

High Resolution Azimuthal Diffraction Imaging of Natural Fracture Zones in Fractured Carbonates and Unconventional Shales

Alexander M. Popovici¹, Ioan Sturzu¹, and Tijmen J. Moser¹

¹Z-Terra Inc., Houston, TX, United States.

ABSTRACT

Diffraction Imaging (DI) is the imaging of discontinuities, or objects which are small compared to the wavelength of seismic waves such as fault edges, small scale faults, fractured zones, pinch-outs, reef edges, channel edges, salt flanks, reflector unconformities, injectites, fluid fronts, caves and karst, in general any small scattering objects. In fractured carbonate reservoirs and unconventional shales, Diffraction Imaging is a high-resolution imaging technology that can be used to image and identify in very fine detail the small scale fractures in the reservoir that form areas of increased natural fracture density. These areas may be associated with higher production wells (Schoepp et. al., 2015). Standard approaches to obtain high-resolution information, such as coherency analysis and structure-oriented filters, derive attributes from stacked, migrated images. Diffraction imaging in comparison, acts on the pre-stack data, and as a result can provide both angular and azimuthal amplitude information in addition to the high resolution structural information. We show that operating in a migration framework on pre-stack data, using procedures which complement those used to enhance specular reflections, allows us to obtain higher resolution information, which is lost in conventional procedures. An efficient way to obtain diffraction images is to first separate the migration events according to the value of specularity angle and azimuth, in a similar way to offset or angle azimuth gathers; diffraction images are produced subsequently using post-processing procedures. The high-resolution potential is demonstrated by several case histories in carbonate reservoirs and unconventional shales, which show much more detail than conventional depth migration or coherence. In addition the variation of the diffractions amplitudes with azimuth gives information about the direction of the local stress field, thus allowing reservoir and drilling engineers to optimize the horizontal well trajectories. We used multidimensional cross-plots in order to create a map of correlations with the wells which were labeled as productive or, respectively, less-productive. We applied this algorithm using clusters of wells, and using multiple attributes. We verified that this set of attributes is not redundant by performing PCA. The background map displays the correlation for similar to productive wells and not-productive wells.