PS A New Approach Solving Lateral Wells Complexity, Integrating Borehole Acoustics Reflection Survey and Facies Derived Borehole Images for a Better Completion Strategy, Wolfcamp, West Texas*

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Abstract

The Greater Permian Basin (GPB) formed and was divided into several sub-basins. It continued to uncover why the Midland Basin and the Delaware Basin were different based on variances in sedimentary depositions and tectonics. The Delaware Basin represents a syn-tectonic deposition; shaping the complexity of the lateral facies variation, which in turn represents a real challenge for lateral wells evaluation and completion design. The Wolfcamp Formation is the deepest in the center of the basin, measuring approximately 12,000 feet deep, concluding major sea level fluctuations outlining high frequency of depositional cycles. Identifying the depositional facies and solving the structural framework, including faults and fracture analysis, will input to the completion strategy, differentiating the reservoir quality (RQ) and completion quality (CQ) for a better fracking stage placement. This case study is approaching a new technique integrating the depositional facies, fracture identification from borehole images, Anisotropic mechanical properties with their correspondence minimum horizontal stress profile along the well combined with the compressional borehole acoustic reflection survey to reveal the dilemma of understanding the reservoir and preparing the stimulation of the well. Facies identification combined with fracture evaluation was obtained from borehole images in vertical and horizontal sections. Good correlation was observed between specific facies and fracture occurrence, which will be discussed in detail in this paper. Near wellbore fracture observation might not be enough to solve for the real variation of fracture occurrence across the formation away from the borehole. The standard means of evaluating the fractures such as stoneley fracture analysis, and shear anisotropy analysis from dipole sonic may reveal the mid-near well bore events. Borehole acoustic reflection technique provides a method for fracture characterization with a larger distance away the borehole; analyzing the compressional and shear reflections generated by fractures, bed boundaries, faults, etc... originated with the state of the art dipole acoustic tool. An integrated analysis providing detailed study of the microresistivity images and the Borehole acoustic reflection analysis, shedding light on the complexity of the lateral wells drilled in the Wolfcamp Formation is used to identify the way forward for future well stimulation within this area.

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A New Approach Solving Lateral Wells Complexity, Integrating Borehole Acoustics Reflection Survey and Facies Derived from Borehole Images, for Better Completion Strategy, Wolfcamp, West Texas

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Presenter: Olfa Zened, Schlumberger; Edgar Arteaga, Schlumberger

POSTER ABSTRACT

After the creation of the Greater Permian Basin (GPB), it was divided into different sub-basins. Studies conducted on comparison between Midland Basin and the Delaware Basin revealed differences between the two especially on variances in sedimentary depositions and tectonics. The Delaware Basin represents a syn-tectonic deposition; shaping the complexity of the lateral facies variation, which in turn represents a real challenge for lateral wells evaluation and completion design.

The Wolfcamp Formation is the deepest in the center of the basin, located at approximately 12,000 feet of depth, concluding major sea level fluctuations outlining high frequency of depositional cycles.

Identifying the depositional facies and solving the structural framework, including faults and fracture analysis, will input to the completion strategy, differentiating the reservoir quality (RQ) and completion quality (CQ) for a better fracking stage placement.

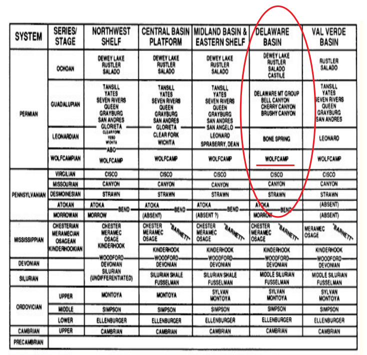
This case study is approaching a new technique integrating the depositional facies, fractures identification from borehole images, anisotropic mechanical properties with their correspondence minimum horizontal stress profile along the well combined with the compressional borehole acoustic reflection survey to reveal the dilemma of understanding the reservoir and preparing the stimulation of the well.

Facies identification combined with fracture evaluation was obtained from borehole images in the vertical and the horizontal sections. Good correlation was observed between specific facies and fracture occurrence which will be discussed in detail in this poster.

Near wellbore fractures evaluation is crucial to understand the different orientation of fracture segments and relation with present day stress. Far field fracture validation is an important main input to simulate the fracture network in a reservoir scale, which will help building a better discrete fracture network model. The standard means of evaluating the fractures such as stoneley fracture analysis, and shear anisotropy analysis from dipole sonic may reveal the mid-near well bore events. Borehole acoustic reflection technique provides a method for fracture characterization with a larger distance away from the borehole, it involves analyzing the compressional and shear reflections generated by fractures, bed boundaries, faults, and other features, originated with the state of the art dipole acoustic tool.

An integrated analysis providing detailed study of the microresistivity images and the borehole acoustic reflection analysis, shedding light on the complexity of the lateral wells drilled in the Wolfcamp formation is used to identify the way forward for future well stimulation within this area.

SIMPLIFIED STRATIGRAPHIC COLUMN



Source: Yang and Dorobek 1995)

CASE STUDY INTRODUCTION

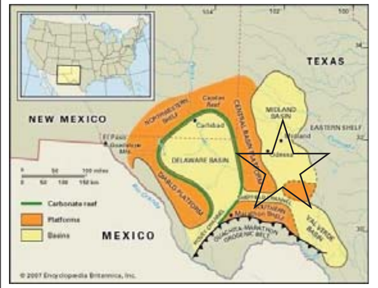
Three pilot wells and two horizontal wells were drilled and analyzed following the integration workflow between borehole image analysis and advanced borehole acoustic surveys.

The wells were evaluated with a comprehensive logging program which included the acquisition of advanced technologies, but was not limited to, Quanta Geo* and Sonic Scanner*, the first one is the latest borehole imager for non conductive mud system, and the last one is the latest acoustic technology which includes cross-dipole and multi displaced-monopole measurements with capabilities of radial measurement to probe the formation for near-wellbore slowness and far-field slowness. The data interpretation was carried out independently from the measurement and integrated in the last phase of the workflow. Focus of the borehole image interpretation was a solid understanding of the fractures typology and distribution, including also the stress analysis from drilling induced fractures recognition. The QGeo data was processed through inversion, an innovative technology which allows the recognition of open or mineralized fractures in a non–conductive mud environment. Such processing allowed a detailed description and classification of the fractures seen. Additionally, borehole image facies derived were distinguished in the pilot holes and easily identifiable in the horizontal section as well.

