Enhancement of Fault Definition by Using Frequency Spectral Decomposition Technique in Mari Gas Field*

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Abstract

In the Mari field, 3D seismic, conventional attribute methodologies on the full stack, broadband data set showed an ambiguous fault definition. Frequency Spectral Decomposition has been applied on Mari 3D seismic data and generated attribute maps, which exhibited substantially more fidelity than full-bandwidth, conventional attributes. It has been found that fault definition is superior to conventional attributes. Optimal integration of Spectral Decomposition with other appropriate information yielded a more comprehensive understanding of the reservoir. Therefore, Frequency Spectral Decomposition is a new and better approach to squeezing out reservoir detail of fault definition from seismic data.

Introduction

The Mari Gas field is located in the central Indus Basin area, Thar slope platform, which gradually slopes westward. The shelf abruptly downwarps represented by the Karachi, Sui-Sulaiman, and Bannu-Soan troughs south to north. At these troughs, post-Jurassic sediments represent great thickness, gradually thinning up on to the shelf. An arcuate axial fold belt was created by the Himalayan orogeny in the western border of the Indus Basin. The Mari structure is more or less similar to the Khairpur high. In the Mari field, gas was found in the shallow reservoir Habib Rahi Limestone of Middle to Upper Eocene, the Kirthar Formation, and in the Lower Goru sandstone reservoir of the Cretaceous age.

Exploration History

Mari has a long exploration history. The first well was drilled by Esso Eastern Inc. in 1957 and tested gas in Habib Rahi Limestone. Later, the field was developed in phases (i.e., 1966, 1968 and 1985) by drilling a number of wells. In 1986, 2D seismic survey was carried out to delineate the structure for further development. Afterwards, a series of 2D seismic surveys were conducted in 1987, 1988, 1995, 1999, and 2000, and ultimately 3D seismic survey was carried out in 2002 for further field development. MARI area is shown in Figure 1.

Frequency Spectral Decomposition

Frequency Spectral Decomposition is a relatively new technology for generating high-resolution seismic images of structural and stratigraphic reservoirs. The seismic wavelet that propagates through the subsurface contains many frequencies. Spectral decomposition breaks down and decomposes any geologic event into a series of frequency slices by using discrete Fourier transforms. These transforms filter the seismic time series into its individual frequency components. To find out detail, spectral decomposition leverages studies in delineating complex fault systems in 3D surveys.

Tuning Cube

Spectral decomposition phase tuning cube was constructed using Landmark's SpecDecomp Software. Extensive parameterization was performed on 3D seismic data (Figure 2) to find out suitable window lengths and frequency values. Frequency values were evaluated from 0-125Hz (Nyquist frequency). Animation is the tool used to decide the suitable parameters.

Volume Interpretation

Discrete frequency volume interpretation was performed by using parameters from the tuning cube. This volume was analyzed and interpreted for the whole 3D survey. By analyzing the volume, we determined that frequency spectral decomposition phase cube demonstrated a well-defined picture of faults, whereas conventional seismic and traditional phase attribute showed poor fault definition (Figure 3). Then this technique was applied along a horizontal section and spectral decomposition phase attribute map was generated for 19Hz frequency slice (Figure 4). This information would be helpful in better understanding fault and fracture patterns. These patterns are important for the optimum recovery of hydrocarbons.

Conclusion

Research on this case history revealed that frequency spectral decomposition phase component provided sharper definition of faults than a conventional phase attribute. It has verified previously seen faults and detected several small faults for the first time. Animation was one of the important tools used to detect subtle changes that were difficult to detect in static seismic display.

