Focussing CSP gather semblance images for foothills time migration

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ABSTRACT

Equivalent offset migration (EOM) was applied to a 2-D numerical model of the Canadian Rocky Mountain foothills. Data beneath a low velocity wedge was particularly difficult to image. Analysis of the common scatter point (CSP) gathers and their semblance plots showed a number of potential velocity picks that came from the same reflector. These multiple semblance points were attributed to lateral velocity variations that tilt the diffraction energy in two-sided CSP gathers.

The energy in a CSP gather was tilted by varying amounts and the semblance computed then combined into a movie. The effects of tilting the CSP gathers can be evaluated by running the movie and comparing the location and size of the semblance clouds with the estimated velocity profile. Unfortunately, the area with the greatest tilt was not available for tilt analysis, but an equally interesting area is evaluated.

INTRODUCTION

Equivalent offset migration (EOM) (Bancroft 1998) was applied to seismic data that was created numerically from a structured geological model. The model had a level surface that produced P-P data with no statics and no multiples. All problems with the time migration imaging could then be attributed to the inability of time migration to image the data, the weakness of the migration algorithm, or the inability to pick reasonable velocities.

Model

The geological model used for the experiments (Figure 1) was created by Dr. D. A. Spratt and is based on a cross-section through the Foothills and Front Ranges of the Rocky Mountains (Kirtland Grech et al., 1998).

EOM AND A CSP GATHER

EOM was able to produce a reasonable image with minimal effort, although many velocity analysis points were required in areas where the geological structure was steeply dipping. Deeper portions of the structure were difficult to focus, which was attributed to a shallower lateral velocity change that produced a tilt on the deeper diffractions (Kirtland and Bancroft 1998). The tilted diffracted energy was evident on a two-sided CSP gather and produced a smear across the semblance plot making it difficult to identify a specific time and velocity of a reflection. Velocity picks tended to follow one cloud of the semblance plot, which would then disappear at one location, and reappear at another location with a different velocity and time, causing a discontinuity in the migrated section.

This paper evaluates the possibility of applying a correction tilt to the CSP gathers in an attempt to improve an interpretation of the semblance plot and to improve the resolution of the velocity and time of the deeper reflections. Only a portion of the original data remains available for processing and a CSP gather was selected at a location that provided shallower horizontal reflectors, but deeper dipping reflectors. This location is at 9500m as indicated by the large arrow on Figure 1.