The anisotropic mechanical properties and stress profiles were derived with the data gathered with the acoustic scanning platform. Both the mechanical properties and stress profiles were later calibrated with the Formation Tester Stress test, which provides minimum horizontal stress, and with an Integrated Stress Analysis that uses dipole and Stoneley waveform radial profiling to derive minimum and maximum horizontal stresses. The results were used to select the best landing point. The calibrated anisotropic mechanical properties (strains) where used to calculate the stress profiles in one of the lateral well from the same pad, while in the other lateral well the mechanical properties where not calibrated. However, it is important to recall that for the laterals is more important the stress contrast than the nominal value, therefore the need of a calibrated stress is not mandatory.

* Mark of Schlumberger

DELAWARE BASIN LOCATION MAP



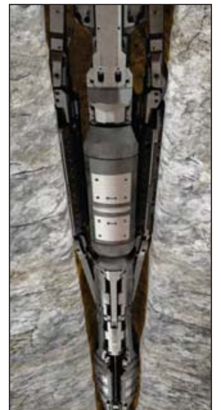
☆ Wells general location

The wells subjects of this case study are located in the Delaware basin, one of the largest oilfield in West Texas and SE New Mexico.

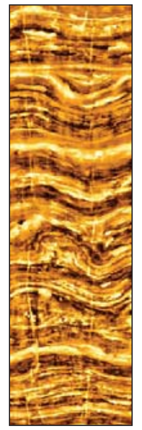
PHOTOREALISTIC RESERVOIR GEOLOGY SERVICE

Quanta Geo service's physics of measurement are entirely new, but they are more similar to WBM imagers than previous generation OBM Imagers. Due to AC voltage applied between the current return and the 192 micro electrodes, the resulting AC current passes directly through each button thus making the tools equally sensitive to horizontal and vertical features. The effective electrical cross section of each button measures only 0.24 in vertically by 0.13 in horizontally. These dimensions define the spatial resolution of the image, although much smaller features, such as fractures, may be imaged where there is significant resistivity contrast versus the background.

The sonde design is composed by eight independent, interlaced trapezoidal dual arms equipped with eight imaging pads. This allows the capability for downlogging utilized in this case study while logging the lateral sections.



Specifications	
Measurement	
Output	Formation images and dip
Logging speed	0.2-in sampling: 3,600 ft/h [1,097 m/h]
	0.1-in sampling: 1,800 ft/h [549 m/h]
Range of measurement	Sampling rate: 0.1 in [0.25 cm]
	Borehole coverage: 98% in 8-in [20.32 cm] borehole
	Formation resistivity: 0.2–20,000 ohm.m
Resolution	Vertical resolution: 0.24 in [6 mm]
	Horizontal resolution: 0.13 in [3 mm]
Accuracy	Caliper: ±0.1 in [±0.25 cm]
	Deviation: ±0.2°
	Azimuth: ±2°
Depth of investigation	0.2 in [5 mm]
Mud type or weight limitations	Nonconductive mud systems such as oil-base mud
Combinability	Fully combinable, top and bottom
Special applications	Downlogging and uplogging
	Horizontal wells
Mechanical	
Temperature rating	350 degF [177 degC]
Pressure rating	Standard: 25,000 psi [172 MPa]
	High pressure: 30,000 psi [207 MPa]
Borehole size—min	7.5 in [19.05 cm]
Borehole size—max	17 in [43.18 cm]
Outside diameter	Tool: 4.5 in [11.43 cm]
	Arms section: 6.5 in [16.51 cm]
Length	31.2 ft [9.5 m]
Weight	696 lbm [316 kg]
Tension	27,000 lbf [122,300 N]
Compression	11,000 lbf [48,900 N]

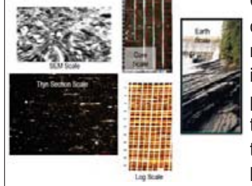


BOREHOLE IMAGES INTERPRETATION WORKFLOW

The following workflow was utilized in regard to the interpretation of the borehole images:

1) Image processing, including speed correction, equalization and normalization. In the case of the QGEO image, the Z90 processing was carried out to isolate the mud impedivity fro the raw data and highlight the formation impedivity.
2) Image was analyzed for fracture presence with specific attention to natural fractures vs drilling induced.
3) Image based facies catalog was defined for the region.
4) Image based facies analysis was conducted in the pilot hole.
5)Comparison between vertical and horizontal fracture propagation was conducted.
6) Comparison between different facies in the vertical and in the horizontal section was conducted.
7) QGEO inversion carried out to output resistivity and standoff image.
8) Reclassification of natural fractures after inversion results
9) Comparison between fractures propagation in the vertical and horizontal well was conducted

SONIC SCANNER IN UNCONVENTIONAL RESERVOIRS



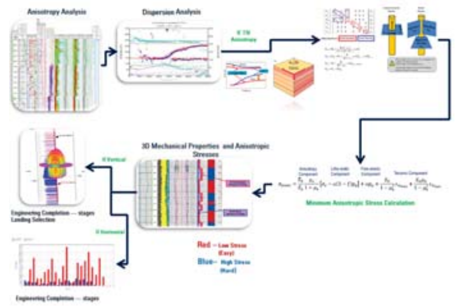
Oil & gas shales are reservoirs of complex mineralogy, variable clay volume, low porosity and extremely low permeability, these reservoirs can produce after multi-stage hydraulic fracturing of horizontal drains, with several sets of perforations per stage. An important input to a hydraulic fracture design is the minimum horizontal stress or closure pressure that is used to understand the fracture initiation pressure profile and fracture containment. Minimum horizontal stress also provides an excellent landing selection criteria. One common characteristic of unconventional reservoirs is the laminated structure nature that have as it can be appreciated in the figure on the left. Laminations are notable in a very fine scale (Microscopic scale) to a very coarse scale (such as outcrop). This laminated/layered nature is known as Transverse Isotropy Vertical (TIV) Anisotropy and is reflected in different physical properties of these rocks such as: mechanical properties, sound velocities, resistivity and others.