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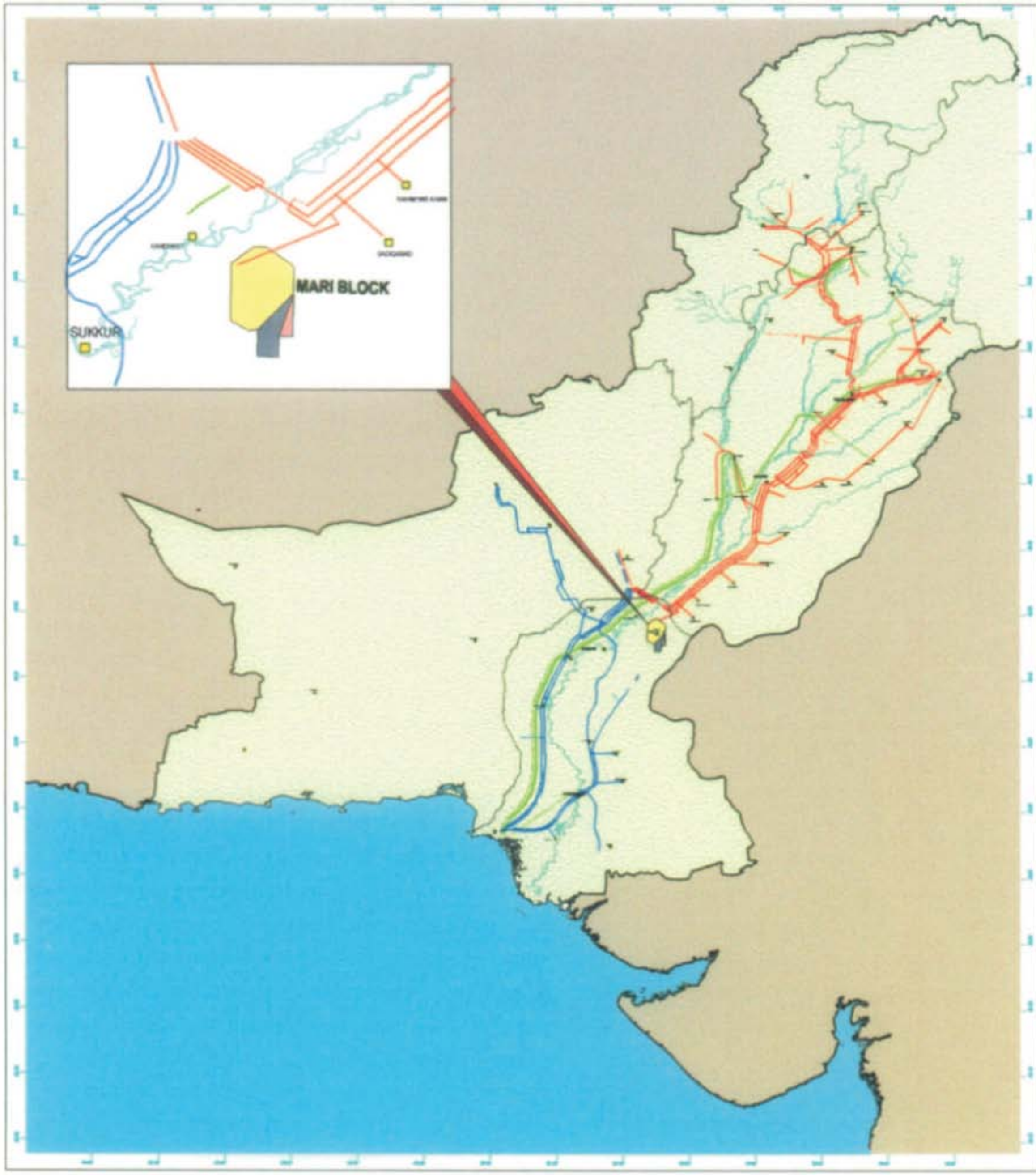

Figure1. Location Map of Mari Gas Field, central part of Pakistan.

