Comparison of pseudo-2D Delta-t-V initial model with 1D gradient initial model, for synthetic data set “Depression” as described by Derecke Palmer (Palmer 2006, Fig. 3 and Fig. 4) :

We built a Surfer .GRD model (Palmer 2006, Fig. 3) and forward modeled 25 synthetic shots into 48 receivers, with our Eikonal solver (Lecomte et al. 2000). See http://rayfract.com/tutorials/palmfig3.zip for model and data, and http://rayfract.com/tutorials/thrust.pdf for instructions. We then inverted this synthetic data with Rayfract™ version 2.64 and true 2D WET inversion (Schuster and Quintus-Bosz 1993). The station spacing is 2.5726 m.

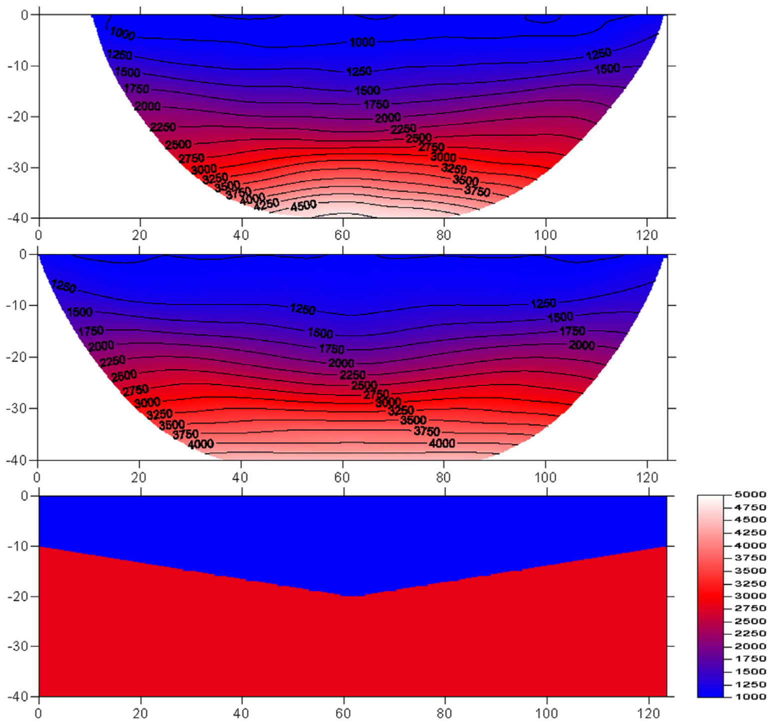

Fig. 1 Top : WET inversion with pseudo-2D initial model (Fig. 3 Top left), with method “Automated Delta-t-V and WET inversion” and default parameters. Note strong velocity artefacts in basement.

Center : WET inversion with 1D gradient initial model (Fig. 3 Bottom left), with method “Smooth inversion” and default parameters.

Bottom : model (Palmer 2006, Fig. 3) from which synthetic shots were generated.

Horizontal axis is horizontal inline offset from first profile receiver, in m. Vertical axis is depth below flat topography in m. Color scale and contours show modeled seismic P-wave velocity, in m/s.

(Fig 1 Top) shows strong velocity artefacts due to a pseudo-2D Delta-t-V initial model (Fig. 3 Top left): too high velocity below syncline center (offset 64 m) and too low velocity below syncline borders (offsets 20 m and 100 m). These artefacts have been described earlier, in (Sheehan 2005), http://rayfract.com/tutorials/broadepi.pdf and http://rayfract.com/tutorials/depress.pdf.

(Fig. 1 Center) shows fewer artefacts, due to a 1D gradient initial model (Fig. 3 Bottom left). Both interpretations show a maximum basement velocity of about 4,500 m/s, which significantly exceeds the true basement velocity of 2,820 m/s. We reprocessed above two interpretations, with a maximum Delta-t-V and WET velocity of 3,000 m/s (Fig. 2). We obtained this maximum velocity estimate with our Wavefront method. You may want to increase such an estimate by about 20%, to allow for a basement internal velocity gradient.