SONIC SCANNER IN UNCONVENTIONAL RESERVOIRS

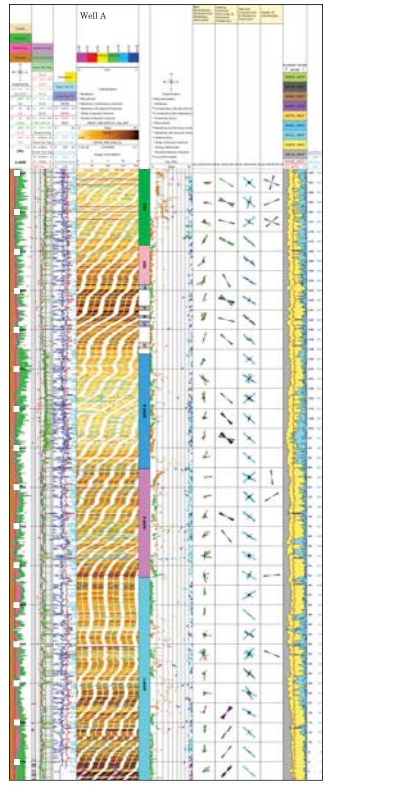
If the differences in mechanical properties are not taken in account (in other words the rock is assumed to be isotropic) the estimated closure pressure will be underestimated and the stress contrast with the surrounding non-reservoir shales (that might contain the hydraulic fracture propagation along the hole) will be overestimated.

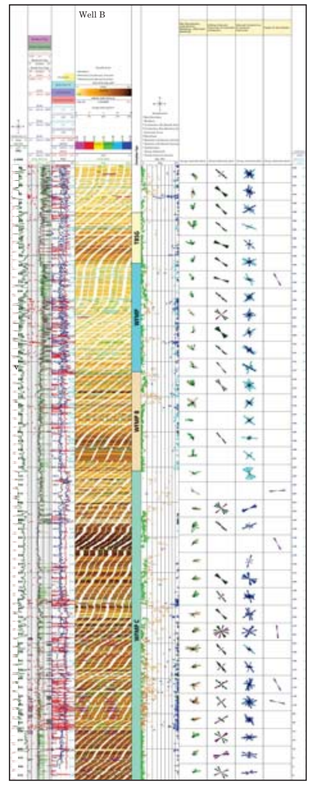
In the past Dipole Sonic technology and applications (such as mechanical properties calculations, closure pressure, Brittle Index) treated the rock as isotropic because the information acquired was not capable to resolve the anisotropic nature of this reservoirs.

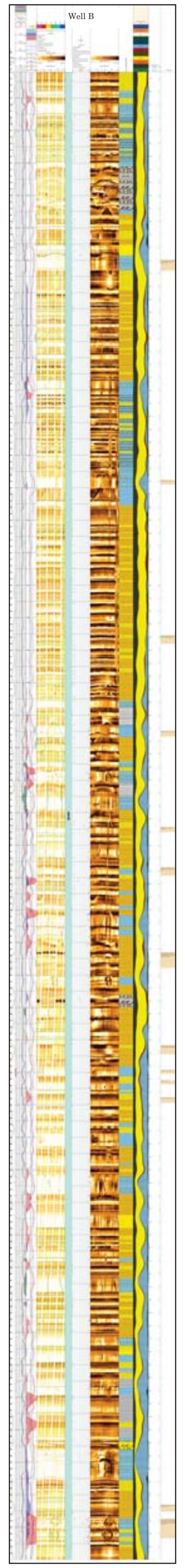
In recent years advance acoustic measurements have been developed to derive anisotropic mechanical properties considering TI anisotropy in vertical and horizontal wells and therefore estimate more accurately minimum horizontal stress values. The workflow varies slightly if it is a vertical or a horizontal well. A brief overview of the steps needed to calculate anisotropic mechanical properties and their applications is showed below.

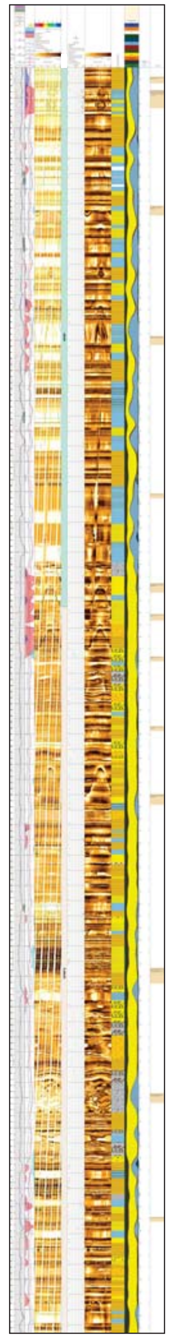


Below: Fracture distribution log for the two vertical pilot wells in the same field. From the below logs can be observed the fracture origin (natural of drilling induced), the fracture typology (resistive or conductive) and the fracture morphology (lithology bound versus continuous). With the side by side view, it is very evident how the maximum stress direction does not change and there is also a very good match on the strike orientation of the resistive fractures.







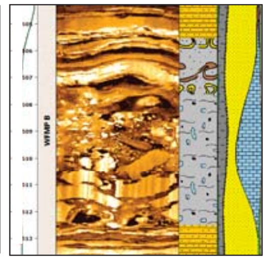


Left & Above: continuous manual facies analysis log for well B. The detailed facies description reveals a complex succession of various facies varying in mineralogical content and varying in the textural characteristics. Some of these facies, ex. Slump sands, might be discontinuous and represent a discontinuities in the deposition.

Calcareous rich facies are abundant and could represent two different phenomenon: deposition of reworked material from the platform and/or shelf, being deposited in the basin with debris flows and mass transport systems, or could be diagenetically related to cementation.

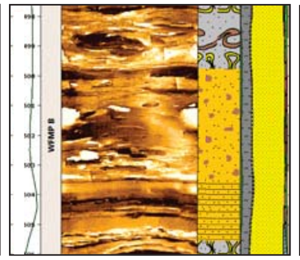
Left: Facies scheme from borehole image logs utilized in the facies analysis conducted in the pilot wells and in general in the studied field. The nomenclature has been based on experienced core to image calibration in the field in studies conducted not in the subjects wells, and take into account textural and sedimentary features seen on the image logs with input from lithology data coming from spectroscopy data or basic open hole logs.

Below and Right: image facies catalog and high resolution features The snapshots have been taken with the 360 deg Full Image: this gap-filling techniques uses multipoint statistics to create a borehole image which covers the full borehole, enhancing the details .



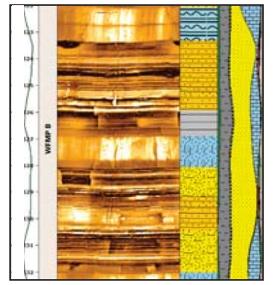
CHANNELIZED DEBRIS FLOW

This debris-flow shows all the components of this deposit type with a typical fining upward profile. Larger carbonate clasts at the beginning of the deposition are triggering an increase in the calcium carbonate reading in the elemental analysis.



