Imaging oblique reflectors

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Abstract

Seismic data are usually acquired with a 3D geometry to eliminate oblique reflectors and sideswipe. However, 2D data is still being acquired and some reflectors may be oblique to the 2D line and may not be imaged correctly. Modifying the velocities during a migration allows oblique reflectors to be imaged correctly. Should the same concept be applied to a prestack time migration?

Prestack time migration is very sensitive to migration velocities, which aids in defining accurate migration velocities. However, small perturbations in velocity can create significant artifacts. Three methods were evaluated using data from the Hussar project.

Theory

Poststack 2D migration for oblique reflectors was described by French (1975). The migration velocity V_{mig} was increased over the RMS velocity V_{rms} using the angle of obliquity γ, i.e.,

$$V_{mig} = \frac{V_{rms}}{\cos(\gamma)}. \quad (1)$$

An example of this method is shown in Figure 2, where a fault plane was identified when the data was poststack migrated at 130%.

Equivalent Offset migration (EOM) (Bancroft et al. 1996) was applied using three different methods to evaluate their effect on the Hussar data.

Method 1

Extending the migration of oblique reflectors has been discussed (Bancroft et al. 2000, and Bancroft 2001) with the intent of providing improved imaging. Equation 5 from Bancroft et al. 2000

$$T^2 = T_0^2 + \frac{4x^2\cos^2\gamma}{V_{rms}^2} + \frac{4h^2}{V_{rms}^2} = T_0^2 + \frac{4\left(x^2\cos^2\gamma + h^2\right)}{V_{rms}^2} = T_0^2 + \frac{4h_{e-new}^2}{V_{rms}^2}. \quad (2)$$

was used to form common scatterpoint (CSP) gathers using the new equivalent offset $h_{e\text{-}new}$, defined above.

Method 2

CSP gathers were formed, then moveout corrected using velocities that represented different angles of obliquity using equation (1). Examples in Figures 3 and 4 show considerable instability, even with a low increase of V_{rms} to 115%. (See Velocities below).

Method 3

Cascaded Migration is a process that *re-migrates* a migrated section to produce a new migrated section. The new migration will be the same as if it was a single migration that used a different velocity. If the original zero offset section was migrated with V_A, then re-migrated with V_B, it would be the same as it the original data was migrated using V_C, where V_C is given by

$$V_C = \left(V_A^2 + V_B^2\right)^{1/2}. \quad (3)$$

The third method of migrating oblique reflectors used EOM to produce one prestack migration using 100% of V_{rms}, then used Cascaded Migration to re-migrate this section to simulate poststack migrations with different velocities.

A reflector at a 30° angle of obliquity would require a poststack migration using 130%V_{rms} to image the reflector. A Cascaded migration of the 100%EO migration using a velocity of 58%V_{rms}, will also image the oblique reflector. Table 1 shows various angles of obliquity γ, the poststack migration velocity required to image a reflector at that angle V_C, and the corresponding Cascaded Migration velocity V_B. Results are compared with Method 2 in Figure 4.

Velocities

After the CSP gathers are formed, velocities are picked for stacking $V(x, t)$. Artifacts were produced when these velocities were increased and the data re-stacked, as in Figure 3. Greater stability was achieved when spatially invariant velocities $V(t)$ were used, as in Figure 4.

Conclusions

Method 1: Required large runtimes and produced many artifacts in the migrated section. Not recommended at this time.

Method 2: Much faster than Method 1, but the results were still unstable. Structures appeared that we not geological. Not recommended at this time.

Method 3: Very fast, and should produce result equivalent to the poststack migration. Needs more testing with modelled data.

Caution is required when modifying the velocities of prestack data as artifacts can be generated.

