ओएनजीसी ONGC

How ONGC Relies on Predictions of Fracture Orientations for Drilling in the Cambay Basin, India

aspentech | Case Study

> "Aspen EarthStudy's integrated approach significantly enhanced our understanding of the fracture system in our reservoir, and helped us plan and successfully drill a new well."
>
> —Shaeb Ghosh, Senior Geophysicist, Special Imaging Services, Processing Division, GEOPIC, ONGC, Dehradun

CHALLENGE

Gain a better understanding of the fault and fracture systems of an onshore field to enable effective hydrocarbon exploitation.

SOLUTION

Used the VVAz and AVAz analysis, diffraction imaging and Automatic Fault Extraction technologies contained in **Aspen EarthStudy 360**™ and **Aspen SeisEarth**™ to generate and validate a high-resolution fracture model that helped locate and then successfully drill a well.

VALUE CREATED

- The outputs obtained offered new insights into understanding fracture systems, leading to more accurate well placement and drilling.
- Reliable predictions of fracture orientations enabled better planning of horizontal wells that intersect multiple fracture sets, thus maximizing production from a single well location.
- As a seismic-driven approach independent of wells, it can be readily implemented in other unexplored basins with similar geological characteristics.

Overview

The characterization of reservoir fractures is one of the most significant challenges for onshore well planning and hydrocarbon production, but it is essential for understanding the natural flow of fluid through the rock. In the Padra field in the Cambay Basin, India, hydrocarbon production primarily occurs from the top of the fractured basaltic reservoir. These fractures are interconnected through a transverse fault system. Understanding these fault and fracture systems is crucial for effective hydrocarbon production.

This study used an integrated approach combining diffraction imaging and azimuthal anisotropy analysis of seismic data to characterize fracture sets and their interzonal connectivity.

A Unique Solution for Understanding Fracture Systems

In order to understand the fracture systems of the field, Aspen EarthStudy 360 full-azimuth depth imaging was performed using an anisotropic VTI velocity model. EarthStudy 360 is unique in the fact that it enables the decomposition of the recorded data into in-situ directional angle-azimuth gathers and reflection angle-azimuth gathers. These gathers include rich information for all available azimuths and angles.

The use of diffraction imaging on the directional angle gathers resulted in a successful delineation of the major/minor fault networks within the subsurface, which are difficult to detect from reflection data alone. Automatic Fault Extraction (AFE) was performed to further enhance the major/minor fault networks. This enabled the identification of different fault blocks and NE-SW transverse faults that were not seen using conventional, post-stack, coherency-based attributes (Figure 1). These faults provided new insight into understanding the migration and accumulation of hydrocarbons within the fractured zone.

Simultaneously, 3D reflection angle gathers captured the azimuthal anisotropy effect induced by the fractures. For fracture characterization, a kinematic velocity vs azimuth (VVAz) analysis was performed to evaluate depth moveout variation due to azimuth, and dynamic amplitude vs azimuth inversion (AVAz) was conducted to analyze azimuthal amplitude variation.

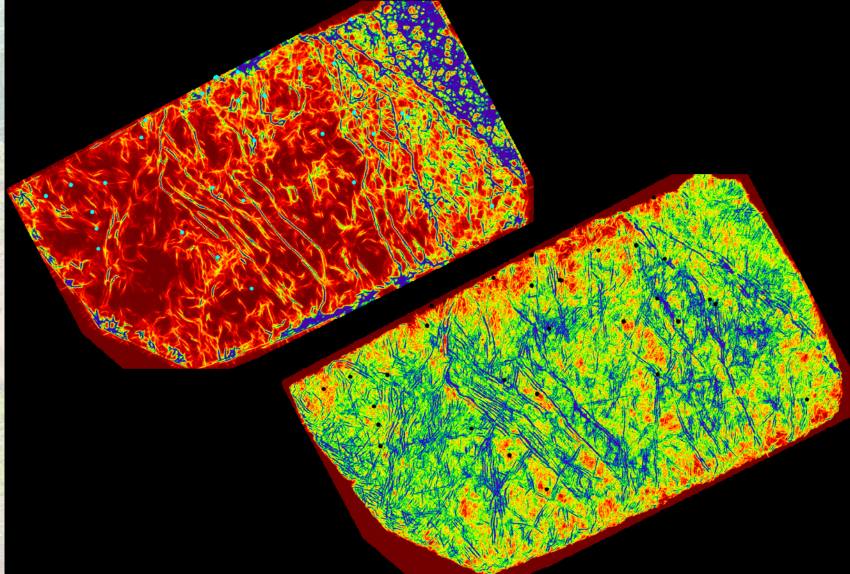

Figure 1. AFE on diffraction image delineating NE-SW trending faults, compared to AFE on coherency image.

Both VVAz and AVAz estimated the intensity and orientation of the fractures in the reservoir rock. These intensity maps were then combined with the diffraction image to generate a high-resolution fracture model.

Results Lead to Successful Drilling and Production

A high-resolution fracture model was generated for the top of the reservoir unit and validated by the incorporation of well production data from the same layer. The wells were categorized as good, fair or poor producers. The analysis revealed that good producers predominantly fell within transversely connected zones with high fracture intensity (Figure 2), while poor producers were mainly located in low-intensity areas.

For example, a high anisotropic gradient was detected near the well in Figure 3b, and it coincided with a transversely connected zone (Figure 3a).

These findings validated the productiveness of the well. Similar comparisons were conducted for other wells, and the results consistently aligned with observed well production patterns.