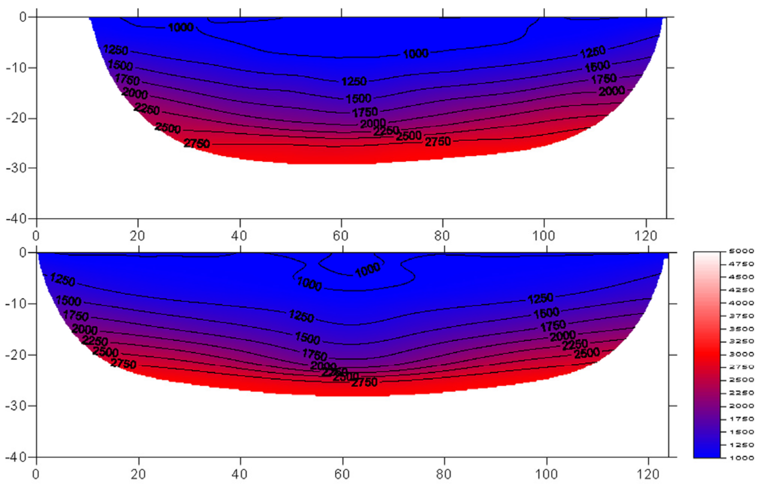

Fig. 2 Top : WET inversion with pseudo-2D initial model (Fig. 3 Top right), maximum imaged velocity of 3,000 m/s.

Bottom : WET inversion with 1D gradient initial model (Fig 3 Bottom right), maximum imaged velocity of 3,000 m/s.

Horizontal axis is horizontal inline offset from first profile receiver, in m. Vertical axis is depth below flat topography in m. Color scale and contours show modeled seismic P-wave velocity, in m/s.

Note how limiting the maximum imaged velocity (Fig. 2) during the inversion helps to reduce velocity artefacts at the interface between overburden and basement (velocity contour 2,000 m/s), at offsets 20 m and 100 m (Fig. 1). Also, in Fig. 2 the sudden model velocity increase (Fig. 1 Bottom) from 1,000 m/s in the overburden to 2,820 m/s in the basement is imaged with closer velocity contours than in (Fig. 1 Top and Center).

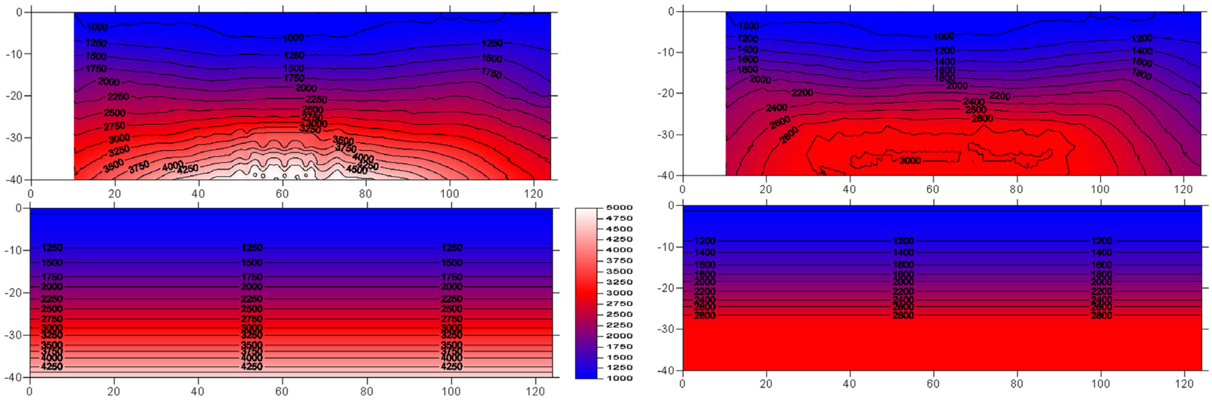

Fig. 3 Top left: pseudo-2D initial model for method “Automated Delta-t-V and WET inversion”, default parameters. Bottom left: 1D gradient initial model for method “Smooth inversion”, default parameters. Top right: pseudo-2D initial model for method “Automated Delta-t-V and WET inversion, maximum velocity limited to 3,000 m/s. Bottom right: 1D gradient initial model for method “Smooth inversion”, maximum velocity limited to 3,000 m/s.

Normally, lateral averaging of the pseudo-2D initial model will result in a 1D gradient initial model with a realistic maximum basement velocity. In this special case, the model covers the syncline only, and does not laterally extend over the edges of the depression. So limiting the maximum velocity becomes more important. For a depression model which does laterally extend over the depression edges, see http://rayfract.com/tutorials/depress.pdf .

We have shown how both using a 1D gradient initial model instead of a pseudo-2D initial model, and limiting the maximum imaged velocity during the inversion can help to obtain better results.

We are grateful to Dr. Palmer, for describing this interesting synthetic model.

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