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Imaging of 2-D multichannel land seismic data using an iterative inversion-migration scheme, Naga Thrust and Fold Belt, Assam, India

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We demonstrate that imaging of 2-D multichannel land seismic data can be effectively accomplished by a combination of reflection traveltime tomography and pre-stack depth migration (PSDM); we refer to the combined process as "the unified imaging". The unified imaging comprises cyclic runs of joint reflection and direct arrival inversion and pre-stack depth migration. From one cycle to another, both the inversion and the migration provide mutual feedbacks that are guided by the geological interpretation.

The unified imaging is implemented in two broad stages. The first stage is similar to the conventional imaging except that it involves a significant use of velocity model from the inversion of the direct arrivals for both datuming and stacking velocity analysis. The first stage ends with an initial interval velocity model (from the stacking velocity analysis) and a corresponding depth migrated image. The second stage updates the velocity model and the depth image from the first stage in a cyclic manner; a single cycle comprises a single run of reflection traveltime inversion followed by PSDM. Interfaces used in the inversion are interpretations of the PSDM image in the previous cycle and the velocity model used in PSDM is from the joint inversion in the current cycle. Additionally in every cycle interpreted horizons in the stacked data are inverted as zero-offset reflections for constraining the interfaces; the velocity model is maintained stationary for the zero-offset inversion. A congruency factor, j, which measures the discrepancy between interfaces from the interpretation of the PSDM image and their corresponding counterparts from the inversion of the zero-offset reflections within assigned uncertainties, is computed in every cycle. A value of unity for $j$indicates that images from both the inversion and the migration are equivalent; at this point the unified imaging is said to have converged and is halted.

We apply the unified imaging to 2-D multichannel seismic data from the Naga Thrust and Fold Belt (NTFB), India, were several exploratory wells in the last decade targeting sub-thrust leads in the footwall have failed. This failure is speculatively due to incorrect depth images which are in turn attributed to incorrect velocity models that are developed using conventional methods. The 2-D seismic data in this study is acquired perpendicular to the trend of the NTFB where the outcropping hanging wall has a topographic culmination. The acquisition style is split-spread with 30 m shot and receiver spacing and a nominal fold of 90. The data are recorded with a sample interval of 2 ms. Overall the data have a moderate signal-to-noise ratio and a broad frequency bandwidth of 8–80 Hz. The seismic line contains the failed exploratory well in the central part.

The final results from unified imaging (both the depth image and the corresponding velocity model) suggest presence of a triangle zone, which was previously undiscovered. Conventional imaging had falsely portrayed the triangle zone as structural high which was interpreted as an anticline. As a result, the exploratory well, meant to target the anticline, met with pressure changes which were neither expected nor explained. The unified imaging results not only explain the observations in the well but also reveal new leads in the region. The velocity model from unified imaging was also found to be adequate for frequency-domain full-waveform imaging of the hanging wall. Results from waveform inversion are further corroborated by the geological interpretation of the exploratory well.