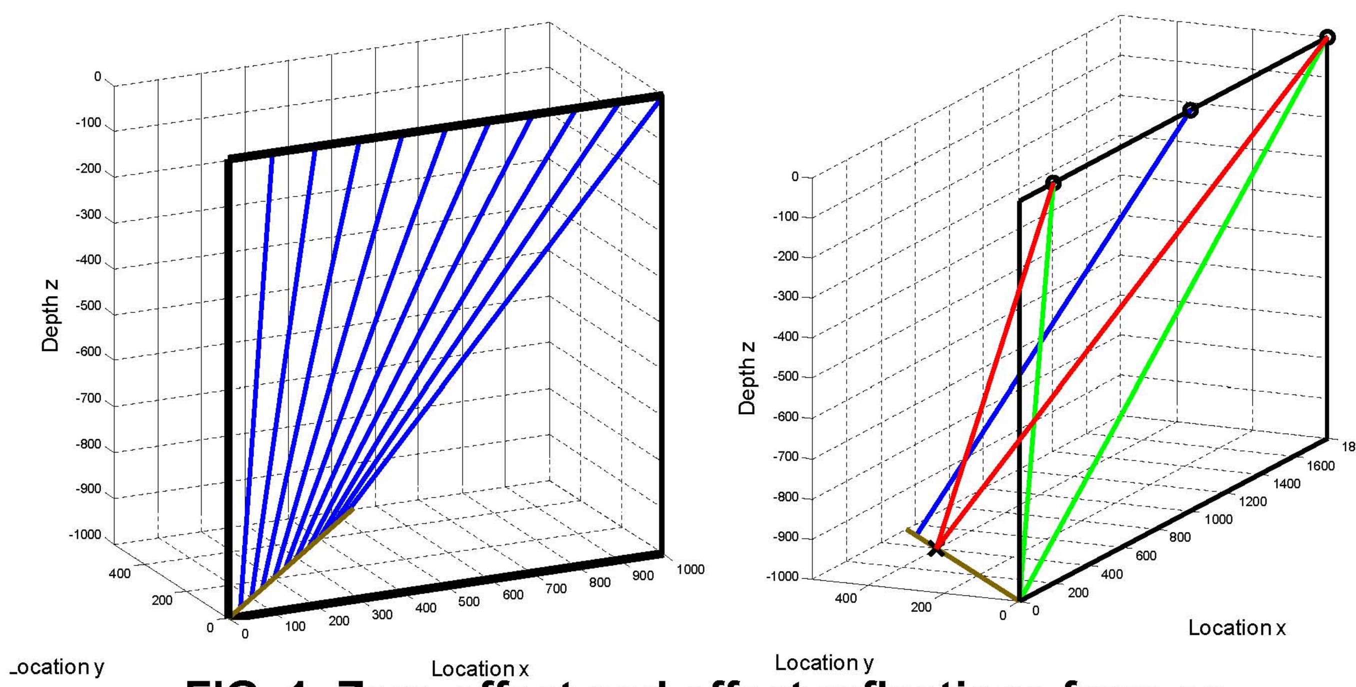

FIG. 1 Zero-offset and offset reflections from an oblique reflector of 45°.

