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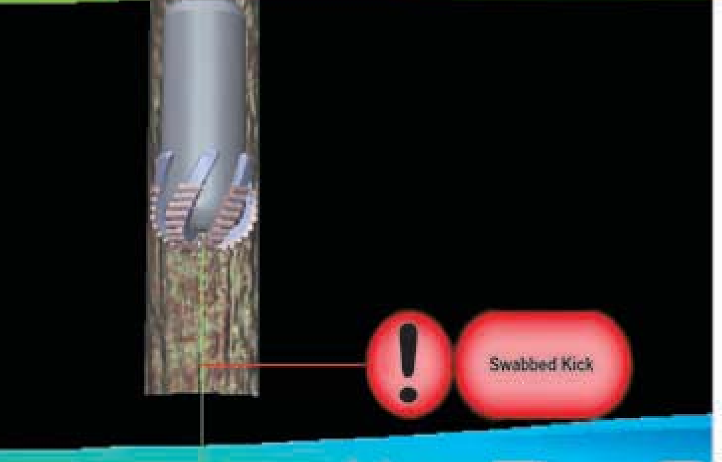
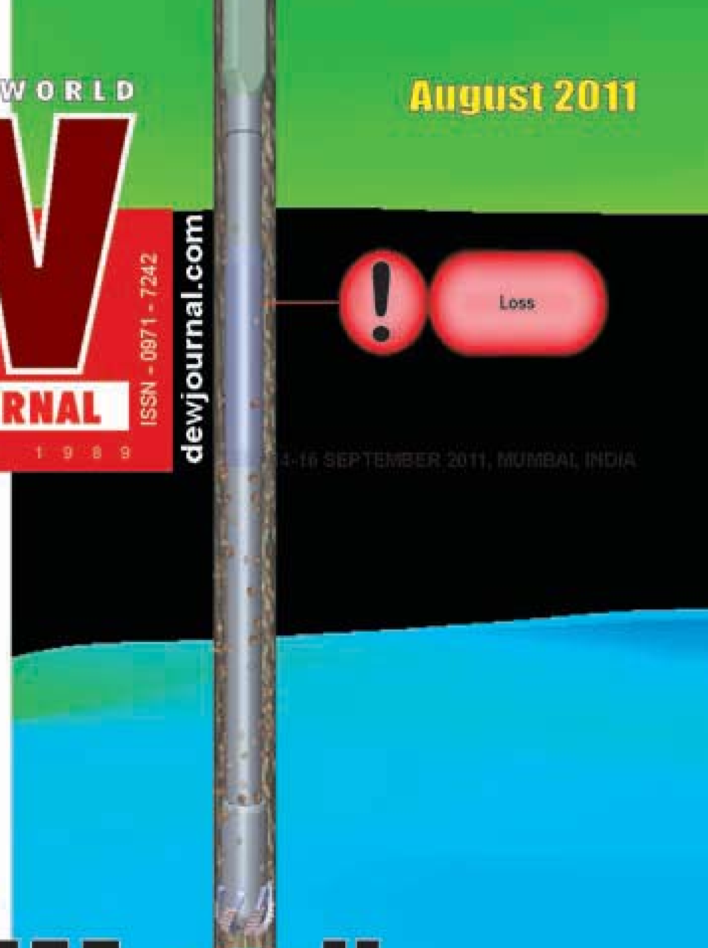
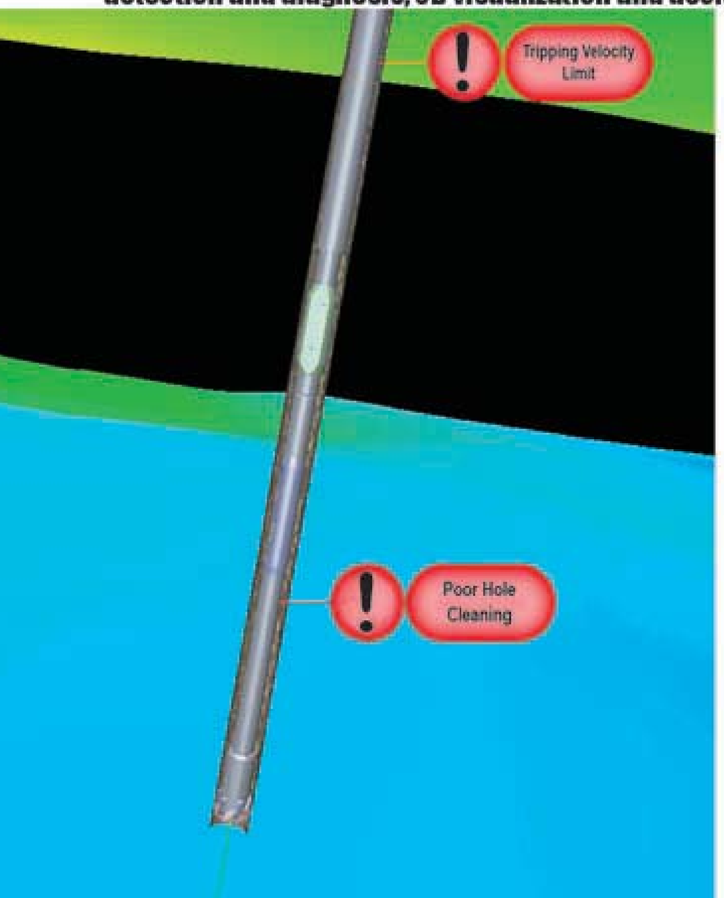
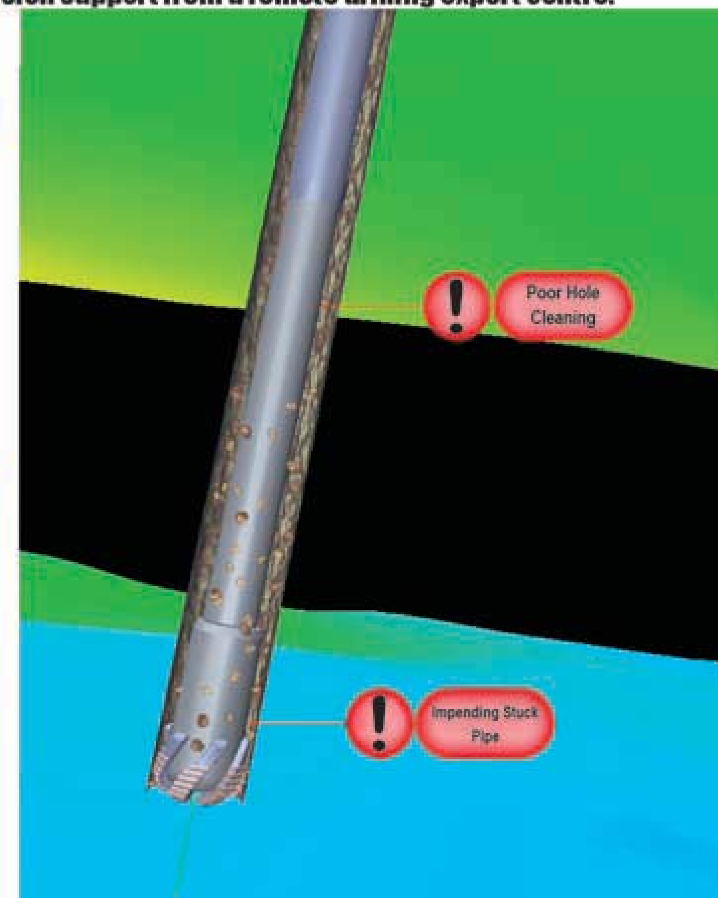




