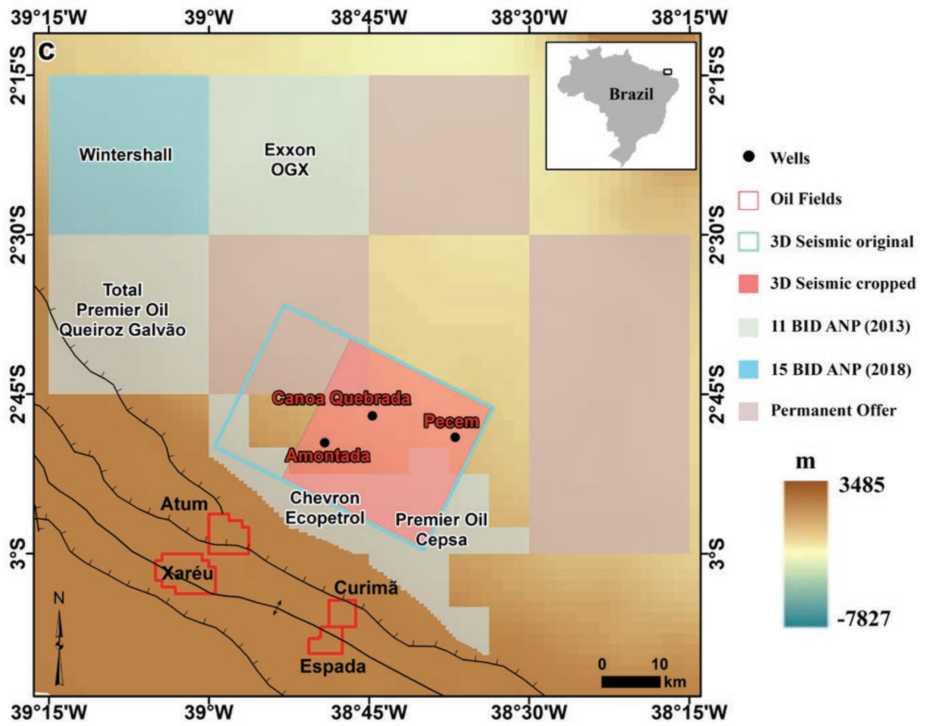
Geophysical Corner

The Importance of Properly Cropping Seismic Data

A Brazilian Equatorial Margin example



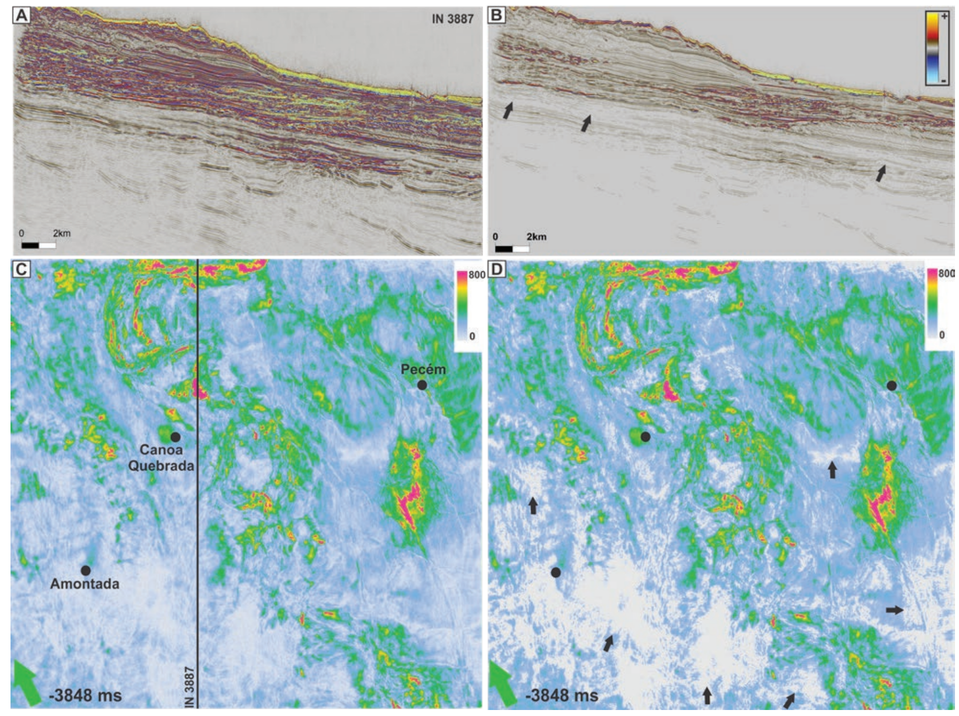


Figure 1 (left): The study area on the Brazilian Equatorial Margin showing the blocks of ANP bidding rounds, deepwater wells and producing areas (in red). The data is gathered from publicly available information (http://geo.anp.gov.br/mapview)
Figure 2 (right): Southwest/northeast-oriented seismic sections showing the amplitude original data (A) and the 8-bit data (B). The black arrows are showing that the study area was affected mainly in the slope. Time slice at t=3848 milliseconds through an RMS amplitude volume showing the location of the three wells and the difference about a 32-bit original data (C) and a realized 8-bit data (D). The slope is more affected by the pitfall in store data (black arrows). The well locations are displayed as a black dot.

The discovery of the Jubilee Field in 2007, offshore Ghana, drew attention to the whole of the equatorial Atlantic as a major hydrocarbon province. After that, a series of discoveries in the counterparts, offshore French Guiana, Brazil, Suriname and Guyana, confirmed the importance of this region as an exploration frontier. Most oil and gas discoveries on the equatorial margin are associated with the presence of stratigraphic traps in turbidite systems. The deepwater of the Brazilian Equatorial Margin is underexplored, as only a few wells have been drilled, however available public domain data from seismic evaluation suggests that there is a high potential for light oil discoveries in the upper Cretaceous turbidite sandstone reservoirs and stratigraphic traps. The Ceará Basin is one of the five basins that comprises the BEM and has seen exploration successes, indicating a working petroleum system and potential hydrocarbon reservoirs. The 15th bidding round of the Brazilian National Agency of Oil, Natural Gas and Biofuels, or ANP, in 2018 had 12 blocks offered in deep and ultra-deepwater in the Ceará Basin, totaling an area of approximately 8,500 square-kilometers. The Ceará Basin is a hydrocarbon producing basin with four fields in the shallow water domains of the Mundaú sub-basin (Xaréu, Atum, Espada and Curimã). In 2012, Petrobras drilled the 1 BRSA 1080 CES well, marking the first deepwater oil discovery in Ceará Basin. After this discovery, the Canoa Quebrada and Amontada exploratory wells were drilled with more complete chronostratigraphic data collection.