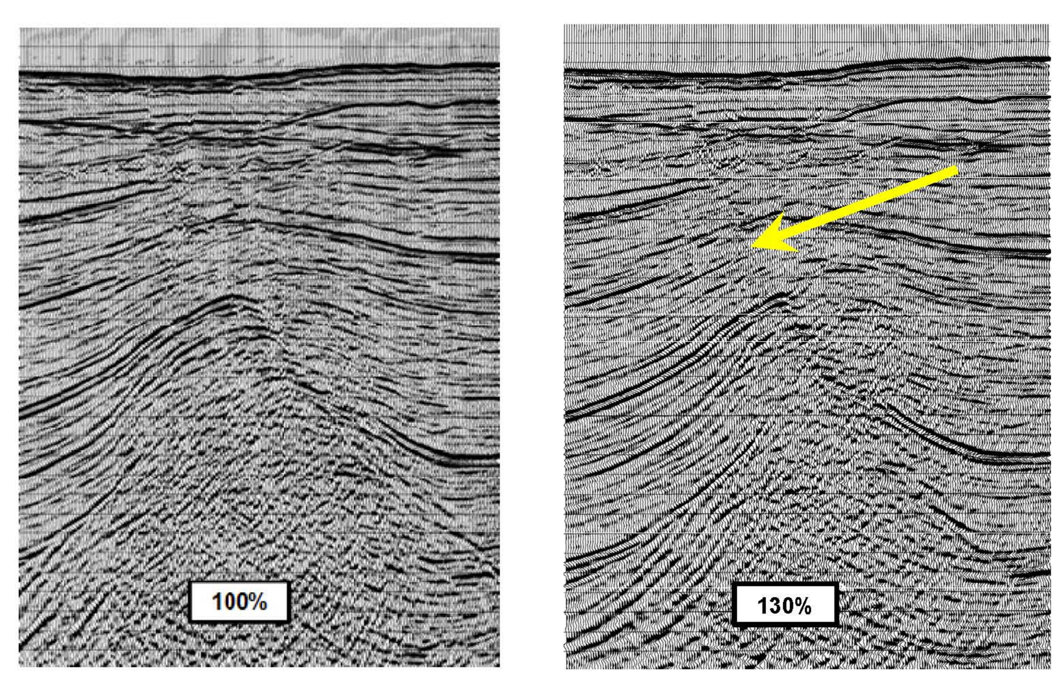

FIG. 2 Poststack migrations at 100% and 130% V_{rms}.

Table 1 Migration velocities for oblique reflectors.

Obliquity angle (degrees)	Poststack migration velocities V_C	Re-migration velocities % of V_A
10	102%	18%
20	106%	36%
30	115%	58%
40	131%	84%
50	156%	119%
60	200%	173%
70	292%	275%
80	576%	567%