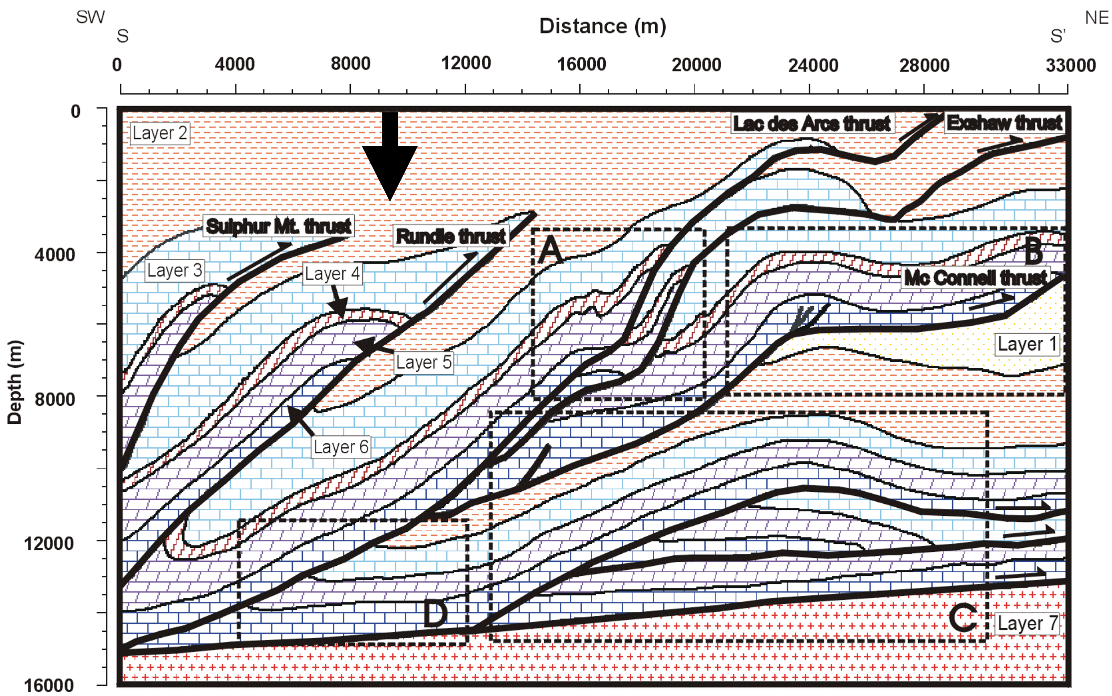


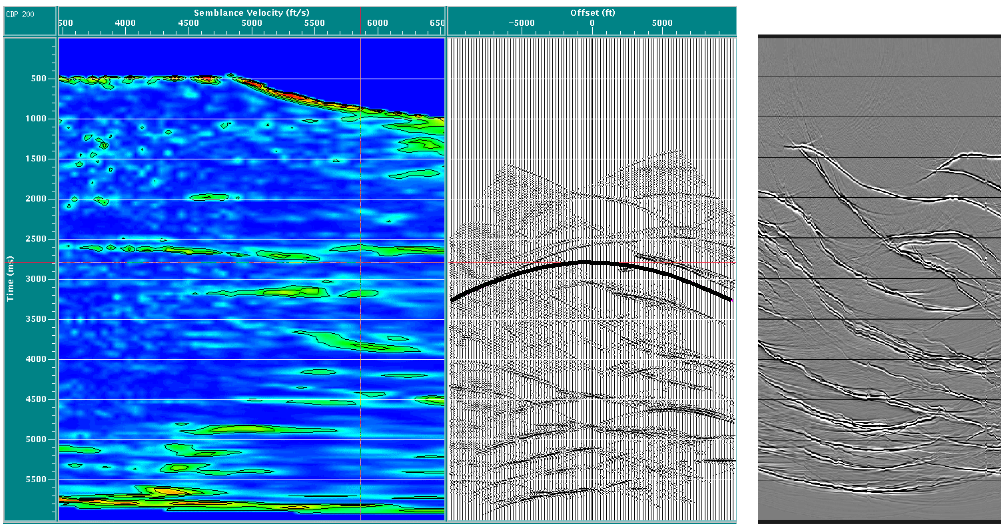
Figure 1. The foothills geological model used to evaluate tilting a CSP gather

A range of 21 tilts were applied to one CSP gather, with each tilt being constant for all times of the CSP gather. The semblance and tilted CSP gathers were formed into a movie that could be continually replayed, or it could be scanned one image at a time. An estimate of the RMS velocity was computed to aid in interpretation. Five of these images are shown in Figure 2 with slopes of -100, -5, 0, 50 and 100. A black hyperbola, at a time of 4500 s, may be used to gauge the relative tilts.