This study is primarily based on a 3-D seismic dataset that covers 1,107 square kilometers of the deepwater Ceará Basin. For this demonstration, the seismic cube was cropped and extends over an area of 765 square kilometers. It covers part of Premier Oil, Cepsa, Chevron and Ecopetrol exploration blocks, as well as ANP's blocks of permanent offer (figure 1). Here we present a broad overview of the seismic geomorphology of the study area aiming at delineating the turbidite channels, as the sands are deposited in the channels and can accumulate the hydrocarbons, which can be exploited for the benefits of the petroleum industry, as well as discuss a pitfall associated with the cropping of seismic data.

Preventing Pitfalls When Storing Datasets

Since the seismic cube of this study was very large, we chose to store it in an 8-bit format. This is a very common practice in academic and industry research, occurring when the original SEGY file is read into the interpretation software of choice. Seismic data is usually delivered from the processor as 32-bit, so when an interpreter chooses to store it in 8-bit, the file will be reduced in size by 75 percent. This reduction in file size allows the data to load and render more quickly, which is particularly useful in 3-D visualizations and interpretations.

However, geoscientists need to be careful that the reduction to an 8-bit volume does not introduce errors into their interpretation. For instance, in seismic analysis, especially with regard to attribute generation, 8-bit data can be problematic. Large anomalous amplitudes with geologic meaning might get clipped and any nuance or subtlety in the data of higher-magnitude samples can be lost. An example of this pitfall and how much data this procedure affected an RMS calculation in our dataset is displayed in figure 2. We found that it is essential to review and adjust the amplitude range in a histogram analysis before the data is rendered to an 8-bit format. At this time, the interpreter must be aware of potential quantitative work that may be planned, to check that the 8-bit format will not affect the generation of attributes and seismic amplitude interpretation.