"eDrilling"

eDrilling is a new and innovative system for real time drilling simulation, automatic problem detection and diagnosis, 3D visualization and decision support from a remote drilling expert centre.





Understanding fault seal risk through 3D Seismic Analysis

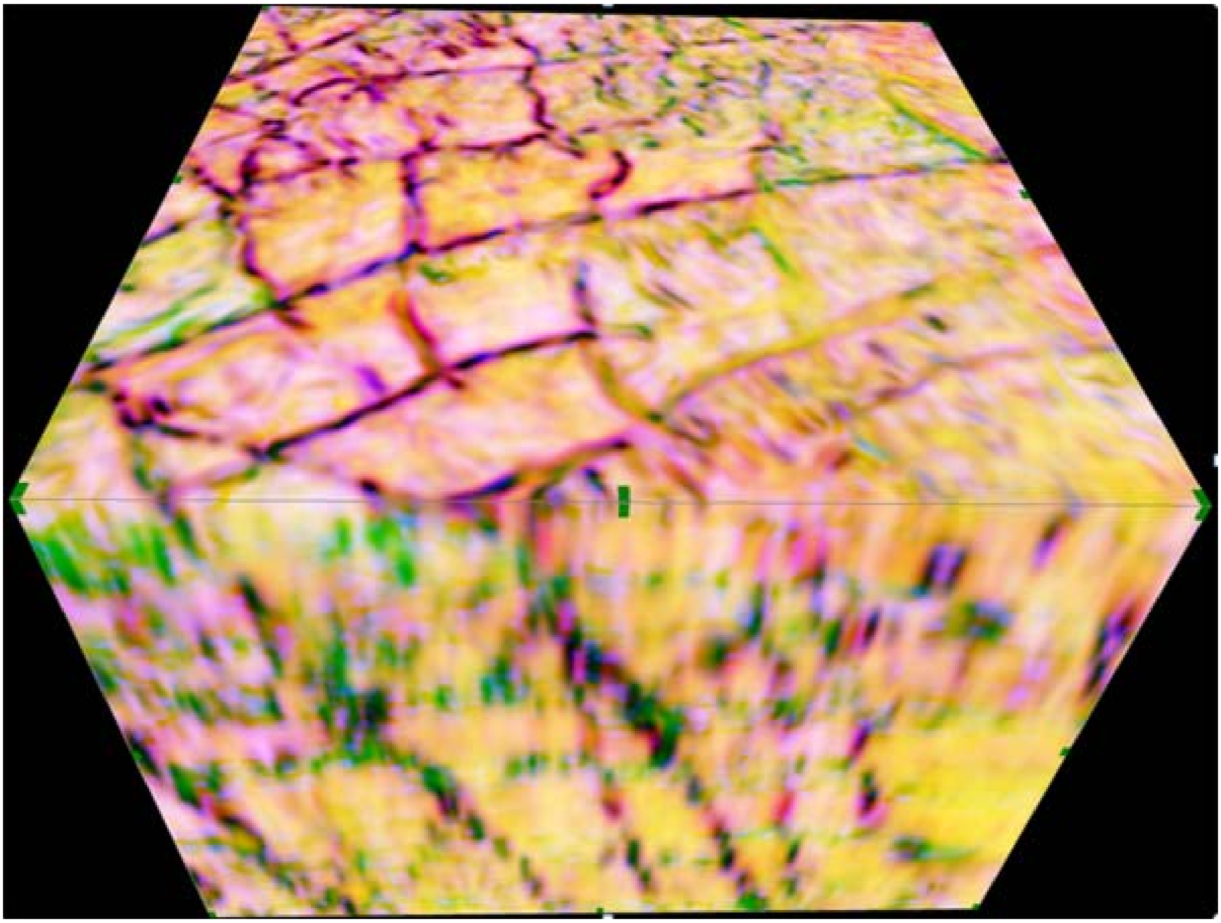
Jonathan Henderson, Managing Director ffA

Billions of dollars are spent each year on acquiring and processing 3D seismic data. Competition in this market has created something of an arms race amongst service providers to deliver improved data quality and resolution. With the costs and challenges of finding and extracting hydrocarbons increasing continually the case for requiring better datais quite forceful. However, whilst the potential for better seismic imaging to unlock more value for E & P companies is widely acknowledged what is sometimes forgotten is that it is not the data itself that is important but the information that it contains.