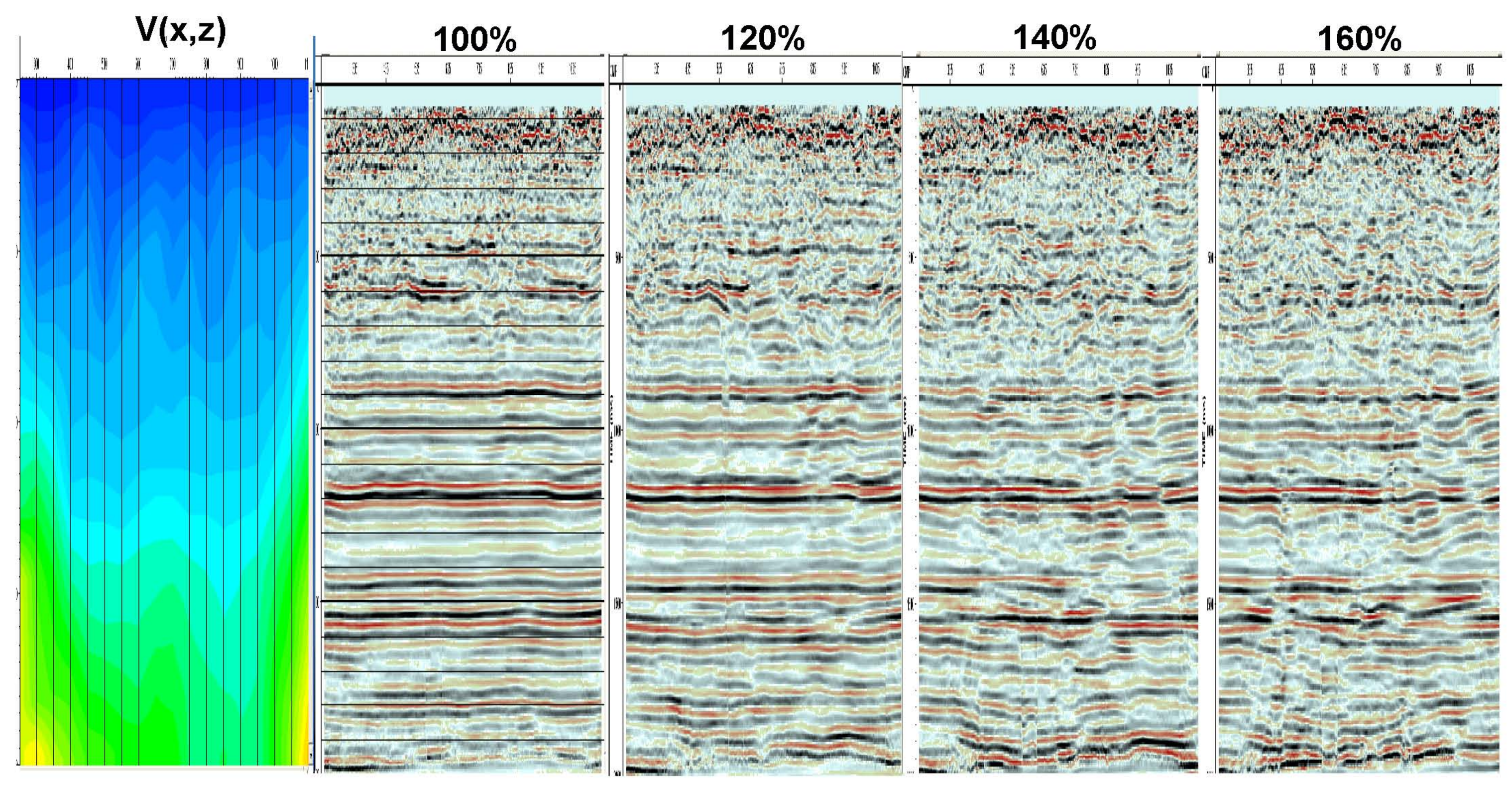

FIG. 3 Method 2 prestack migrations V(x,t).

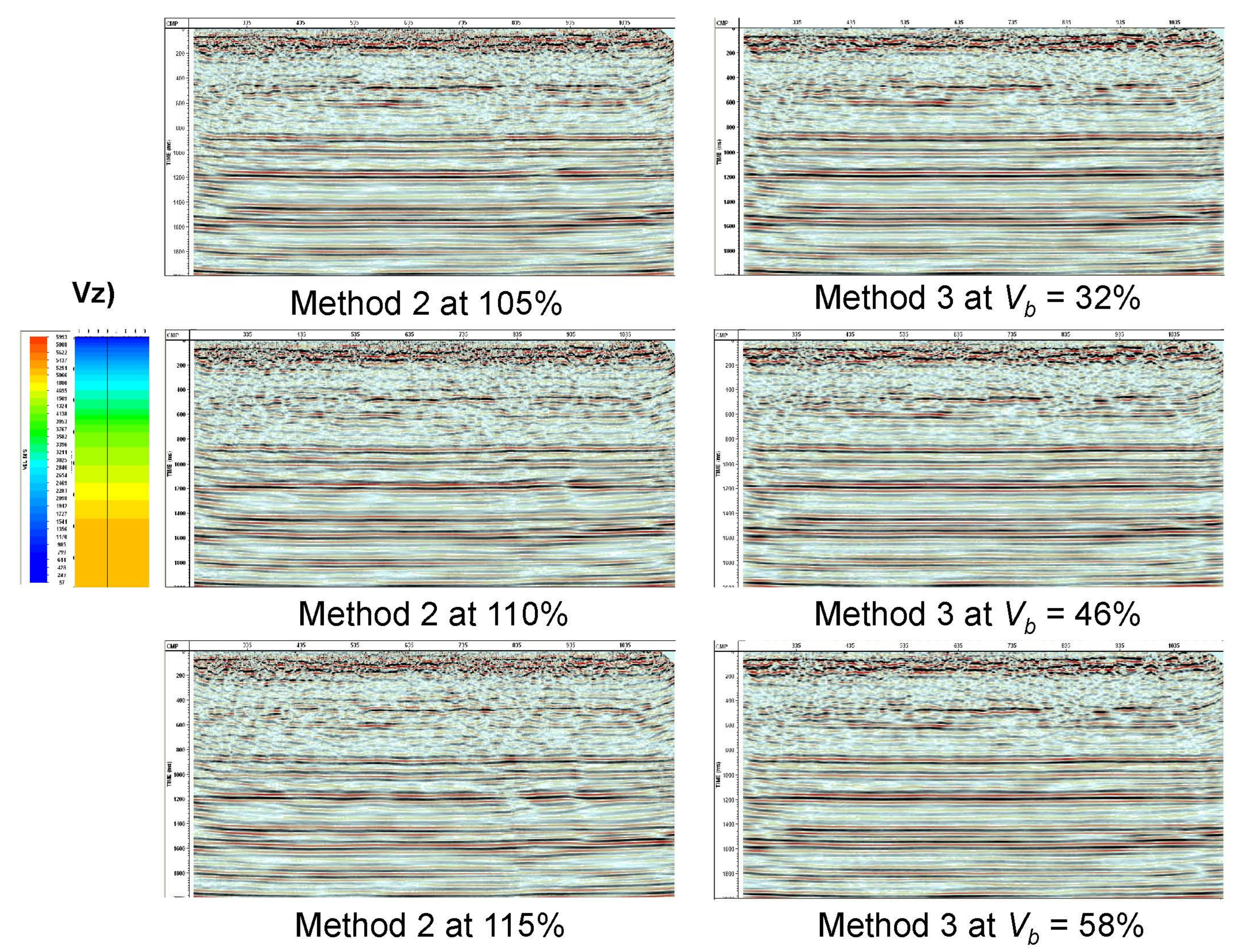

FIG. 4 Prestack migrations V(t) for γ = 5°, 10°, and 15°.

