Geometrical corrections for poststack image focusing velocity analysis with application to georadar data

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Abstract

Knowing the subsurface velocity structure is crucial to being able to generate accurate images from geophysical reflection data. For seismic reflection and georadar (GPR) surveys, preliminary velocity information commonly comes from moveout analysis on shot and/or CMP gathers. In cases where we do not have offset information, we can collapse diffractions in the data through migration to obtain velocities. However, there are a number of reflection geometries where the reflection signature appears hyperbolic in shape similar to that of a point diffractor. Collapsing such hyperbolic events gives inaccurate velocity information which may distort the final image. We investigate three geometrical cases where this may occur: circular, hyperbolic, and parabolic. We derive zero-offset traveltime equations for each case, assuming a simple homogeneous media between the surface and a reflector. Generating a set of randomly distributed diffractors over a range of depths and medium velocities at georadar scale, we use a grid-search method to determine the best-fitting parameters for each of the geometric cases. We find that in all three cases, observed diffractor velocities are always higher than the "true" medium velocities, and in the circular and hyperbolic cases we are able to estimate a crude velocity factor relying only on an estimate of one scale parameter. We apply a velocity correction to a georadar dataset with circular culverts, and show that it gives a more accurate final image than using just a diffractor velocity.

Reflector geometries

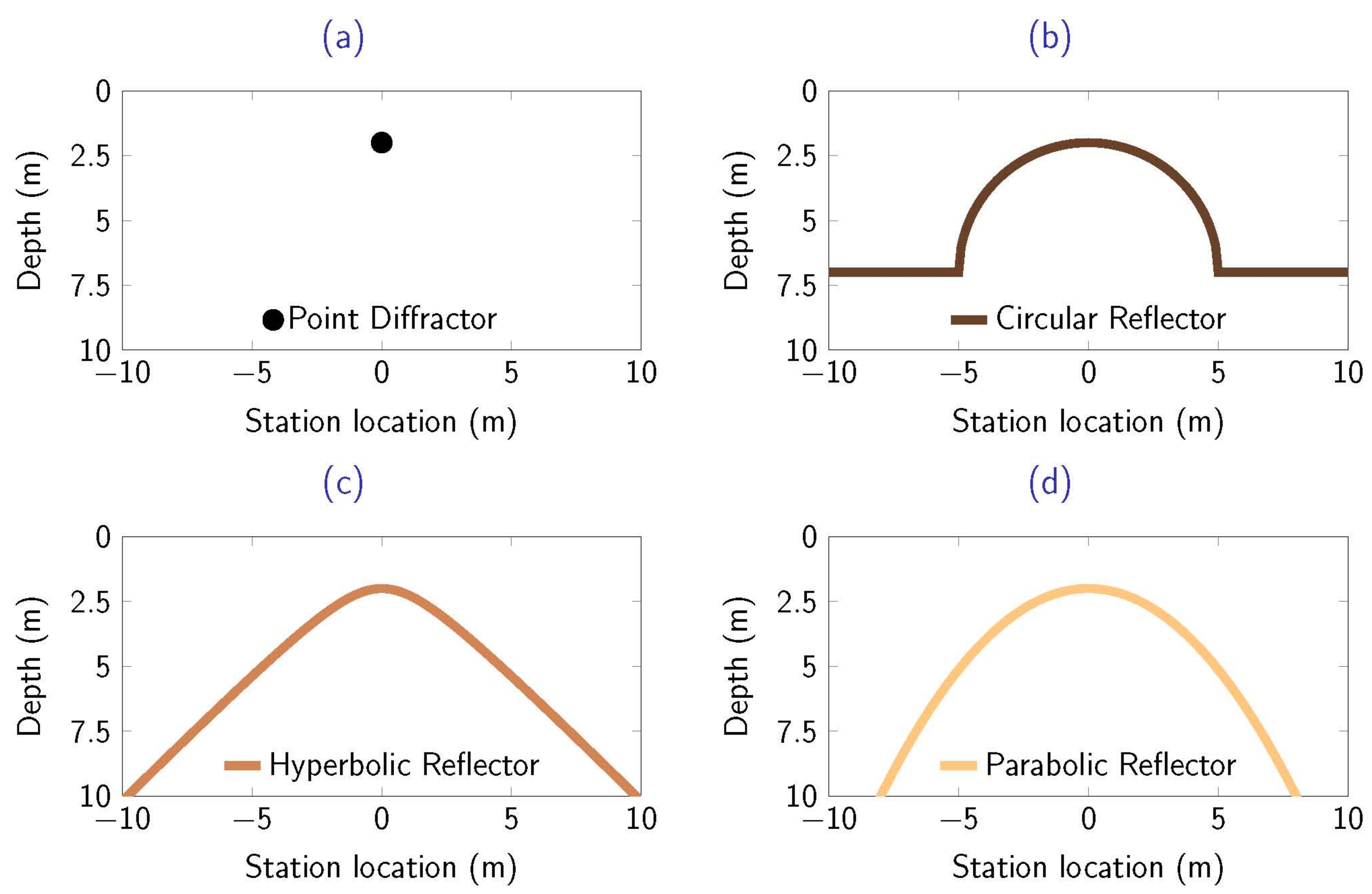

Figure : 1. Illustration of reflector geometry for 4 different cases: (a) - point diffractor buried at 2m, (b) - circular reflector, (c) - hyperbolic reflector, and (d) - parabolic reflector

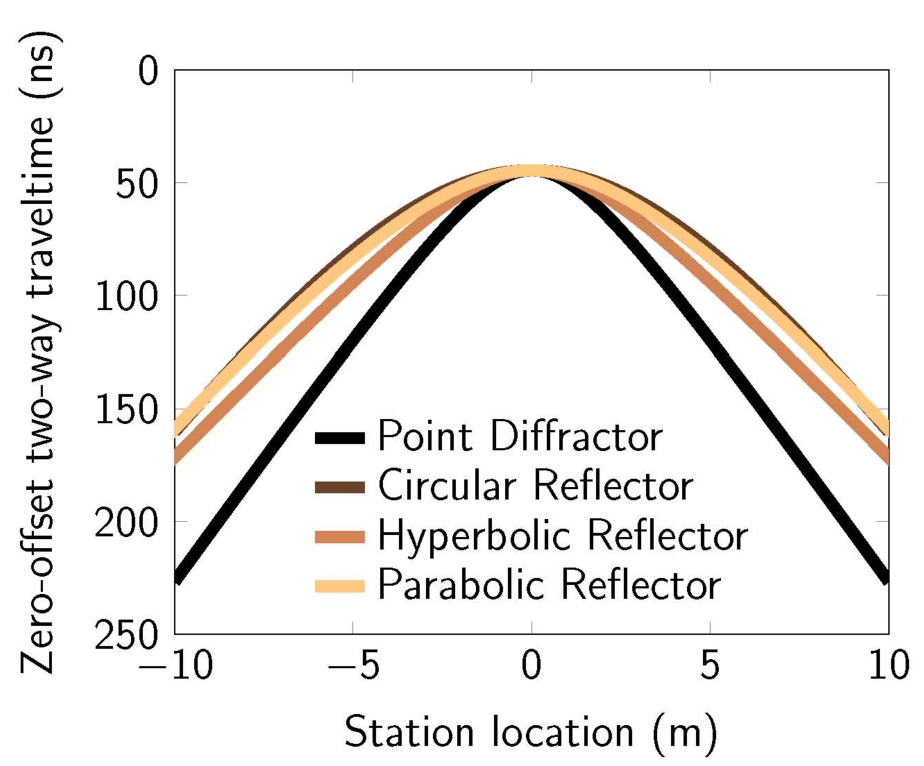

Figure : 2. Illustration of two-way traveltimes from zero-offset reflections for the four different geometric cases shown above, with an upper homogeneous medium velocity of 0.3c.