Converting large volumes of seismic data to information is not a trivial task and, at least in the geoscience domain, our industry has the problem of being veryrich in data but poor in information. To redress this imbalance there is a pressing need for techniques that can convert seismic data to geological information much more effectively and efficiently.

Unfortunately, in the current seismic workflow,the problem of data overload is often dealt with by simply ignoring large amounts of the available data even though this data may have been very costly to acquire. This is particularly true at the seismic interpretation stage where, despite

Faults are generally interpreted as a set of 2D planes (orange plane) whereas the 3D geometry of the fault needs to be known to assess fault sealing capacity fully.



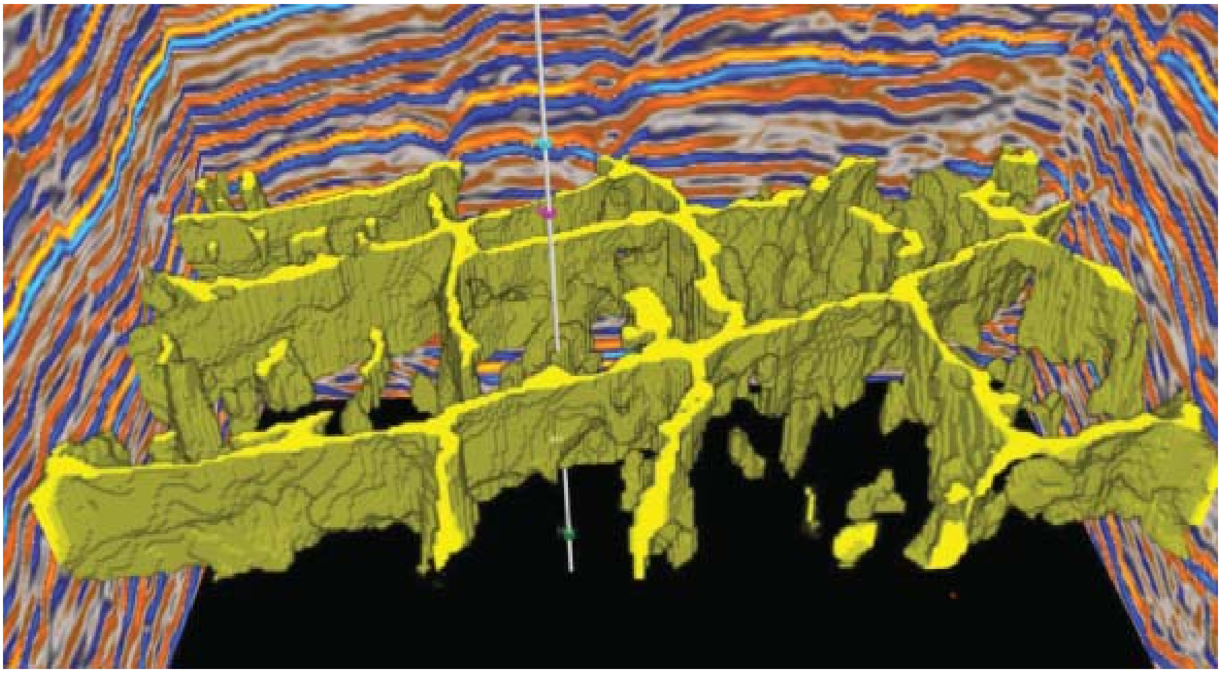
Application of 3D seismic analysis, and using sophisticated colour visualisation techniques to allow different characteristics to combine different characteristics, make it possible to gain an understanding of very complex fault systems much more quickly and intuitively than conventional fault picking.

some significant advances in interpretation technology, a large part of the process is still reliant on tools that arose from the desire to have software applications that replicate paper section interpretation methods.

There are a number of serious shortcomings in the way that current seismic interpretation tools work. Firstly, information is revealed incrementally as the interpretation progresses. So the interpreter has to plot a path through the data maze with no overall map to give certainty as to whether the interpretation they are compiling is converging on a correct model of the imaged geology. In addition, there is rarely time to consider or generate the alternative interpretations that are necessary to understand fully the uncertainties in the interpreted geological model. The second problem arises from not taking full advantage of the seismic resolution to accurately delineate the true 3D geometry of complex geological elements. When this is combined with the inability to fully analyse what the seismic data is telling us about properties of the imaged geology, such as whether a fault is sealing or not, we have an interpretation process that is not delivering information that can be crucial to the technical and economic success of E & P projects even though we have data which contains this information.