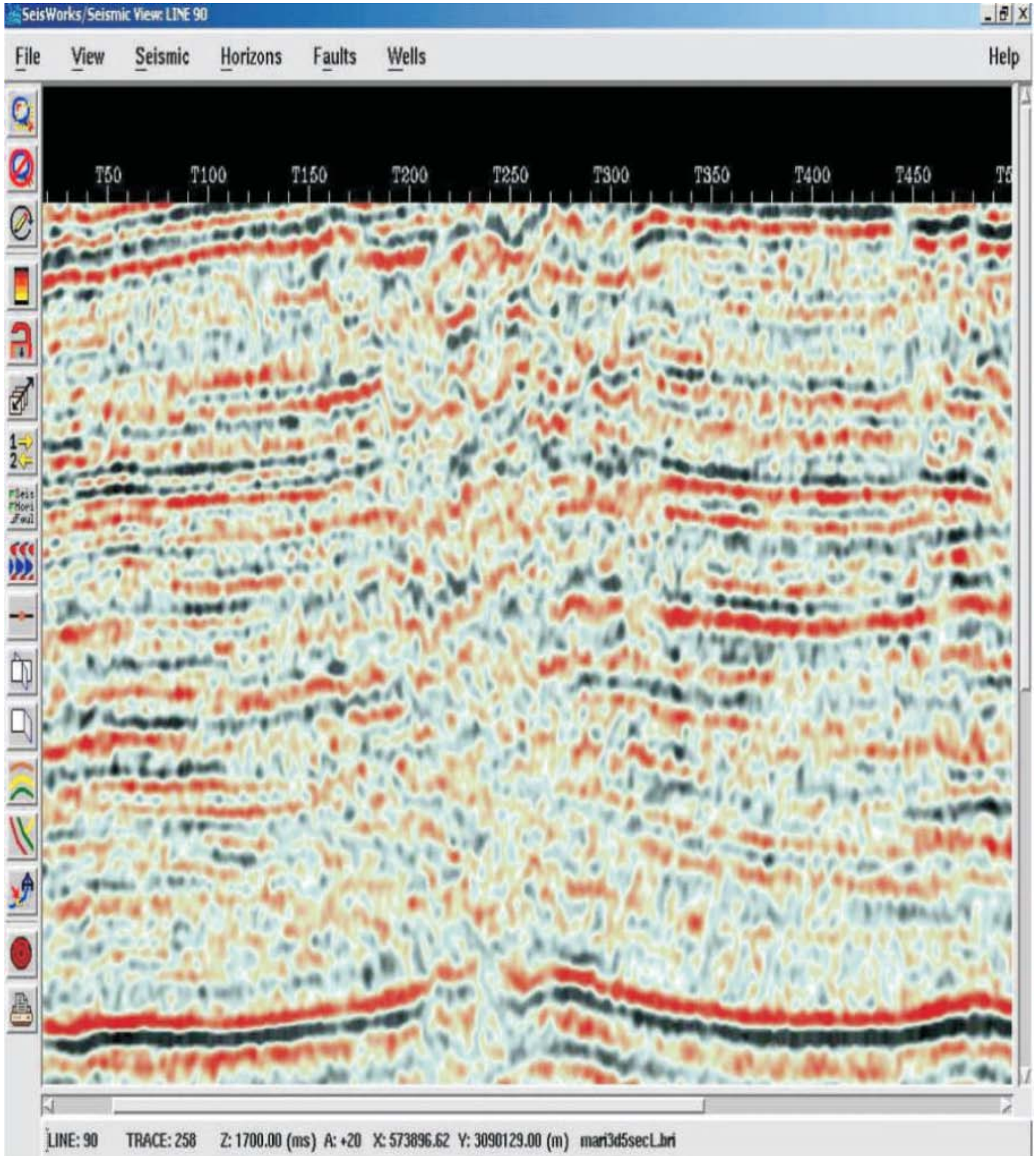

Figure 2. Seismic cross-section at which parameterization was performed.

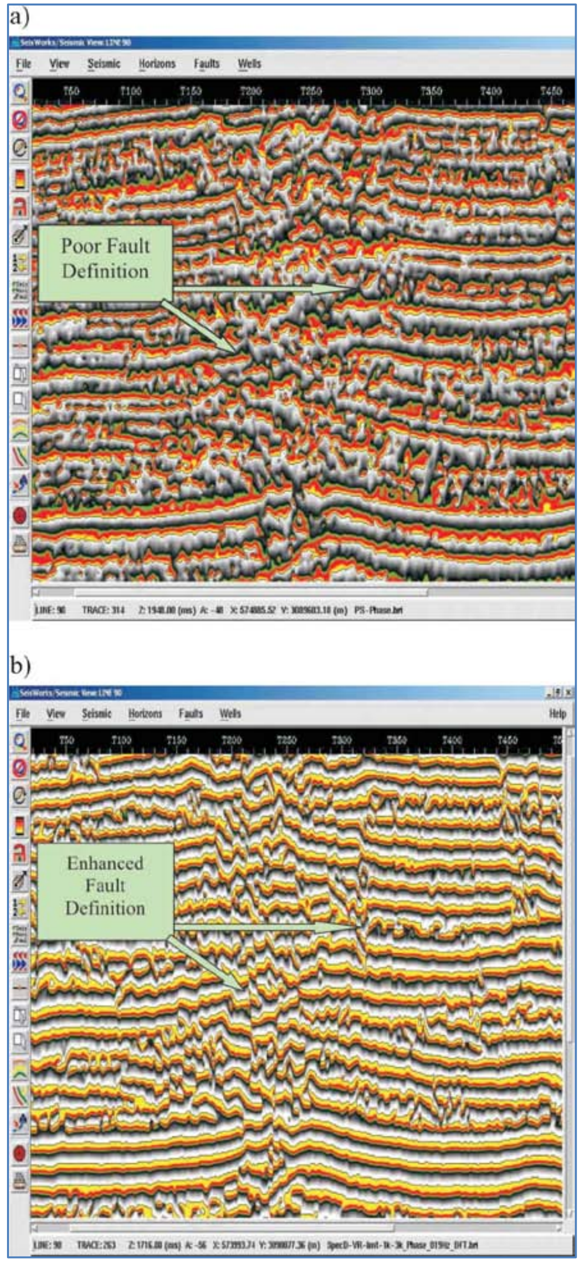

Figure 3. (a) Traditional phase attribute in vertical seismic section, (b) Spectral decomposition phase attribute at 19-Hz in vertical seismic section.