Velocity correction factor

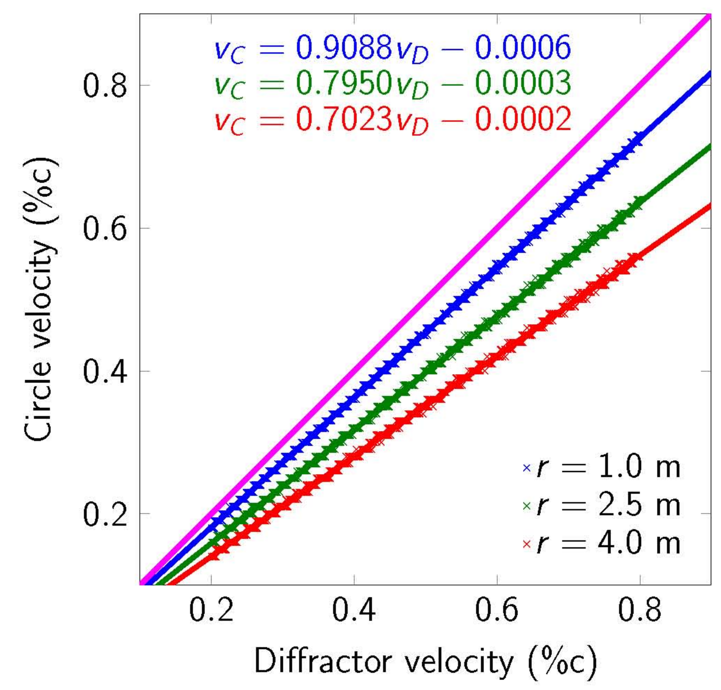

Figure : 3. Grid search results of circular velocity (v_C) vs. diffractor velocity (v_D) for select circle radii. Lines of best fit are plotted over the inverted results for each radii. The magenta line represents a 1-1 velocity line.

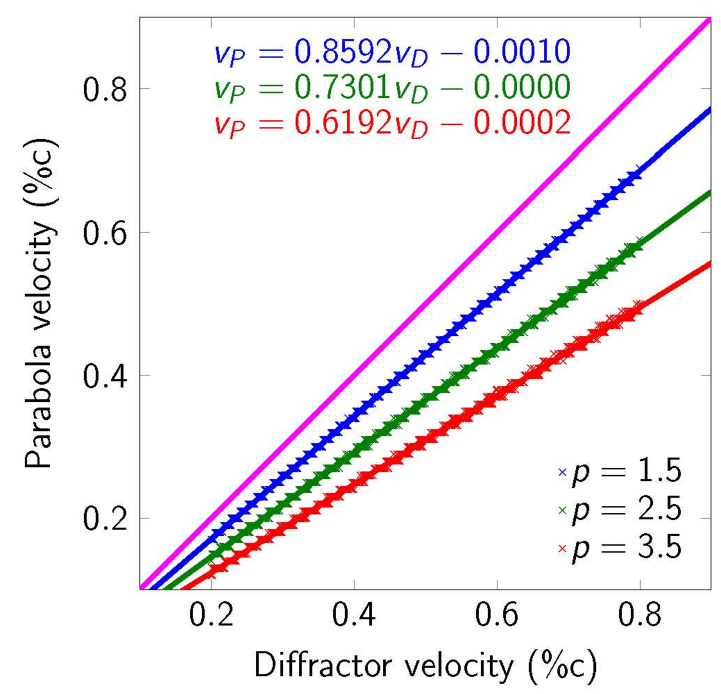

Figure : 4. Grid search results of parabolic velocity (v_P) vs. diffractor velocity (v_D) for select parabolic curvature parameters (p). Lines of best fit are plotted over the inverted results for each p-value. The magenta line represents a 1-1 velocity line.

