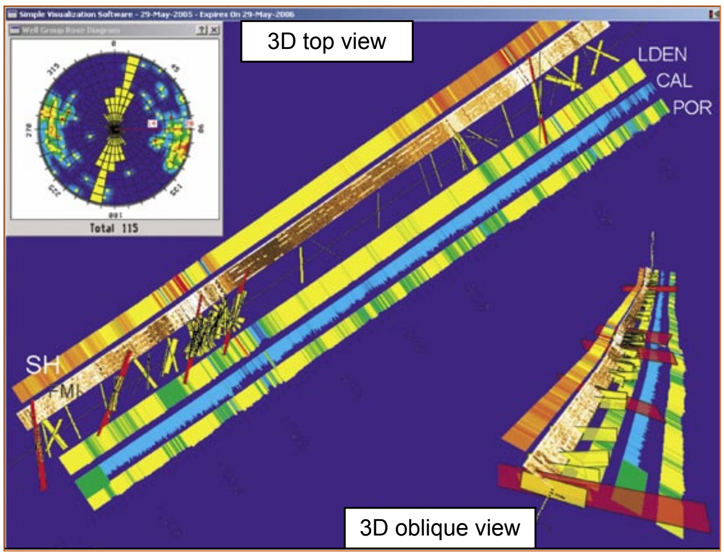

Figure 2: Combination of FMI images, fracture interpretation and open logs in 3D. The fractures displayed correspond to electrically conductive fractures of different width. Minor and major fractures are represented by the yellow and red rectangles respectively, with true dip and strike. The rose diagram of the fractures is shown in top left corner with the density of poles to the fracture plane as a property.

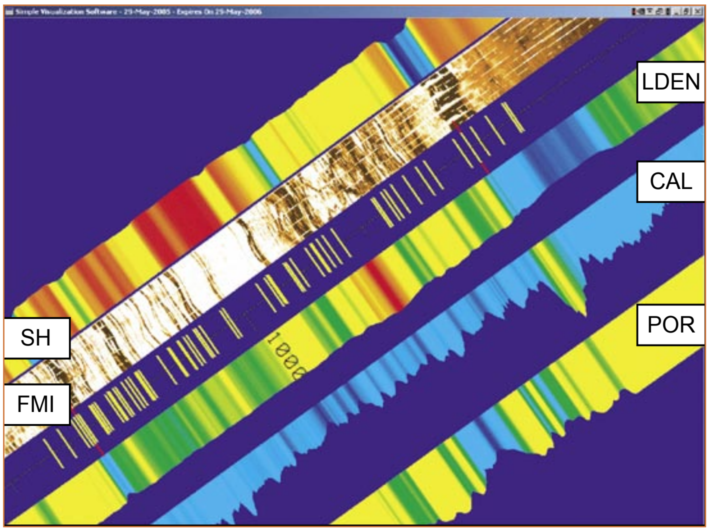

Figure 3: Combination of BHI images, BHI picks and open logs in 3D (zoom of Figure 2). The fractures are represented by simple lines perpendicular to the well trajectory to help the analysis of the fracture/BHI/open-hole log relations.

and an FMI image in map and oblique views. The BHI picks displayed correspond to electrically conductive fractures of different width. Minor and major fractures are represented by the yellow and red rectangle respectively, with true dip and strike. The rose diagram of the fractures is displayed in the top left corner, with the density of pole to the fracture plane as a property. The distribution of fractures along the borehole is heterogeneous. An important cluster is observed around 1000 m along hole. A detailed view of this cluster is displayed on Figure 3. On this display, the fractures are represented by simple lines perpendicular to the well trajectory to help the analysis of the fracture/BHI/open hole logs relations. Although all the fracture are electronically conductive, the major open fracture which might have the greatest impact on fluid flow is interpreted as the one associated with lowest hydrocarbon saturation (SH). The low SH is interpreted in this case as a fracture flushed by the drilling mud.

Combining BHI and seismic

The Figures 4 and 5 illustrate the specific combination of seismic data with BHI. The displays correspond to chair displays showing cross sections and time slice immediately below the well trajectories. The rectangles correspond to electrically conductive fractures picked on the BHI. In Figure 4, the White feature in the middle of the cluster of white rectangles was interpreted as a mega fracture (due to its relative size) but no displacement associated with it was identified from the image. When combined with the seismic, one can identify the presence of a fault (as indicated by the black arrows). This subtle fault (at the well location) is consistent with the larger faults further to the SE (indicated by the yellow arrows). In Figure 5, a total of 9 wells with BHI are displayed. Loading multiple wells enable the interpreter to check whether features in a given well could correspond to other features in nearby wells. This is particularly useful when attempting to identify fracture corridors in the subsurface.

3D BHI interpretation

In order to be able to interpret high level features based on both BHI and seismic data, an interactive 3D interpretation interface has been developed. The idea is not to carry detailed BHI interpretation in SVS (this has to be done in appropriate tools such as Recall Review or Geoframe) but to use the added information gained from the integration with other data. Figure 6 illustrates a zoomed portion of a BHI (note the scale bar of 25 cm) on which bedding (greenish plane) and fractures (pinkish planes) has been picked. When picking in 3D it is important to display the borehole without distortion in order to pick features with their real dip and azimuth rather than the apparent ones. For large features cutting through several wells it is possible to create lines or surfaces in 3D.