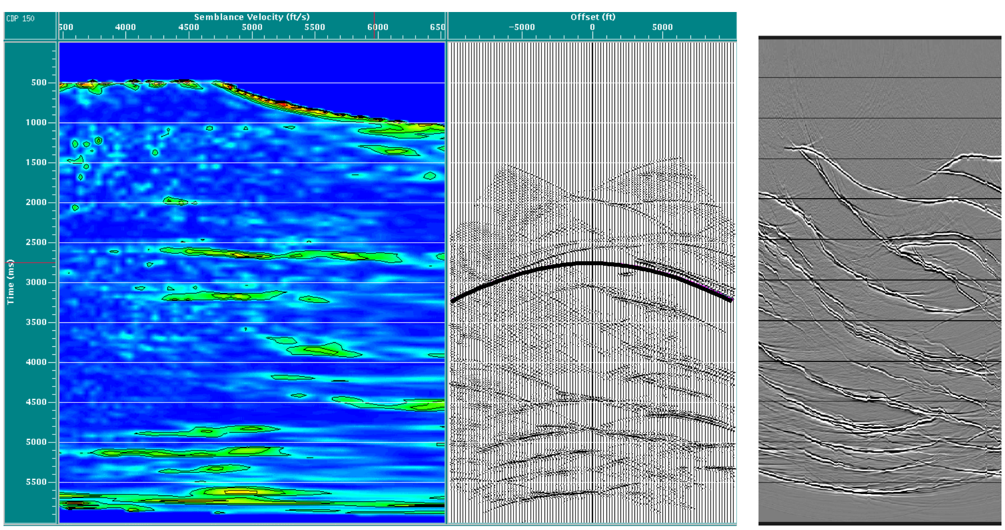
Figure 2c is the original CSP gather and the tilts rotate from a positive to a negative value. At zero offset, most of the scattered energy tends to be localized at the reflector location, but spreads with a butterfly type shape at larger offsets. After NMO correction, all this energy, (apart from that which could be muted out), is summed into the migrated trace, independent of the migration algorithm. The CSP gather only displays this information in a convenient manner. The lateral direction of the data in the CSP gathers is the reverse of that in Figure 1, however, a portion of the EOM prestack migration is displayed to the left of each CSP gather with the same direction.

Interpretation of the semblance plots becomes subjective, but there are some rules that may be applied:

- Zero offset energy may be visible on the gathers, which, if dipping or structured, may confuse the interpretation.
- The reflection times are defined by the center of the butterfly, which should be close to zero offset.
- The velocity of a cloud of energy on the semblance should match energy at zero offset on the CSP gather.
- The first reflection must match the velocity of the first layer.
- Subsequent layers should match the RMS velocity.
- A tilt may be required to match the velocities of the deeper reflections.

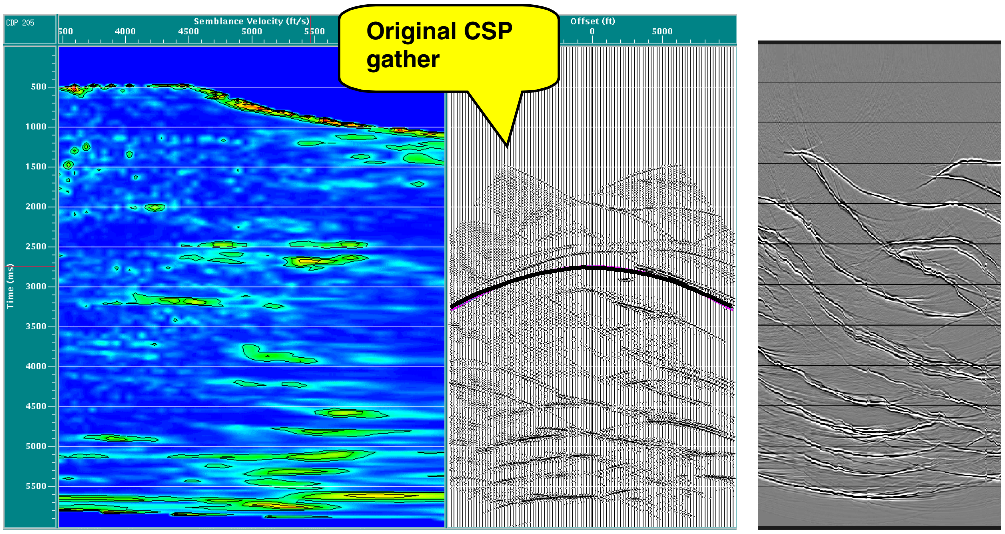


a)