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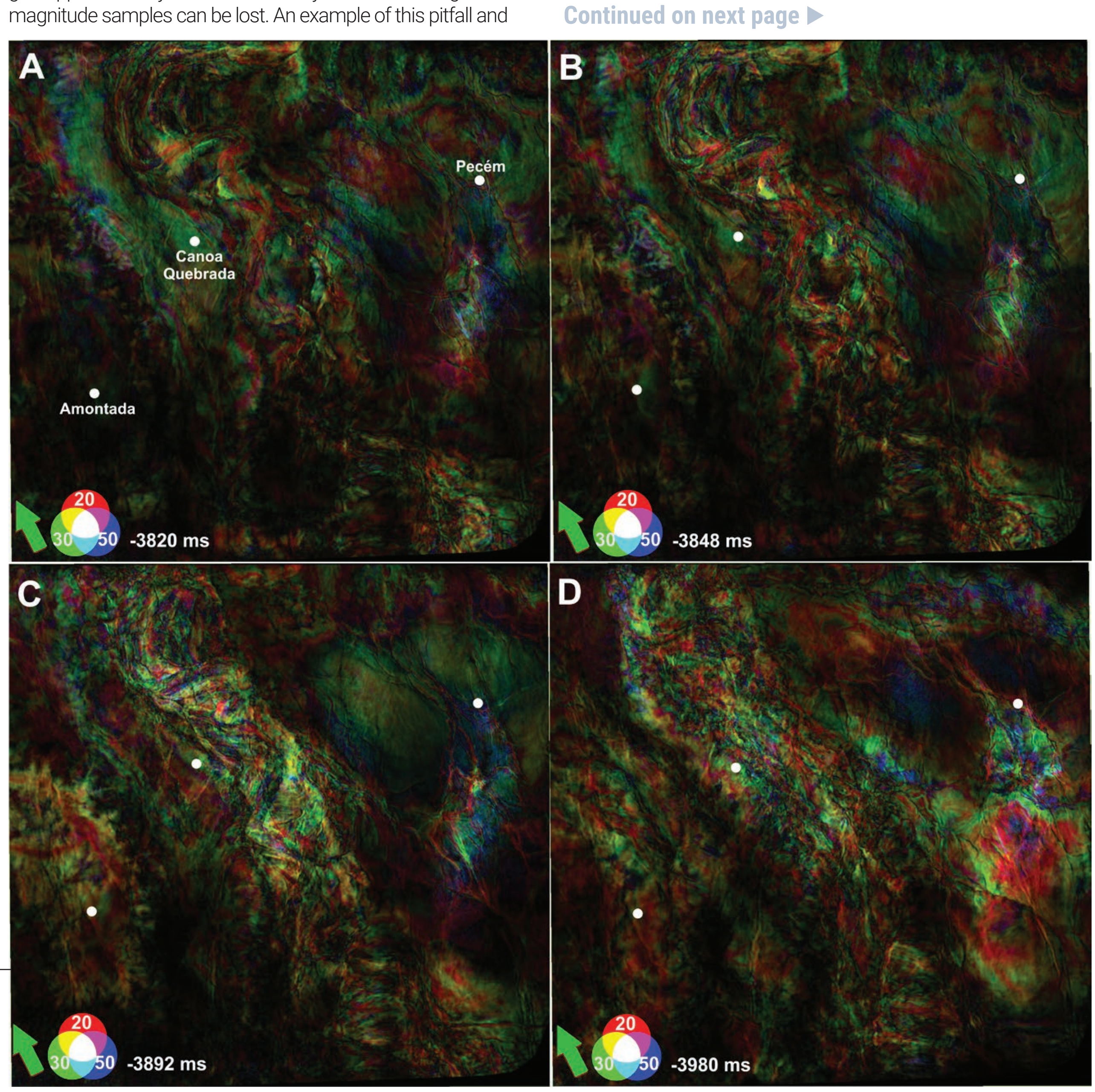

Figure 3: Spectral magnitude components plotted against an RGB color using a combination of 20–30–50 hertz: A) The youngest horizon (-3820 milliseconds); B) the second horizon (-3848 milliseconds); C) the third horizon (-3892); and D) the fourth horizon (-3980 milliseconds). The well locations are displayed as a white dot.