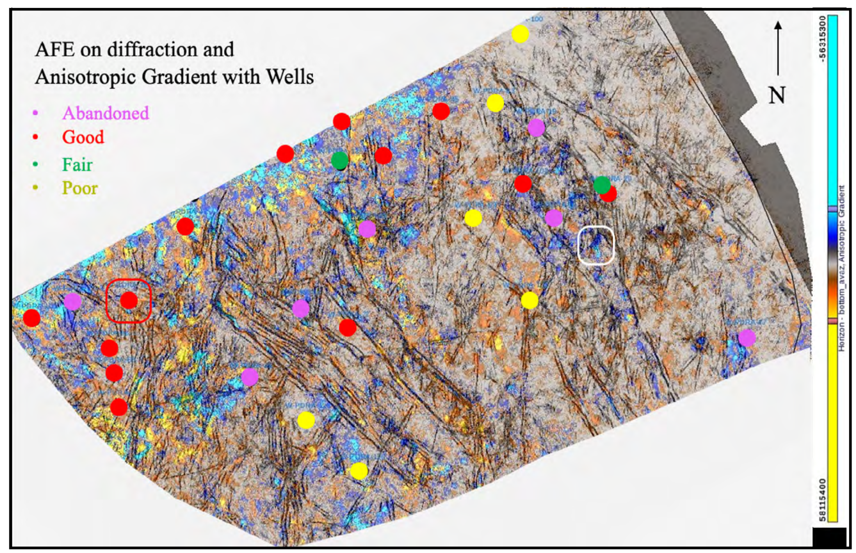

Figure 2. Integrated maps of AFE on diffraction and AVAz anisotropic gradient at trap top with classification of wells.

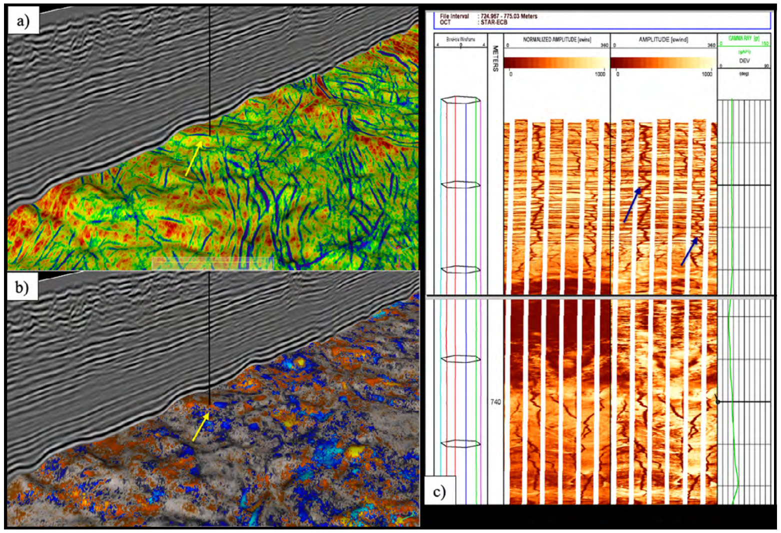

Figure 3. Validation of results: a) connecting faults from AFE on diffraction, b) anisotropic gradient and c) FMI logs.

Based on these findings and after incorporating other interpretation data, an exploratory well was successfully drilled, and the well is now producing commercial oil from the fractured reservoir. The fracture orientations identified in the study also corresponded well with recorded FMI image logs (which measure resistivity in the well bore and are used to directly detect fractures and faults) (Figure 4), confirming the efficacy of this approach. The study is currently serving as a basis for the identification of new development locations.

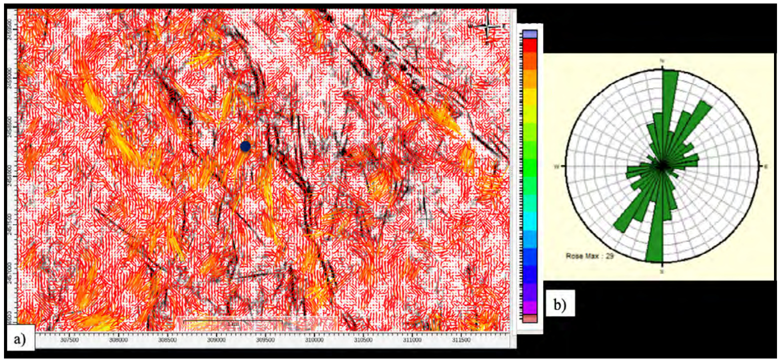

Figure 4. a) Integrated fracture map at trap top showing orientation & intensity (color map) of fractures and b) fracture orientation at trap top from FMI log at well location (black dot).

Enhanced Confidence in the Decision-Making Process

The successful outcome of the drilled location reaffirmed the efficiency and effectiveness of this integrated approach. The application of three different methods to the Aspen EarthStudy 360 direction and reflection angle gathers enables comparison and correlation of the results, and the combination of outputs obtained offers new insights into understanding fracture systems beyond what is possible using traditional post-stack attribute-based studies. Together, these enhance confidence on the part of decision-makers.

As this approach is entirely seismic-driven and independent of wells, it can be readily implemented in other basins with similar geological characteristics. AspenTech is also implementing this technique in Eastern Europe and other regions of the world.

Moreover, the method has been proven to deliver reliable predictions of fracture orientations, enabling better planning of horizontal wells that intersect multiple fracture sets, thus maximizing production from a single well location.

About Aspen Technology

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in asset-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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