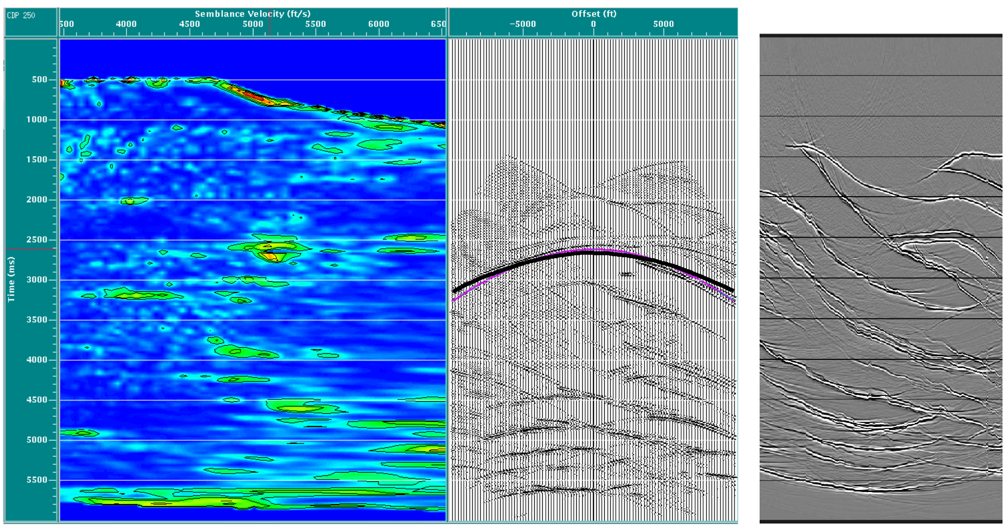


b)

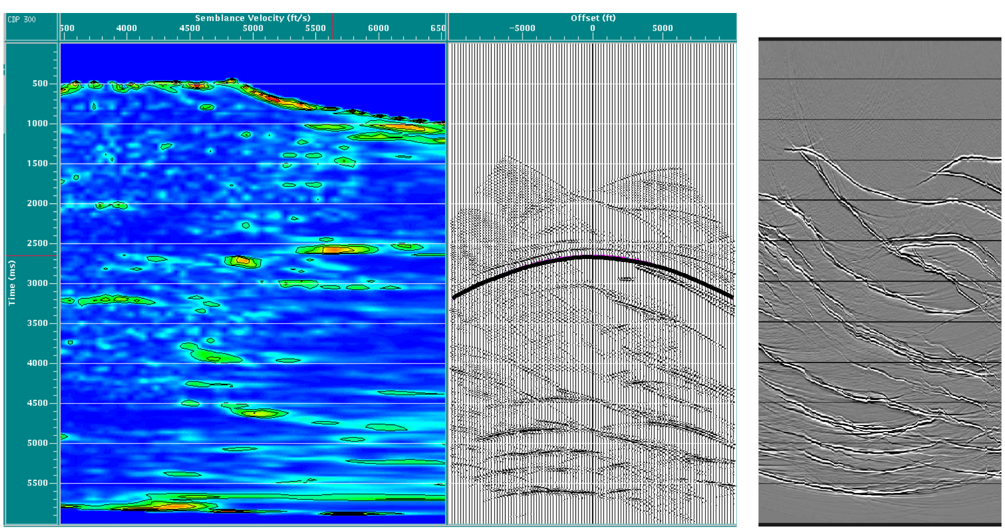
Figure 2. Images of tilted CSP gathers and their corresponding semblance plots for tilts of: a) -100, b) -50, c) 0, d) 50 and e) 100.


Original CSP gather
Semblance Velocity (ft/s)
Offset (ft)
Time (ms)

c)


Semblance Velocity (ft/s)
Offset (ft)
Time (ms)

d)


Semblance Velocity (ft/s)
Offset (ft)
Time (ms)

e)

CONCLUSIONS

The interpretability of a CSP gather, from highly structured geology, can be improved by applying a tilt to the CSP gather. Applying a tilt to a CSP gather helps focus the cloud of reflection energy at the correct time and velocity of the reflection. Additional information may be required to aid in interpreting the clouds of energy on the semblance plots

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