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After this cropping issue was addressed and resolved in our dataset, horizons were mapped and gridded to produce continuous surfaces with a grid-cell size of 50 meters. Then, the 3-D seismic data set was cropped between the Albian and Turonian age intervals, and a seismic geomorphology workflow was used to highlight structural and architectural elements by means of attribute analysis.

Spectral Decomposition Analysis

Spectral decomposition has turned out to be a useful tool in delineating paleo-channels in 3-D seismic data during the past two decades. It is also quite helpful in fault detection, and imaging lateral changes associated with variations in lithology, depositional environments and sediment bed thicknesses. To perform spectral decomposition, our seismic cube was decomposed on three components using the continuous wavelet transform method. Figure 3 displays the RGB blending of the three different spectral magnitude components (20, 30, and 50 hertz). Note the enhancement of channel geometries as this method visually combines together the channels that are delineated in the three frequencies.

The youngest horizon (-3,820 milliseconds) in figure 3 reveals the meandering channel in the central portion of the area of interest. Also, we note that the infill of the channel tends to tune at the lower frequency, while the flanks are more coherent around 30 hertz. A few dendritic lobes are well imaged on the western side, feeding smaller channels. In the northeast, the depocenter and its edges are well delineated at 20 and 30 hertz, respectively. The spectral magnitude analysis also defines faults in this region, imaging them in addition to the stratigraphic features.

Continuing deeper to the second horizon (-3,848 milliseconds), the channel complex is wider and has high sinuosity following a northwest-southeast trend. In the southwest of the area, near the Amontada well, a geological feature similar to a mass transport deposit has its central portion tuning at the low frequency (20 hertz) while its edges are more coherent at around 30 hertz. This structure is linked with a few dendritic lobes that are feeding a straight smaller channel. A fan-like feature is delineated in the eastern area, with its central portion tuning at the intermediate frequency (30 hertz).

The third horizon (-3,892 milliseconds) reveals a widening of the channel complex. The central meandering channel is no longer well delineated because of the various adjacent channels that are interfering with the visualization. The two depocenters are well imaged and their central portion tends to tune at intermediate frequencies (30 hertz), as does a fan-like feature imaged in the eastern area. The faults on the northeast are well highlighted on this horizon.

On the oldest horizon (figure 3D, -3,980 milliseconds) the composite RGB image delineates thin beds inside the channels. The infill of the small channels tends to tune at low frequencies while their flanks are more coherent around 30 hertz. The wider channel complex follow a northwest-southeast trend and it is composed of small meandering channels. A fan-like feature is well delineated in the east of the area and its central part tends to tune at low frequencies (20 hertz) while its edges are clearly better displayed at 30 hertz. This horizon is more affected by faults than the horizons above.

Conclusions

The variations in the frequency decomposition of these deepwater elements provide some indication of the potential variation in depositional thickness and may help in the selection of possible well locations and turbidites targets. After proper cropping and storing of the seismic data volume, and application of spectral decomposition methods, this region has been analyzed to better understand the structural and stratigraphic elements. The fan-like structure has a northwest-southeast normal fault cutting its feeder channel and changing the sediment supply to the southwest of the structure. This feature is very similar to those in the Jubilee prospects and allows insight into the upslope petroleum potential of the Ceará Basin.

Acknowledgements

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(Editors Note: The Geophysical Corner is a regular column in the EXPLORER, edited by Satinder Chopra, Founder and President of SamiGeo, Calgary, Canada, and a past AAPG-SEG Joint Distinguished Lecturer.)

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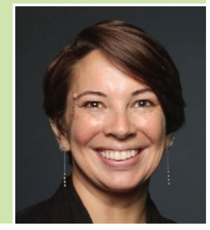

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