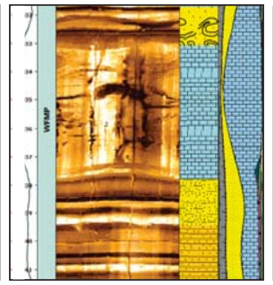
SAND WITH INTRACLASTS

This facies in sand appears in a deposition characterized by high energy deformed sediments. It is characterized by sparse intraclasts of different nature; some carbonate rich and some muddy. The intraclasts are not organized in beddings nor in granulometry profiles.



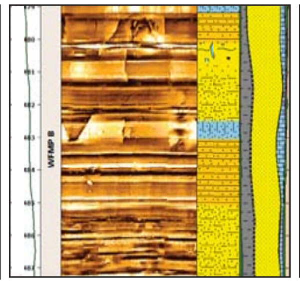
CALCAREOUS SAND; LAMINATED SAND; LAMINATED SHALE;SHALY-SAND; BEDDED CARBONATE

Thin-bedded depositional sequence where the identifiable laminas can be inches thick. Within this interval carbonate rich sands are visible and distinguished by the highly resistive appearance. The presence of calcium carbonate can be related to later cementation and these are the intervals which encourage fracture propagation. The fractures appear to be bounded by more clay rich layers. The differentiation between shaly-sand and parallel laminated sand and shale is made from the elemental analysis output.



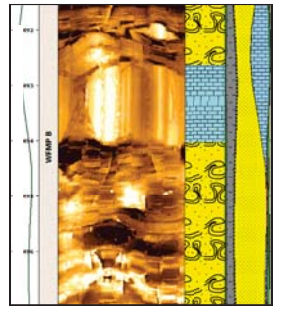
MASSIVE CARBONATES

These carbonate bodies are bounded by siliciclastic facies. They are typically fracture reach ad in this example some dissolution features can be observed.



SANDY DEBRIS FLOW

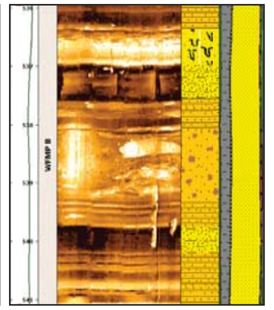
Present within a sand rich deposition. Characterized by presence of predominantly calcium carbonate rich clasts and bounded above and below by laminated facies. Thickness of this deposit is not enough to trigger the flag on the elemental analysis.



DEFORMED SAND

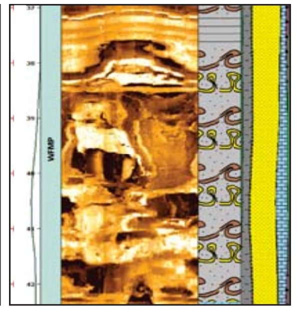
Bedding deformation visible on image. Compaction and dewatering features are often occurring.

In this example, the massive carbonate body visible on the image, might represent a large carbonate boulder as element of the slump which cause the deformation of the sand. The elemental analysis highlight the predominance of quarts in the system, a part over the carbonate boulder, where calcium carbonate presence is highlighted.



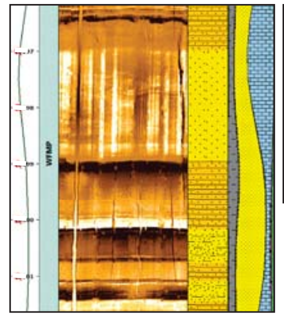
BIOTURBATED SAND

A shortfacies where internal structures are not visible and the typical "mottled" appearance is present on the borehole image. In this example, it is also visible a sand with intraclasts facies, possibly representing the end of a depositional sequence of a channel.



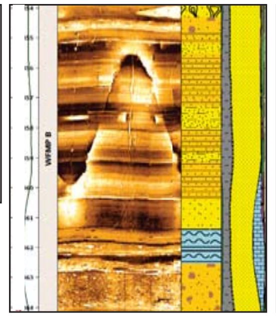
SLUMPS

Deformed beddings are visible on the image. Mixed lithology is highlighted by the elemental analysis. Large shale clasts are observed. The slumps is a solid proof of slope instability, referring to the syn-tectonic depositional motif observed in the well. Lateral prediction of these types of facies is not easy to map; only with image/core data. Fracture propagation is affected laterally.



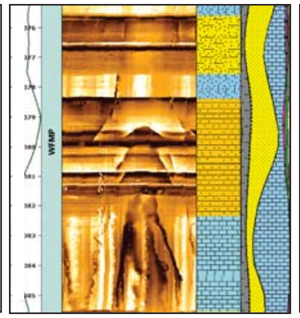
MASSIVE SAND

Identified as predominant sand lithology with lack of internal organization. The sedimentary features inside might be present but not visible at borehole image resolution, or the original beddings might have been altered by bioturbation. In this example, they are bounded above and below by more laminated sand facies.



CONTINOUS FRACTURE

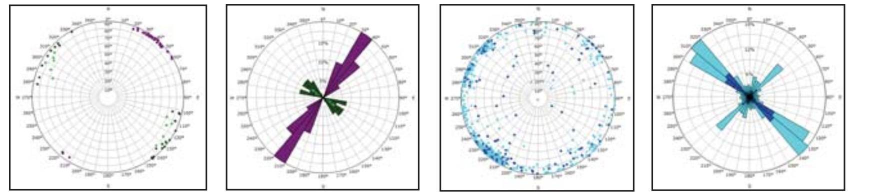
About 4 ft height continuous fracture occurring in a relatively homogeneous facies distribution: all is within shaly-sand parallel laminated facies. At the bottom a parallel bedded carbonate rich interval is observed overlaying a sand with fine grained intraclasts.



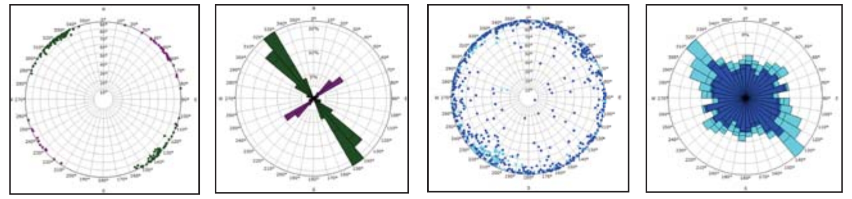
LITHOLOGY BOUND FRACTURES

When the system is enriched in calcium carbonate and the thin or thick beds are characterized by different lithologies, the fractures do not propagate as continuous but they experience a stop and a shift at lithology boundaries. This very well explained some of the complexity created during stimulation.