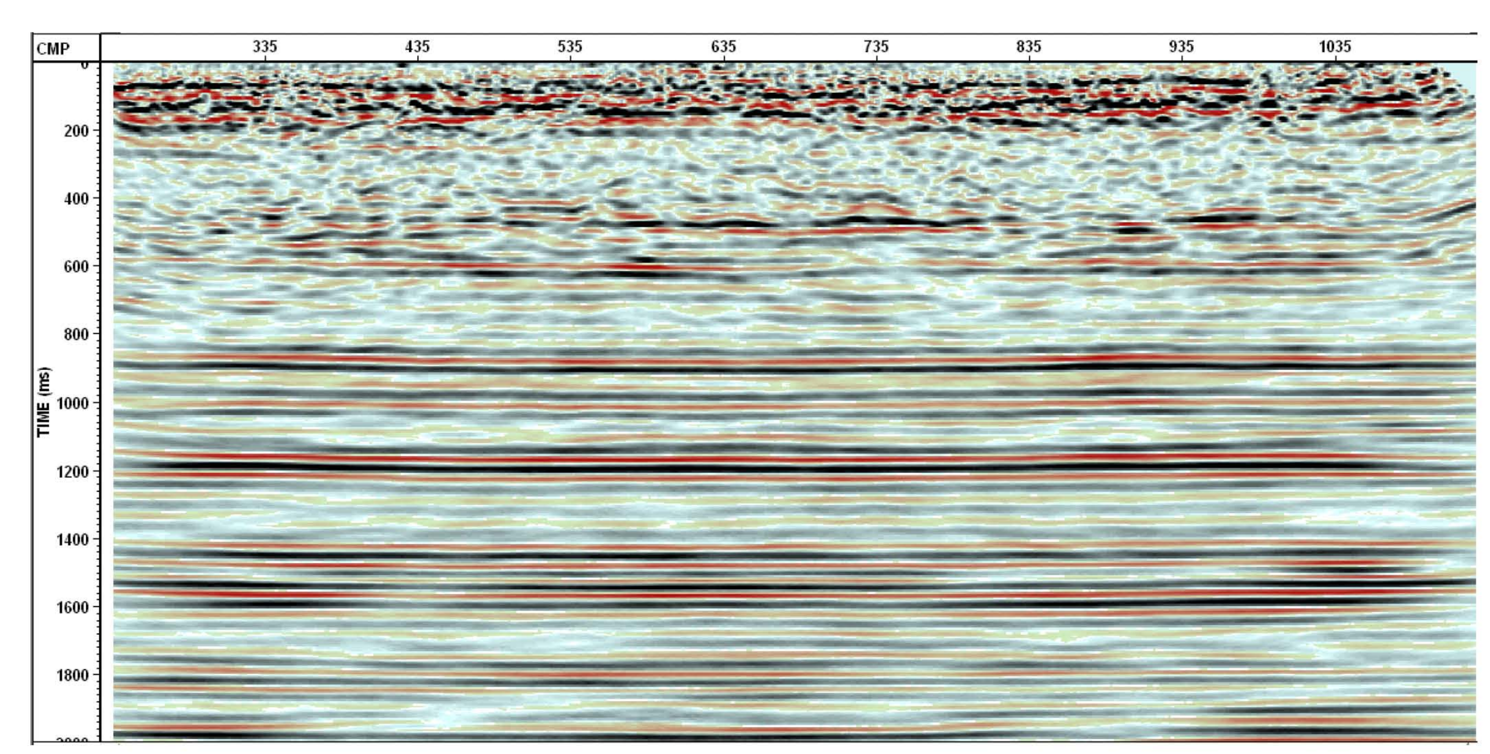

FIG. 5 Method 3 using V_B = 173% V_{rms} for γ = 60° obliquity.