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CRS Offset-azimuth Regularisation of Wide-azimuth Seismic Data for Optimized Imaging and Amplitude Studies

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SUMMARY

Wide azimuth (WAZ) marine seismic data commonly provide an enhanced but varying coverage in azimuth-offset domain, which decreases towards crossline azimuths and near-offsets. The variable offset-azimuth illumination of WAZ data is commonly exploited in prestack depth migration in order to resolve complex subsurface structures, but often leads to amplitude footprints due to the variation, that disturb AVO and AVAZ analyses. An interpolation in azimuth-offset domain based on the CRS technique may largely reduce these footprints, and effectively precondition the data for amplitude studies. The CRS, or Common Reflection Surface method is essentially a multi-parameter stacking method that is used here to regularize and interpolate the data in one step. A regular coverage in CMP-offset-azimuth is thus achieved in most part of the data. Subsequent azimuth-dependent prestack time migration provides high resolution images at low migration noise, with strongly reduced footprints and well-preserved amplitude trends as a basis for subsequent amplitude studies.

Introduction

In 2010, a 3D wide azimuth (WAZ) survey was acquired for PEMEX in the northern Gulf of Mexico in order to obtain an adequate illumination of the complex salt geology in the subsurface, and to access azimuth dependent characteristics of the lithology. Offset-azimuth coverage, however, showed systematic stripe patterns of alternating coverage and gap zones, and random patterns with large gaps, causing pronounced amplitude variation in in the seismic data. These footprints persisted in initial prestack migration, thus obscuring the amplitude trends in offset, azimuth, and CMP domain, to be extracted for well calibration and porefill prediction.

Such difficulties related to irregular geometry are commonly tackled by data regularization. Multi-parameter stacking techniques like the Common-Reflection-Surface (CRS) technique are well-suited for regularization tasks since they describe traveltime of local reflection events across several CMP locations. The CRS technique was previously used in the regularization, e.g. of acquisition geometries (e.g. Höcht et al. 2009, Endres et al. 2011). Here, CRS regularization is performed in offset and azimuth domain, followed by time domain imaging as a base for further lithology studies.

CRS azimuth-offset regularization

CRS zero-offset stacking (Jaeger et al. 2001) assumes local reflector elements with dip and curvature in the subsurface that give rise to the seismic reflections. The corresponding CRS stacking parameters of individual seismic events, the so-called CRS-attributes, define hyperbolic CRS stacking surfaces that extend across several CMP locations. They are thus suited to map event contributions to regular bin locations from the surrounding sparse prestack data. In azimuth-offset regularization, the surrounding data region of a regular trace is defined in the azimuth-offset-CMP domains.

Geometry and fold analysis showed that CRS regularization at offset intervals of 200m and azimuth intervals of 30 degrees approximately match the total coverage of the initial data. Six adjacent azimuth bin sectors of 30 degrees cover a half circle of 180 degrees, taking into account the reciprocity of the shot-receiver direction. Azimuthal coverage is most dense around the inline azimuth of 90 degrees, and degrades towards the crossline azimuth of 0 degrees. The input data in individual CRS regularization bins are sufficient to interpolate the regular CRS bin output traces in most parts of the inline azimuth sectors, whereas crossline sectors require flexible input bin sizes with overlap.

In all azimuth sectors, the regularized CRS gathers provided an almost complete offset coverage at offsets up to 4.1 km (Fig. 1). Only some large coverage gaps beyond the systematic irregularity of the data could not be interpolated completely.