Below: Stereonet plots for stress direction and strike of natural fractures from the borehole image interpretation for well A and well B. It is observed as the maximum horizontal stress direction is quite consistent across the two wells and the same applies to the orientation of natural fractures. One main difference is observed in the frequency of natural conductive fractures which seem to be higher in Wolfcamp C in well B.



Well A



Well B

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QUANTA GEO (QGEO) INVERSION INTRODUCTION

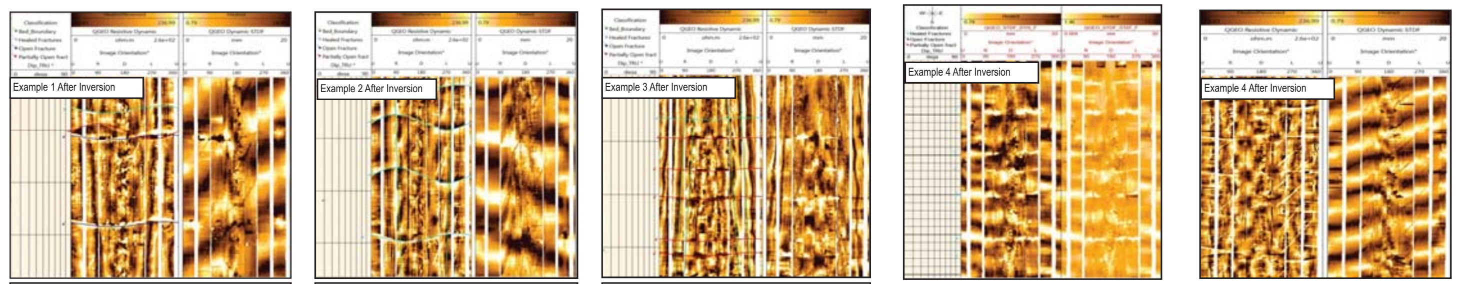
QGEO Inversion represents a novel, methodology aiming to produce a quantitative interpretation of microelectrical images in non conductive mud. The inversion complements the standard images and provides resistivity, dielectric permittivity, and standoff images that can be used for refining interpretations made on standard images.

Inversion is required for a more quantitative approach to the interpretation as the “raw” measurements are still not directly usable for quantitative interpretation of formation resistivity due to an increased sensitivity to large standoff, and response nonlinearity .For complete removal of these environmental effects, the model-based inversion is applied and it serves to the determination model parameters such as: formation and mud resistivity and dielectric permittivity and standoff.

The inversion algorithm and the workflow were validated on a synthetic data set generated using finite-element simulator. The test cases are designed to assess the inversion performance for a wide range of formation, mud, and standoff parameters.

The inversion-generated standoff image, as expected, has a proven valuable complement for the quality control of both the inverted resistivity images and the composite impedivity images. Moreover, it contains unique and interpretable geologic and geomechanical information, clearly delineating breakouts, determining whether fractures are open or closed, and detecting fault slips. Previously applications were exclusively interpreted using ultrasonic acoustic imaging tools. (Yong-Hua Chen at al, SPWLA 55th Annual Logging Symposium, 2014).

On the right side of this column, the two horizontally displayed logs represent the lateral images from well B of the case study. The upper one represent the results after inversion while the bottom one, the results before inversion. On the side of the horizontal logs, the two cross sections with the interpreted fractures are displayed.



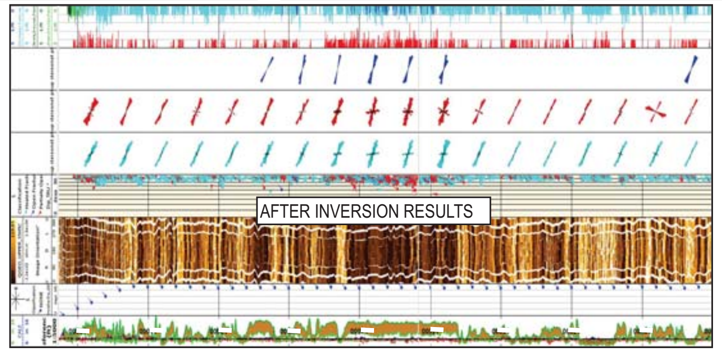
Example 1: Natural fractures continuous across the borehole. The bottom most fracture shows a fine trace on the standoff image (partially open), while the top most fractures shows no trace in the standoff image (mineralized).

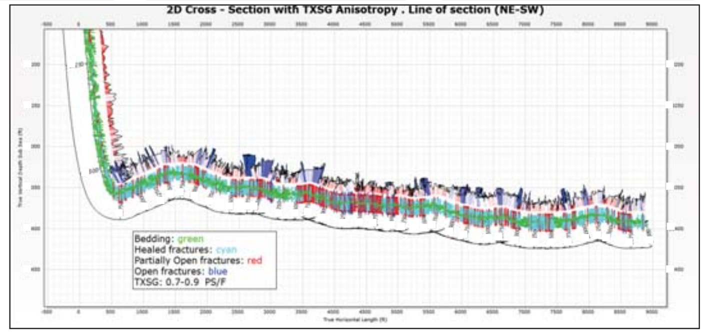
Example 2: Excellent example of continuous natural fractures showing consistent strike in the interval. No trace is visible on the standoff image (mineralized) and a resistive trace is still visible in the resistivity image (calcite filling).

Example 3: Fracture continuous trace is visible on the raw, resistivity and standoff image. The larger standoff is only visible ion a portion of the sinusoid (partially open fractures).

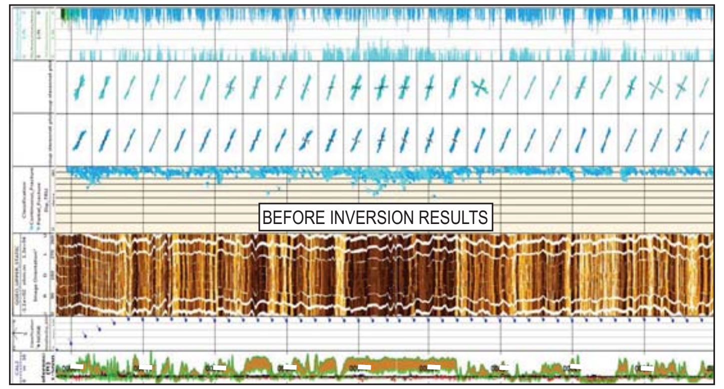
Example 4: These lithology bound fractures are confirmed to be mineralized after inversion processing. Additionally the utilization of the standoff and resistivity image helped in confirming the morphology of these fractures as discontinuous.