Houston Coastal Center

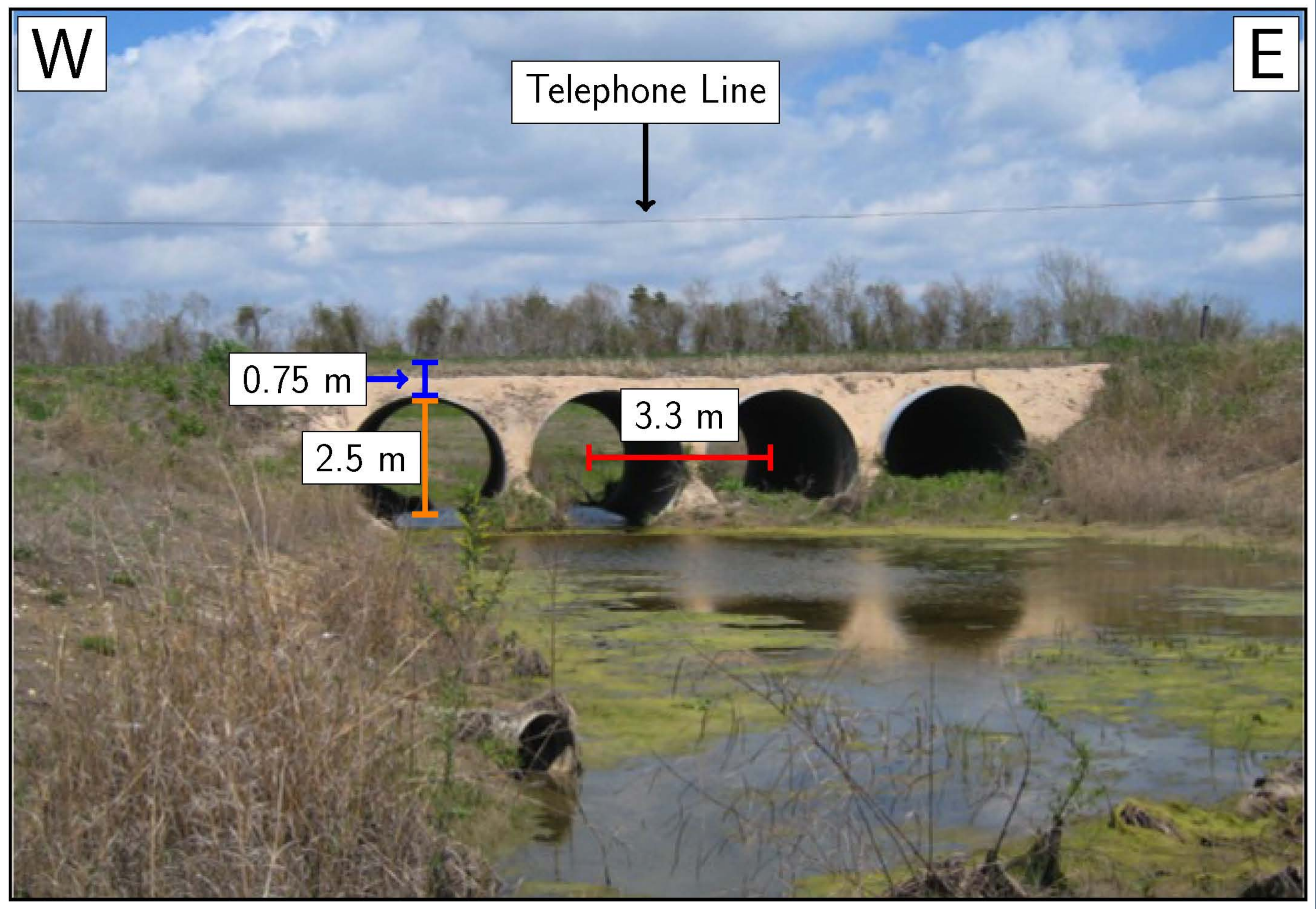

Figure : 5. Cross-sectional view of the culverts at the Houston Coastal Center. The distance from the road surface ($z = 0$m) to the top of the culverts, the distance from the top of a culvert to its base, and the separation of the centers of two adjacent culverts are shown. All distances are approximate. Note the location of a telephone line over the survey area.