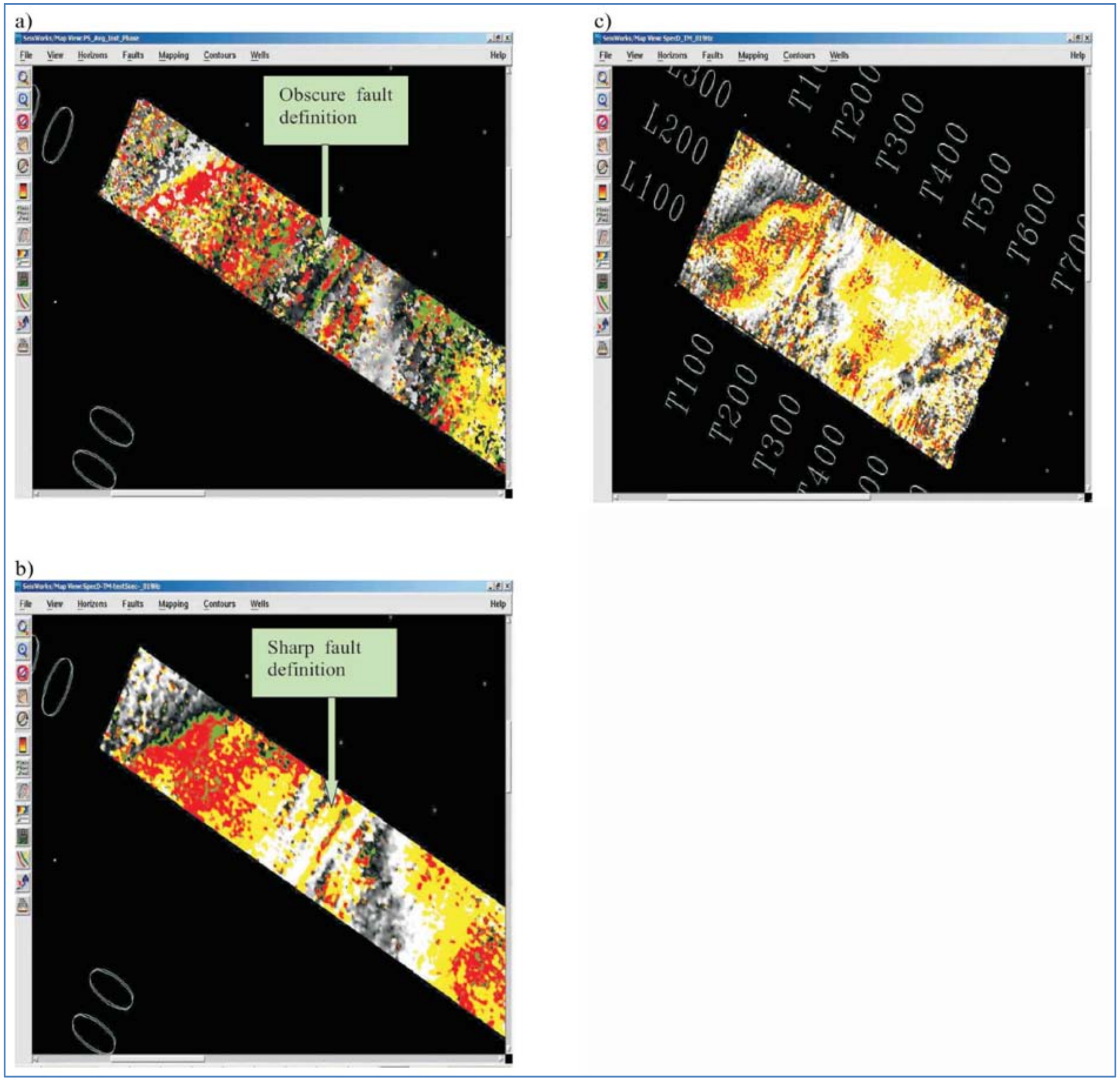

Figure 4. (a) Traditional phase attribute map for portion of survey, (b) Spectral decomposition 19 Hz phase attribute map for portion of survey, (c) Spectral decomposition 19 Hz phase attribute map for entire survey.