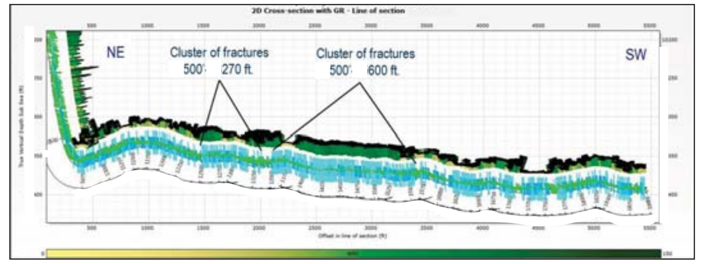
Example 5: An additional information from the standoff image is related to the borehole conditions and can help in geomechnical analysis. In this case the cork-screw shape of the well is very well evident from the standoff image.

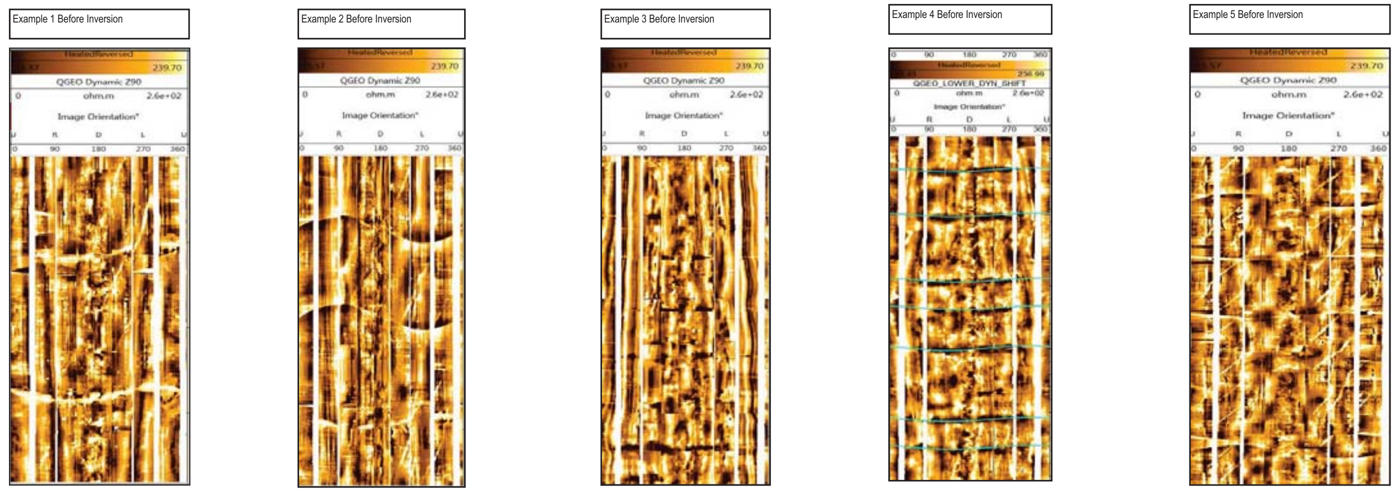


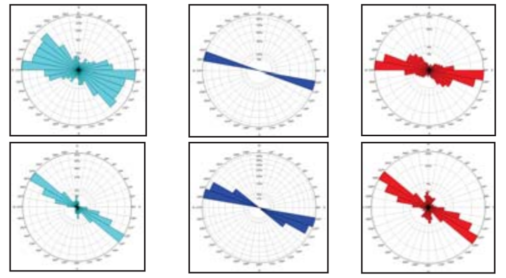


Above: Fracture density log after inversion results. Below: Facture density before the inversion results.









Above: Fracture strike stereonets for natural fractures in the lateral section of well A & B. Natural mineralized fractures are in cyan, natural open fractures are in blue and natural partially open fractures in red. In well B, a total of 1755 mineralized fractures, 30 open fractures and 647 partially open fractures were classified. In well A, a total of 474 mineralized fractures, 1 open fracture and 1444 partially open fractures were observed. Comparing these results with the pilot hole analysis, highlight how in the lateral section the fracture set with strike orientation in the NW-SE direction is very predominant over the secondary fracture set with orientation NE-SW. This comparison also validates the existence of a natural fracture system in this field which could be under represented if looking only at pilot hole images, due to the risk of not imaging sub vertical fractures in vertical boreholes.

The good consistency of fracture orientation between mineralized and partially or open fractures could lead to the following interpretations: the fractures were generated under the same stress regime which has been unchanged for a long period of time, allowing the first generation of fractures to mineralize. Or the two fracture system could represent a single system of mineralized fractures in the subsurface and the aperture observed along the trace of some of these fracture is the result of the drilling process causing reopening along the rock pre-existing weakness.

IMPLICATION OF COMPARISON BETWEEN PILOT AND LATERAL BOREHOLE IMAGE INTERPRETATION: LEARNINGS AND APPLICATIONS

The comparison between the analysis done in the vertical and in the horizontal wells had quite few implication on both of the front: fracture distribution and facies propagation.

From the fractures distribution, it was highlighted that even though a good correspondence in terms of orientation is found, it is difficult to predict the fracture distribution in an horizontal well if we only have available a vertical section of the hole. Additionally the nature of the fractures, if mineralized or open, does not seem to have a perfect match. This is also true in relation to facies distribution. Infact similar facies can be observed in the vertical and in the lateral wells, but it is difficult to predict the extension of these facies, especially the one related to discontinuous depositional systems. If we highlight a debris flow in the pilot well, we can also find a debris flow in the lateral well. The two deposition might belong to the same event but might not represent the same interval within the depositional unit. Figure 1 and Figure 2 below represent an example of debris flow facies seen in the pilot (figure 1) and in the lateral section (figure 2).