To overcome these issues we need to insert a much fuller analysis of the data into the seismic interpretation process. Many of the seismic analysis processes that need to be incorporated into the workflow already exist. What is exciting now is that advances in GPU processing, which allow sophisticated seismic analysis and 3D modelling to be carried out on the interpreters desktop, and allow more detailed models to be constructed, have now reached the stage where we have the potential to build a new generation of subsurface workflows. The gains in efficiency that can be achieved in workflows built around these technologies are a fundamental requirement if we are to start making the most of the advances in seismic imaging.

The gains that can be achieved through integrating 3D seismic analysis into the interpretation



3D seismic data allows the true 3D geometry of faults to be delineated providing information that can be crucial to understanding fault sealing capacity when well data is sparse or ambiguous.

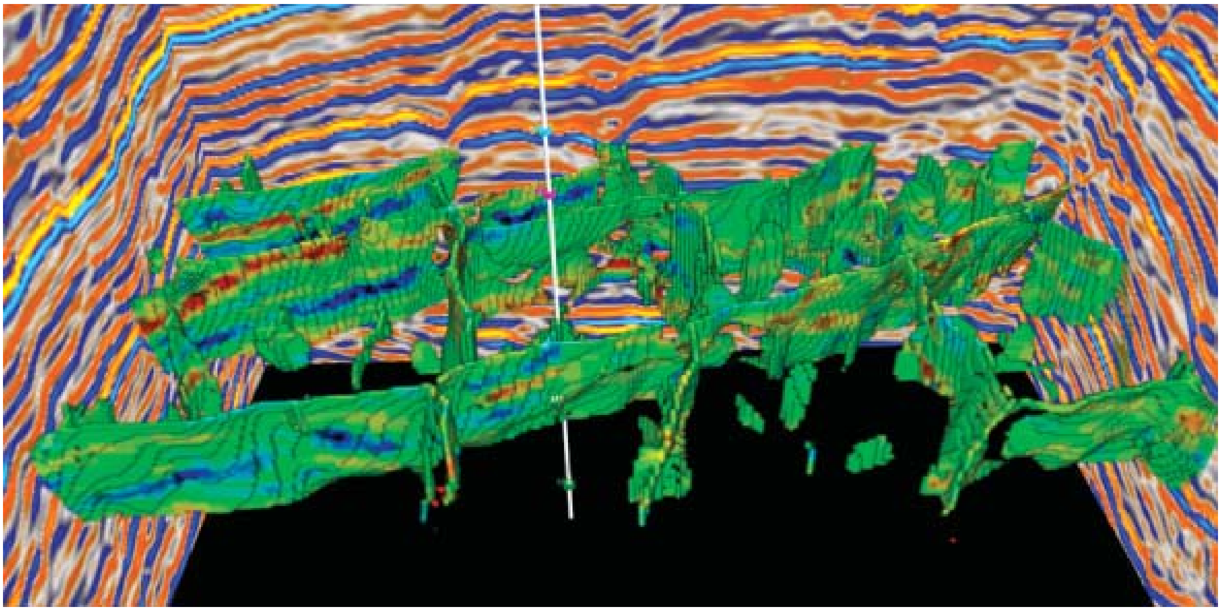
workflow are best shown by example. One of the main jobs of seismic interpretation is to generate a structural framework that allows the influence of faulting on basin evolution and hydrocarbon migration and trapping to be understood. An accurate understanding of geological faulting is central to successful oil and gas exploration and production in every hydrocarbon province.

Geological faults are complex 3D systems that can be very heterogeneous. The impact of faulting on hydrocarbon exploration and exploitation can be very varied. Faults can be the pathways along which hydrocarbons migrate to form reservoirs, the trapping mechanisms that allow hydrocarbons to pool within reservoirs,the source of the permeability required to produce reservoirs, or the reservoir itself.

