Paradigm®

Customer Insight

Prospect Generation

Processing & Imaging

Fractured Carbonate Reservoir, North Sea

The Challenge

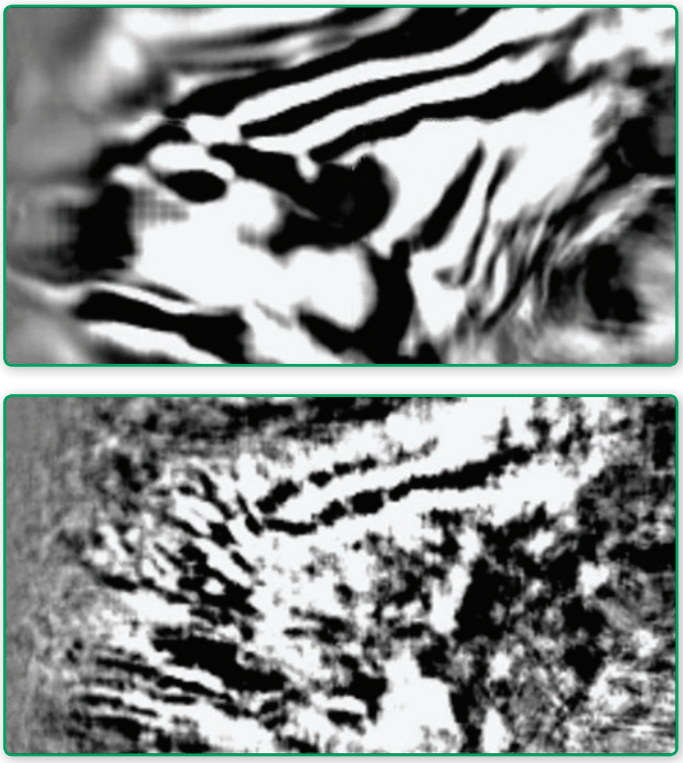
This study depicts a fractured carbonate reservoir in the North Sea, which has been in production for many years. Traditional technologies had resulted in low-resolution images, which did not sufficiently reflect the details within the reservoir. Image 1a shows the quality obtained using a standard migration.

The Solution

Image 1b shows the same reservoir at much higher resolution, and emphasizes the fracture system and the channels. This image was obtained using EarthStudy 360 directional angle gathers where the specular energy was dimmed, and only the remaining diffraction energy was used to create the image. The direct visualization of the fracture system orientation provides extremely valuable information for the production of oil and gas.

The next step was to obtain indirect evidence to support the fracture pattern displayed in the reservoir image, using azimuthally kinematic and dynamic analysis. Full-azimuth reflection angle gathers were created using the EarthStudy 360 Imager. One of the 3D reflection angle gathers in this area (Image 2) is displayed as a cylinder and with transparency, so that the full dimensionality of the amplitude versus opening angle and opening azimuth can be studied.

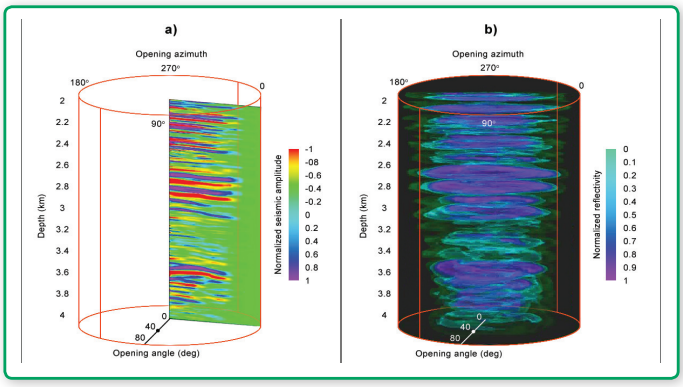
Full-azimuth image gathers can provide diagnostic quality control for the accuracy of the velocity models, and enable the automatic detection of residual moveout (RMO) errors from all angles and all azimuths. The gathers can also be sampled in full-angle or full-azimuth sectors to better understand the influence of azimuth on the velocity model, and to better understand the behavior of seismic amplitude as a function of opening angle and azimuth.