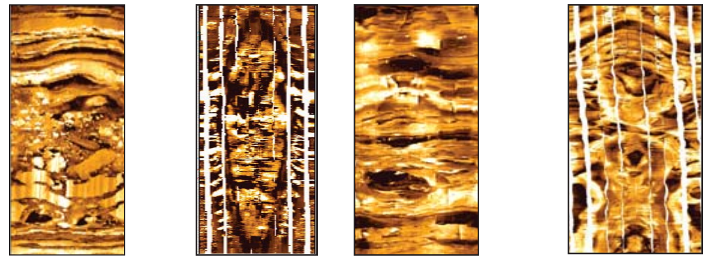
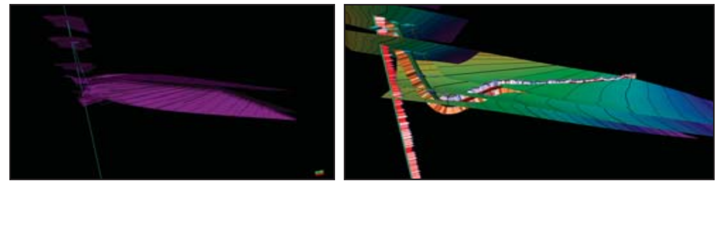
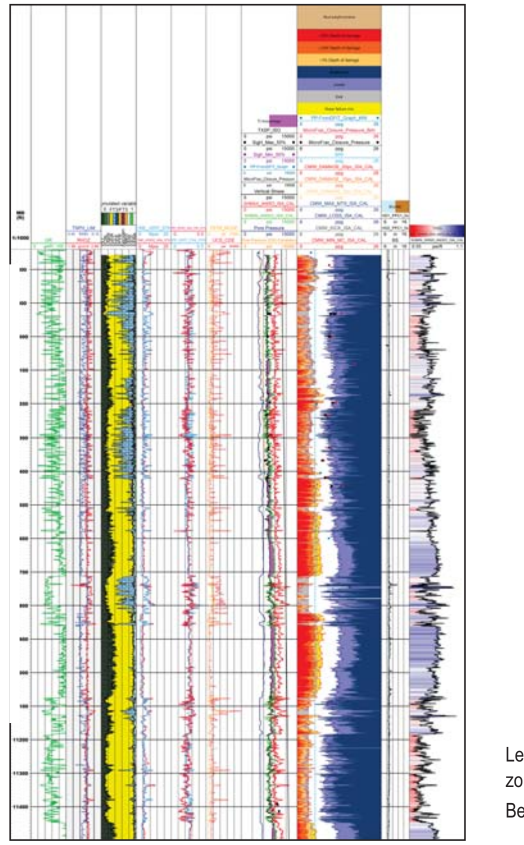


Figure 1 Figure 2 Figure 3 Figure 4

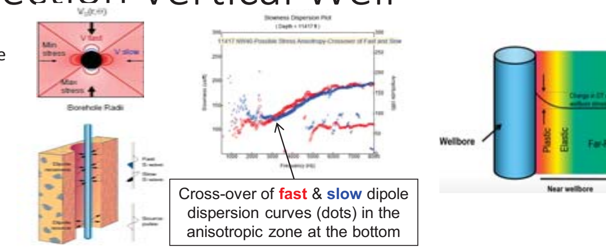
Above, Figure 3 and 4 also represent one of the discontinuous facies, which could have major implication while selecting lateral targets and could play a major role while drilling lateral wells. They are observed in pilot (figure 3) and in the lateral (figure 4) and are contributing to the heterogeneous succession of facies. The data provided through the distribution of facies also proved that simple layered cake structural model can play an ambiguous role in the reservoir modelling as they do not take into consideration this fast and dramatic change of facies that has been seen The two figure below show infact a simple structural model made utilizing formation tops and structural dips only, but might not provide the full understanding of the reservoir facies complexity.





Stress Induced Bottom Section Vertical Well

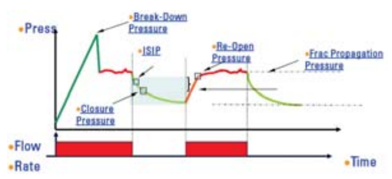
- Cross-over of dipole dispersions indicate the presence of differential stress
- Formation needs to be ‘stress-sensitive’
- No wellbore failure is needed, continuous measurement
- Workflow estimate minimum and maximum horizontal stress values using radial profiles and stoneley horizontal shear.



Cross-over of fast & slow dipole dispersion curves (dots) in the anisotropic zone at the bottom

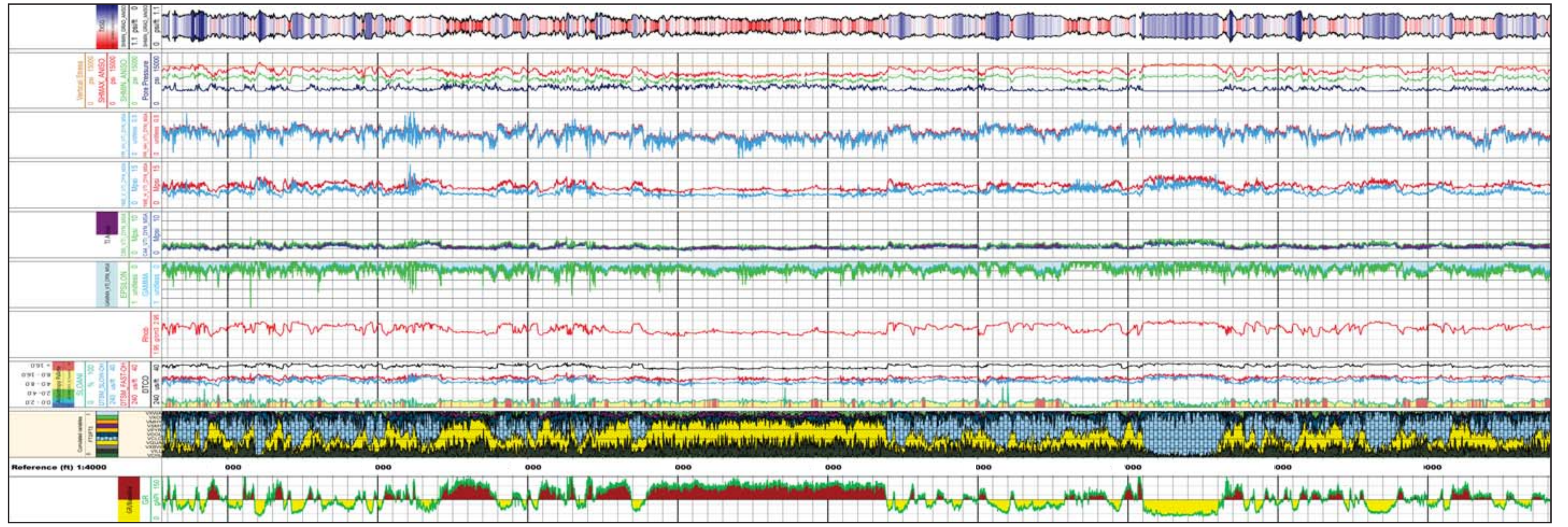
Stress Test on Wireline…

- Using dual packer, down hole pumps and flow control module
- Smaller volume allowing stiffer hydraulic system
- Crisp pressure recording with high quality quartz gauge
- Information provided to calibrate MEM
- Minimum Horizontal stress (closure pressure).
- Breakdown Pressure.