Seismic imaging of faults is associated with significant issues that mean drawing inferences within or adjacent to a fault can be associated levels of uncertainty that are much higher than for the strata surrounding a fault. For this reason, until very recently, little attention has been given to analysing seismic data associated with faults. This has changed due to pioneering work carried out by ffA in collaboration with GDFSuez. This work consisted of a three year Fault Damage Zone (FDZ) analysis project to look at whether it was possible to obtain information on fault sealing capacity directly from 3D seismic data with no or only very limited well data. The motivations for this work were a need to understand fault seal risk in exploration projects and better understand compartmentalisation in producing fields, particularly when there were discrepancies between expectations arising from standard interpretation results and production data.

The FDZ project resulted in the development of a set of tools for seismically driven fault analysis. With these tools it is now possible to accurately delineatethe 3D geometry of the fault damage zone as expressed in the seismic data. Once you have an accurate representation of the fault damage zone the tools are then used to compare the seismic response or properties derived from the seismic response across the fault to provide indicators relating to the likelihood that fluid migration could occur across the fault. An important factor in these techniques is that they provide information about faults that was previously unobtainable at the very high lateral resolution that seismic data gives us within a workflow that can be achieved very quickly. To quote Jean Francois Dutzer, Geoscience Manager at GDFSuez, the FDZ tools "...provided new insights within half a day starting from scratch".

The detailed representation of the 3D geometry of the fault damage zone on its own allows inferences about variations in fault seal along the fault to be made. However, combining this information with fault throw analysis and an examination of Direct Hydrocarbon Indicators (DHI), fluid or lithology indicators and how they vary across the faultcan greatly



Comparison of the seismic response across and within the seismically delineated fault damage zone adds another dimension to the information available for understanding fault seal risk.

increase confidence in fault seal prediction.

No matter how sophisticated the technology it is always possible to mis-interpret seismic data. For this reason the FDZ tools, like all robust seismic analysis techniques, have two important characteristics. They allow the results at each stage in the analysis process to be examined and multiple realisations to be generated quickly and easily. The FDZ tools,provide the required robustness through defining the analysis as a workflow so it is possible to examine and optimise the results ateach step of the process. Giving the interpreter the ability to review what is done to the data at each stage is extremely important. The whole purpose of 3D seismic analysis is to empower interpreters so that they can put their training and expertise to best possible use in making the important interpretative decisions. As the parameters controlling the outcome at each stage can be varied, the ability to produce several realisations and therefore examine different scenarios has been built into the FDZ tools.

ffA's approach to 3D seismic analysis draws heavily from its experience in medical imaging which has some strong parallels with seismic interpretation. The first of these is that we are a long way from being able to automate either seismic interpretation or diagnostic imaging. It is clear in both domains that automated analysis techniques have huge value in providing the information seismic interpreters / radiologists require to make decisions. Experience in the medical domain also highlighted how important it is for decision makers to have control over how the information on which they are basing their decisions is generated if they are to understand the uncertainties and have confidence in their decisions.

As the FDZ example illustrates, 3D seismic analysis has the potential to completely change our understanding of the geological risks in all E & P projects. It is not easy to develop hard economic metrics around a technology like 3D seismic analysis which is just one part of a long value creation processes. However, we are in an industry that is reliant on information achieved through remote sensing techniques and if we consider that 3D seismic analysis provides one of the most cost effectiveways of accessing more information from data we already have then its value is clear. dewjournal.com

about the author

Jonathan Henderson is a physicist with over 20 years of extensive experience in imaging and image analysis. His initial interests were in medical imaging, where he had worked on developing new methods for extracting and quantifying the information contained in x-rays and ultrasound scans. Since joining ffA in 2001, he has used his knowledge of medical image analysis to help the Company develop unique seismic image analysis technologies. Jonathan has been Managing Director of ffA for 5 years during which time the Company, its global customer base and its software portfolio have all expanded substantially.