Culvert line

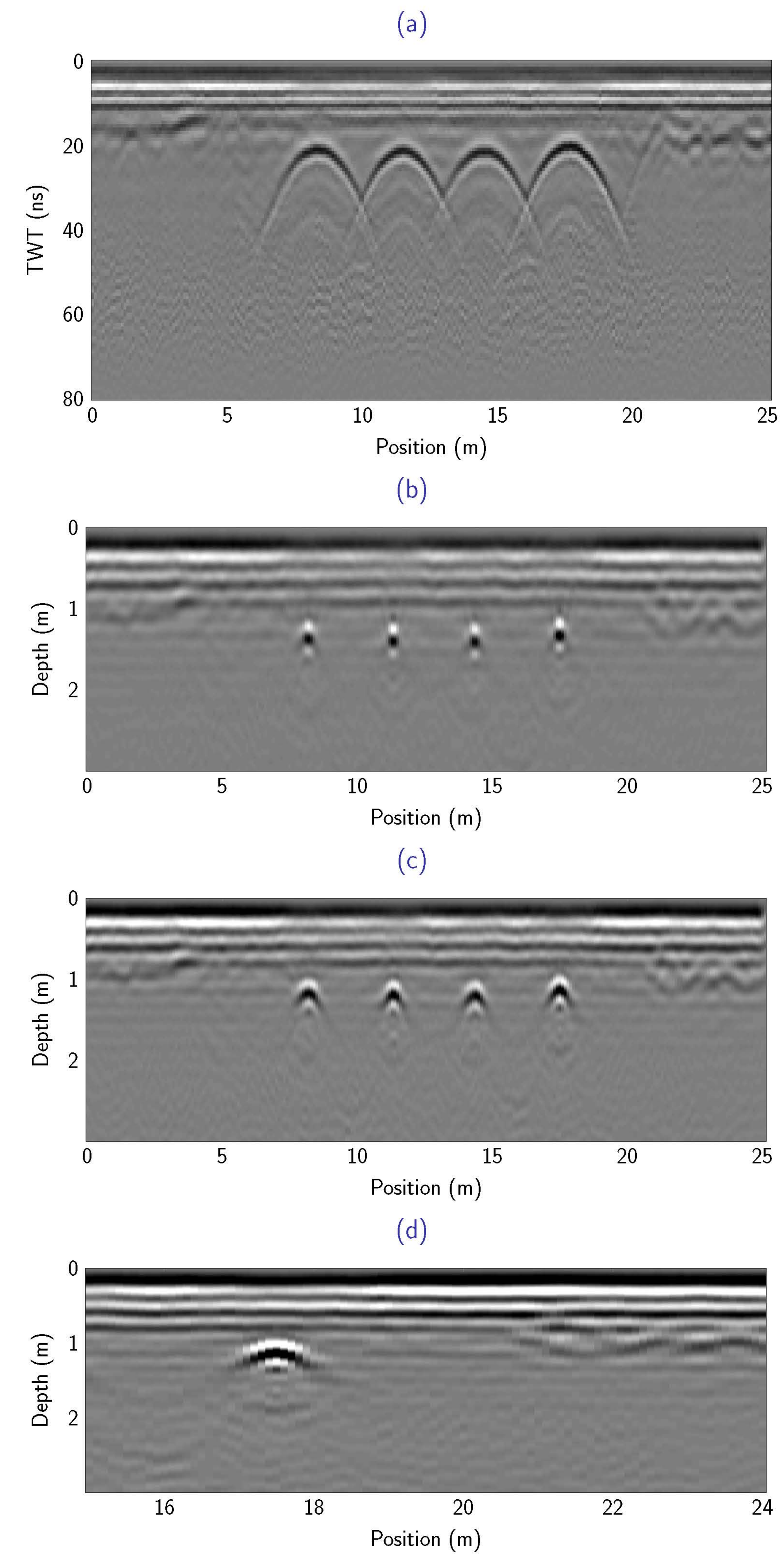

Figure : 6. (a) Georadar record after Gabor deconvolution and bandpass filter, with no mute applied. (b) Gazdag shot record migration using constant velocity model determined from collapsing "diffractions" in a). (c) Gazdag shot record migration using constant velocity model determined from applying circular velocity correction to the model used in b). (d) 1-1 view of part of c).

Future work

- Improve grid-search alogorithm to better constrain velocity corrections
- Develop 2D velocity model and PSDM using PSPI operator
- Process and image other 2D lines and 3D grid in the Houston Coastal Center dataset

Acknowledgements

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