PRE-STACK DIFFRACTION ENHANCEMENT USING A TRAVELTIME DECOMPOSITION APPROACH

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The imaging of diffracted waves is crucial in seismic data processing, because they carry important information about small-scale subsurface structures such as edges, faults, pinch-outs and small-size scattering objects. Reflected waves, however, are not suitable to image these features below the Rayleigh limit of half a seismic wavelength. Key steps of diffraction imaging are their enhancement and their separation in the pre-stack domain, which require finite-offset processing. In contrast to the commonly used zero-offset scheme, finite-offset stacking is less stable and computationally more expensive, because the problem is of higher dimensionality.

Based on the decoupling of diffraction raypaths, we introduce a straightforward traveltime decomposition principle for diffractions, which establishes a direct connection between zero-offset and common-offset diffraction operators. We show theoretically and on simple diffraction examples that each common-offset diffraction operator can be decomposed exactly into two independent zero-offset operators. This principle, which is applicable in arbitrary media provided reciprocity, allows the direct prediction of common-offset diffraction attributes solely based on zero-offset information without any further optimization. Application of the new approach to complex synthetic and field data reveals its ability to reliably image and enhance diffractions in the common-offset domain using only results from zero-offset processing as input. Particularly on weak events and in sparsely illuminated regions such as subsalt areas the new method shows its strengths. The promising results in terms of both image and attributes reveal a high potential for improved pre-stack data enhancement and suggest the formulation of an efficient diffraction-based tomographic scheme.