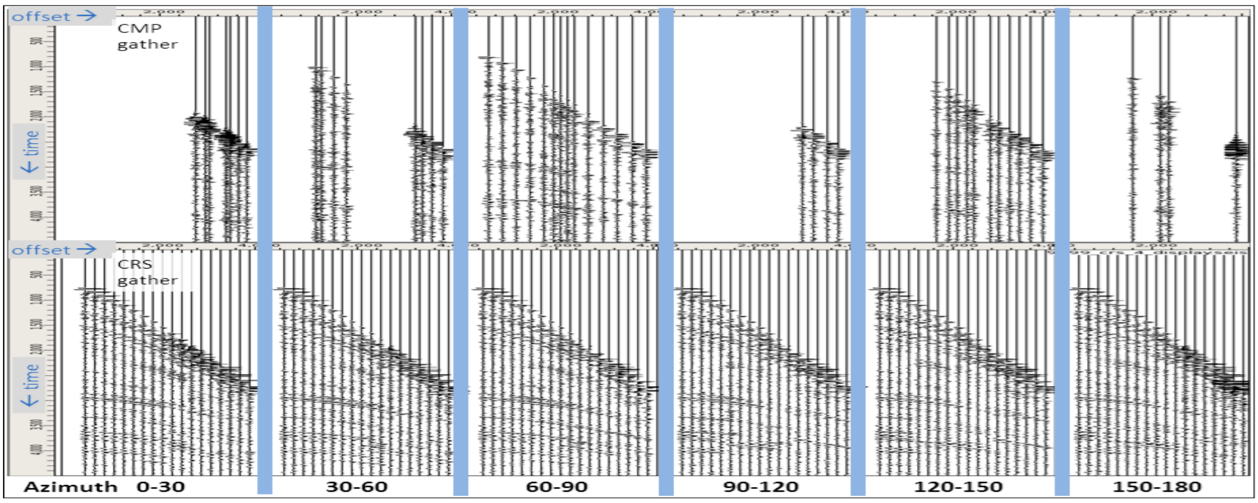

Figure 1 *Initial CMP gather (top) versus CRS gather (bottom) at the same CMP location with azimuth decomposition at intervals of 30 degrees.*

For QC purposes, CMP gather stacks of the initial data, and corresponding CRS gather stacks were produced in each individual azimuth sector at intervals of 30 degrees. The CMP stacks exhibited acquisition footprints like periodic data gaps in the shallow sediments, and periodic vertical noise trains through the data that are largely removed in the CRS stacks (Fig. 2). The CRS gathers thus supported azimuth dependent prestack time migration through regular coverage even at crossline azimuths. The migrated volumes of the six azimuth sectors will be presented showing a good azimuth dependent subsurface resolution with strongly reduced footprints and operator noise.

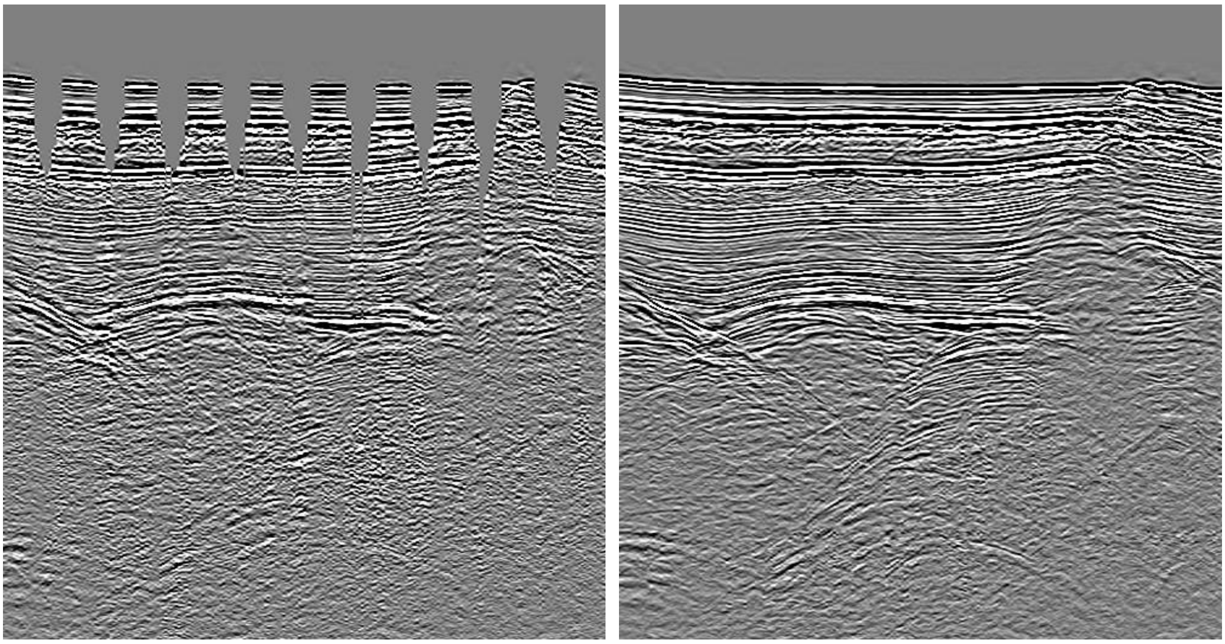

Figure 2 *Initial CMP stack (left) and CRS stack at the central azimuth of 105 degrees.*

Conclusions

The CRS workflow has been extended to offset-azimuth regularization and interpolation of WAZ data providing an almost complete coverage at all azimuth sectors and yielding a high resolution in azimuth dependent prestack imaging. Operator noise and footprints largely disappear even at angle sectors where coverage was poor before CRS processing. Continuous datasets of good accuracy are provided for studies of amplitude trends in the offset-azimuth domains, as a key to details of subsurface lithology that could not be analyzed in conventional processing results before.

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