Left: Anisotropic mechanical properties and Mechanical Earth Model results. The Minimum horizontal stress profile was calibrated using formation tester stress test. Maximum horizontal stress profile was calibrated using integrated stress analysis workflow from advance acoustic measurements (as shown above).

Below: Mechanical properties and stress profile in horizontal well using calibration parameters obtained in the vertical well.

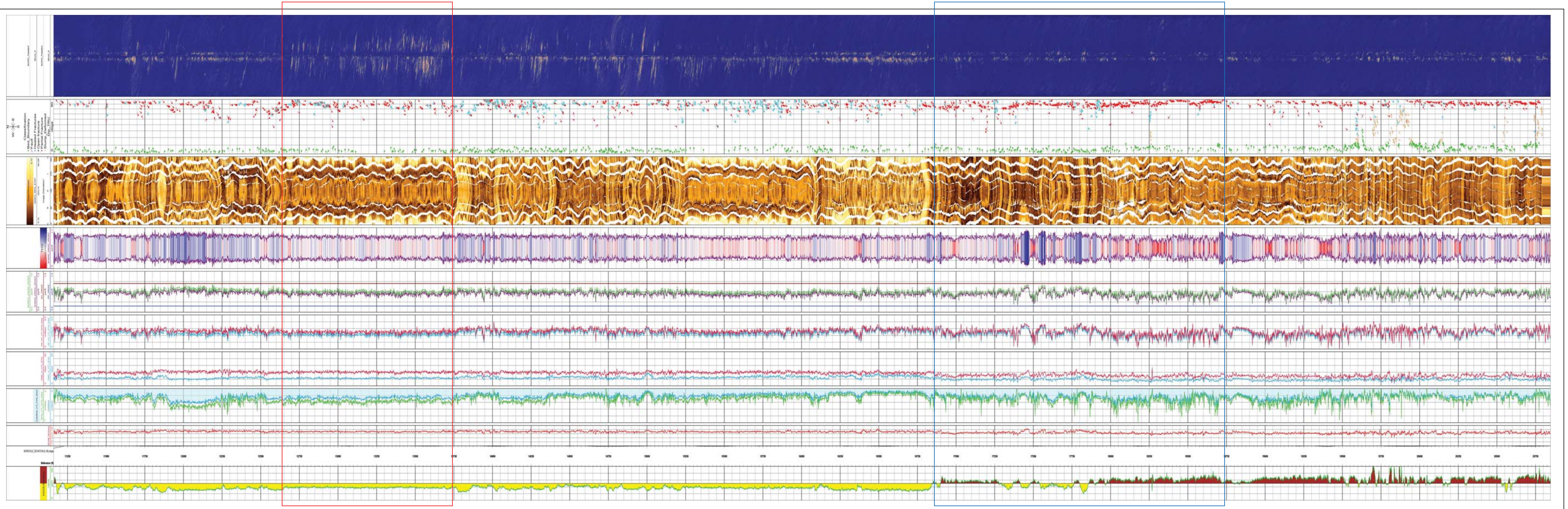


100 AAPG ANNIVERSARY ACE 2017 ANNUAL CONVENTION & EXHIBITION

A New Approach Solving Lateral Wells Complexity, Integrating Borehole Acoustics Reflection Survey and Facies Derived from Borehole Images, for Better Completion Strategy, Wolfcamp, West Texas

E.V. Arteaga, C.C. Contreras, E. Haddad, G. Martinez, V.Vallega, O. Zened - Schlumberger

Presenter: Olfa Zened, Schlumberger; Edgar Arteaga, Schlumberger



The figure is showing an Integrated Interpretation generated from borehole images, acoustic processing and borehole acoustic reflection survey migrated images. The original fractures were reclassified according to the standoff inverted image results.

The reclassification was based on the fracture appearance,

Red tadpoles=partially open fractures

Cyan tadpoles=Mineralized fractures

The highlighted area (inside the red rectangle) is actually showing an area with partially open fractures as concluded from the borehole images and supported by a good extension of those fractures in the far field as observed in the reflection migrated image results. This zone in the horizontal well exemplifies a good case where the completion design might accommodate some changes due to the presence of open fractures as well as their extension into the formation .

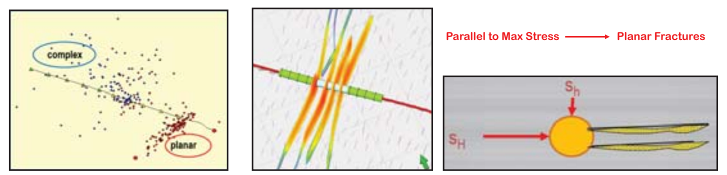
The other highlighted portion of the well (Blue rectangle) a swarm of fractures with a partially open classification was observed. When compared with the acoustic reflection images, it is noticeable that this fracture zone is not contributing to a deep far field fracture propagation. Therefore, the completion design may not need changes in this particular zone.

A well-observed mix of mineralized fractures and partially open fractures within the interpreted interval provides more information to the relationship between a pre-existing tectonic fracture episode and present day stress acting parallel within the same strike orientation.

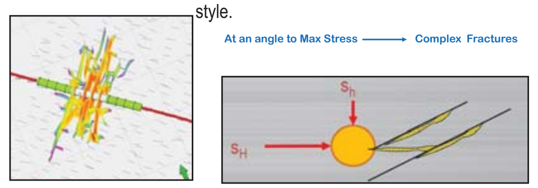
CONCLUSIONS

The integration between several pieces of data acquired, will help in identifying a more robust discrete fractures network model. The model is the main input to identify zones and simulate behavior of the anticipated fracture if any, or reengineer the placement of the stages in an efficient and smart way to avoid extra stages at more cost and more complications. The below mentioned case study is one of the good examples of how the two inputs integrate in one simple input to several completion and frac modeling software.

This type of inclusive logging program allows for data to be integrated and use to engineer completion. General studies conducted through microseismic survey and tied back to borehole images, highlighted the different fracture growth and initiation in interval characterized by natural fractures with strike parallel to the maximum stress orientation, versus those interval characterized by natural fractures with strike at an angle to the maximum stress orientation. Below is a cartoon extracted from a different case study which is used to illustrate the concept of fracture propagation in comparison to a microseismic map.



The understanding of the natural fractures distribution along a lateral wells, helps in predicting fracture growth and propagation style.



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