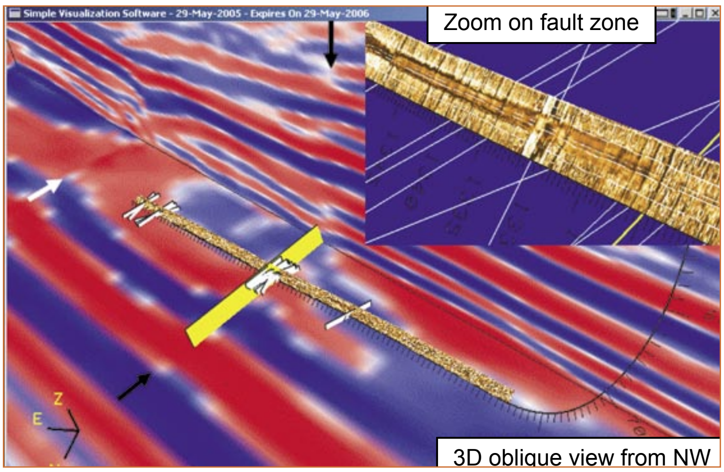

Figure 4: Combination of seismic data with BHI. The displays correspond to a chair display showing one cross section in the back and a time slice immediately below the well trajectory. The presence of a fault (indicated by the black arrows) is highlighted by the fracture cluster (white and yellow rectangles) interpreted on the BHI.

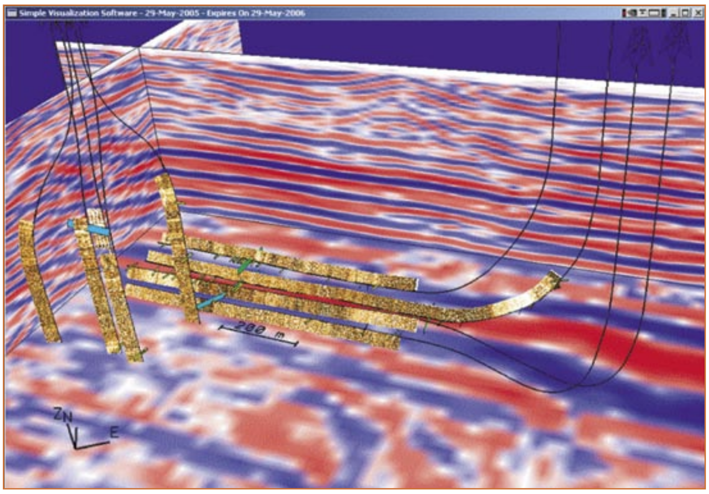

Figure 5: Combination of seismic data with BHI. The display corresponds to a chair display showing 2 perpendicular cross sections and time slice immediately below the well trajectories. The rectangles correspond to electrically conductive fractures picked on the BHI. Loading multiple wells enables the interpreter to assess the possible extension of features in nearby wells. For example, this is particularly useful when attempting to identify fracture corridors in the subsurface.

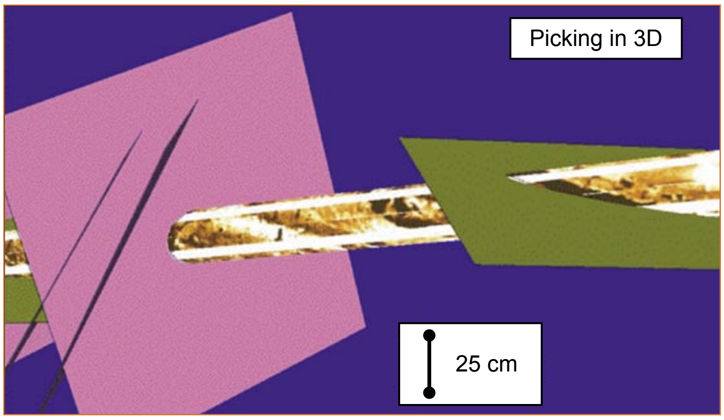

Figure 6: Interactive BHI interpretation in 3D. A utility to pick features in 3D has been developed to interpret high level feature based on both BHI and seismic data.

Conclusions

We hope that this short article has given you a good insight of the benefit that what 3D visualisation of BHI can bring you. We strongly recommend to everyone dealing with BHI data to try it. Furthermore, while this technology is being applied, further developments can be recognised and implemented. SVS is easily accessible though the Carbonate Development Team in EPT Rijswijk. For more information please contact Keith Rawnsley (Keith.Rawnsley@shell.com), Salah al Dhahab (Salah.Dhahab@shell.com) or Pascal Richard (pascal.richard@pdo.co.om).

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Reference

1. Rawnsley, K., Swaby, P., Bettembourg, S., Dhahab, S., Hillgartner, H., de Keijzer, M. Richard, P., Schoepfer, P., Stephenson, B. and Wei, L., 2004. *New software tool improves fractured reservoir characterisation and modelling through maximised use of constraints and data integration*. SPE paper 88785.

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