1. Two depth slices from a fractured carbonate reservoir in the North Sea

1a. Image obtained using standard Kirchhoff migration

1b. Image with high-resolution features obtained using diffraction energy weighted stack

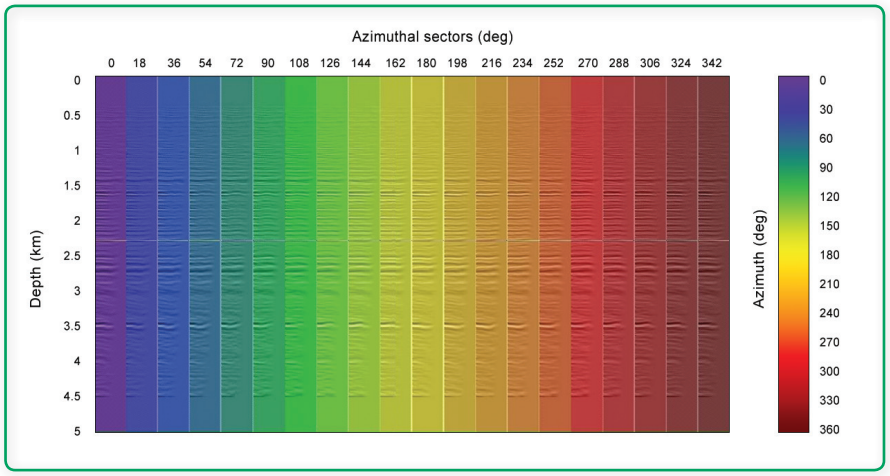


2. 3D reflection angle gather

2a. Selected azimuthal sector

2b. Full 3D volume in transparency mode, emphasizing high reflectivity values

The figure to the right shows 20 azimuthal sectors of the same reflection angle gathers that were extracted on-the-fly from the cylindrical gather shown above.



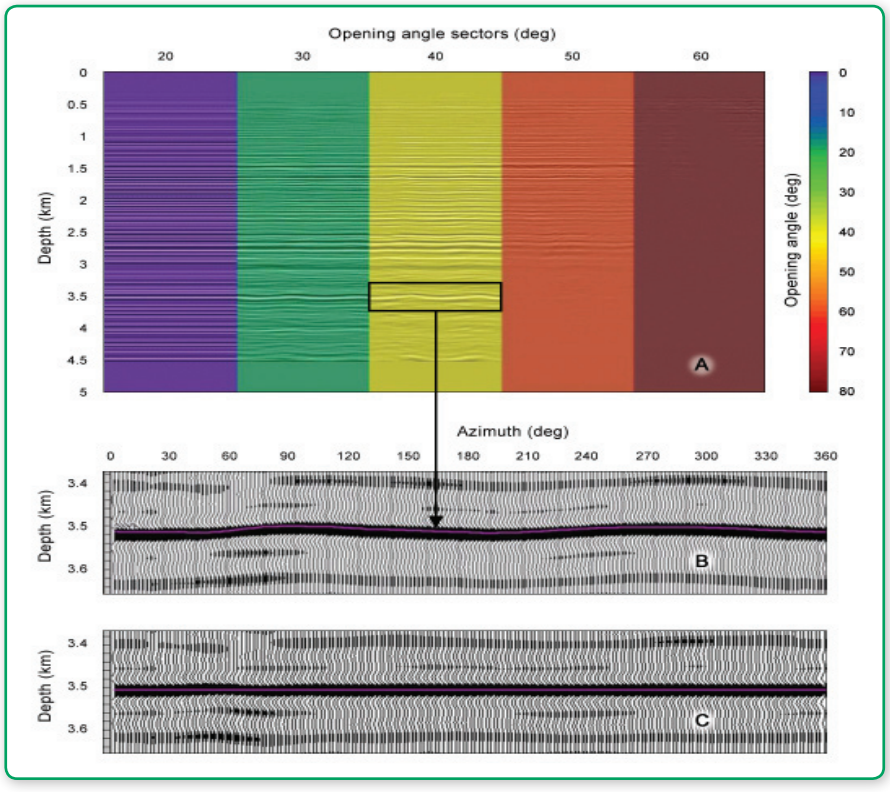
Azimuthal sectors of reflection angle gathers: Residual moveouts vary with azimuths, indicating azimuthal anisotropy effect.

Another view of the data shows five extracted opening angle sectors (20, 30, 40, 50 and 60 degrees), each of which displays full-azimuth reflections. The azimuthally varying reflector indicates an azimuthal anisotropic effect, and is marked by a rectangle. In the figure at the bottom, the reflector is magnified and overlain by automatic RMO picks, which are used to flatten the event. Horizontal transverse isotropy (HTI) analysis was used to extract the dominant fracture system orientation.

Angle sectors of reflection angle gathers: Residual moveouts vary with reflection angles, indicating azimuthal anisotropy effect.

Magnified reflector overlain by automatic RMO picks →

Same event flattened →



The Results

The result of this process confirmed a high correlation with the fracture system orientation visualized above, which increased certainty and confidence regarding the reliability of the analysis.

For further information, contact your account representative or visit www.pdgm.com.