Which way is up?—experiences with processing physical model data

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Introduction

This demonstration was intended to illustrate the **usefulness of physical modelling**, not only to **test seismic techniques** like time-lapse analysis, but to **test processing algorithms** and runstreams on data whose characteristics can be controlled by the choice and configuration of the materials in the model and the acquisition parameters. It also ***inadvertently*** became a test of the **seismic exploration paradigm**.

The storyline

This project initially began as an attempt to test **time-lapse analysis** techniques using **physical model data**, instead of **numerical model data**. Accordingly, the Processor (Henley) was given two data sets by the Modeller (Wong), who conveyed ***no information about the physical model*** used in the creation of the two data sets, except to say that one survey corresponded to a 'baseline' survey, and the other to a 'time-lapse' survey of the **same model** with a **portion** of one **layer altered** to simulate the time-lapse phenomenon.

Initial processing of the data set labelled **model B** showed the presence of strong **surface-related multiples**, so the Processor decided to test a de-multiple technique first described in 1980 by M.T. Taner*. Two variations of the basic method, which is applied in the **radial trace (RT) domain**, were tested and found to be successful. To keep the data sets compatible, the **de-multiple** technique was applied to **both Model B and model E** (which showed no multiples) before forming the **CMP stack** images for both data sets.

The **project became more interesting** when the Modeller presented the Processor with what he claimed was a **diagram of the physical model**. Proceeding in good faith, the Processor was, nevertheless, **unable to reconcile** all features of the processed **seismic data with this model**. When challenged, the Modeller supplied a **second diagram**, which ***also failed*** to satisfy all the criteria for matching the processed data. Challenged a second time, the Modeller finally (and sheepishly) produced a **third diagram** whose characteristics **satisfied** all the **constraints** of the seismic data.

The lesson:

Preconceived notions are highly overrated in seismic exploration—believe the data!!

***Reference:** Taner, M.T., 1980, Long-period sea-floor multiples and their suppression, Geophysical Prospecting, **28**, No. 1, pp30-48.

The processing

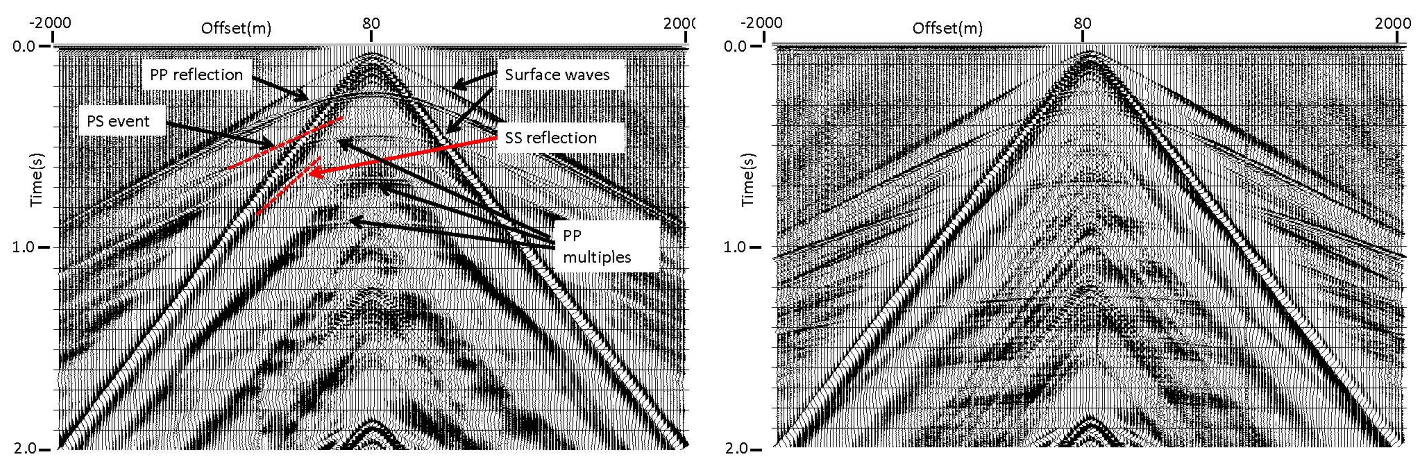

FIG. 1. Raw trace gather from the centre of model B (left), and raw trace gather from the centre of model E (right). Strong surface waves mask underlying backscatter events, but deeper reflections are move visible on model E.

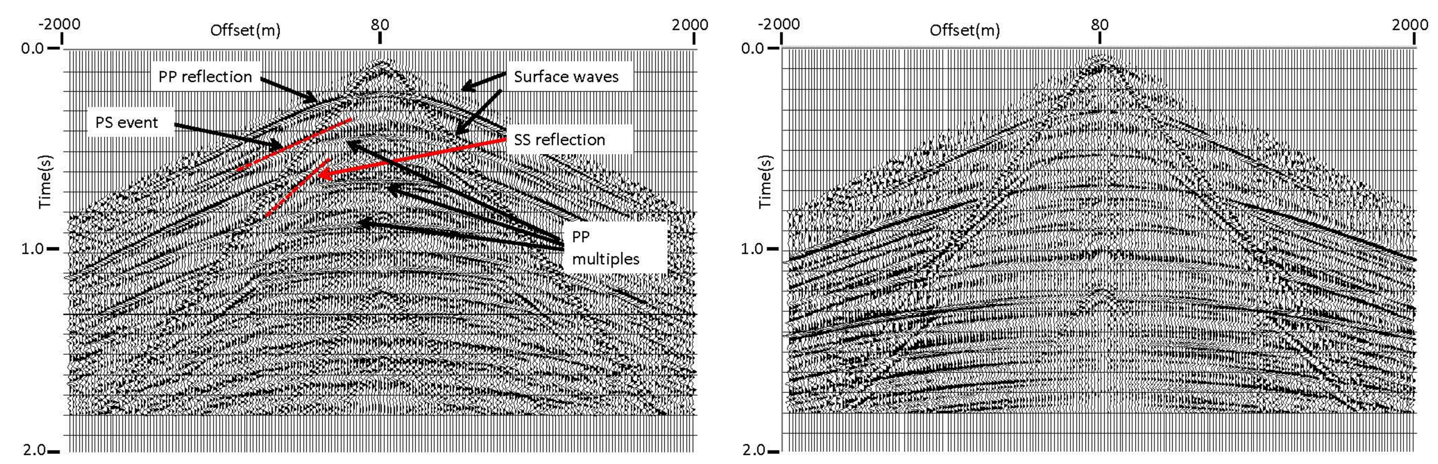

FIG. 2. Trace gathers from Figure 1 after coherent noise attenuation by RT filters applied to model B (left), and model E (right). Many deep reflections are visible on model E, but these events are masked by surface-related multiples on model B.

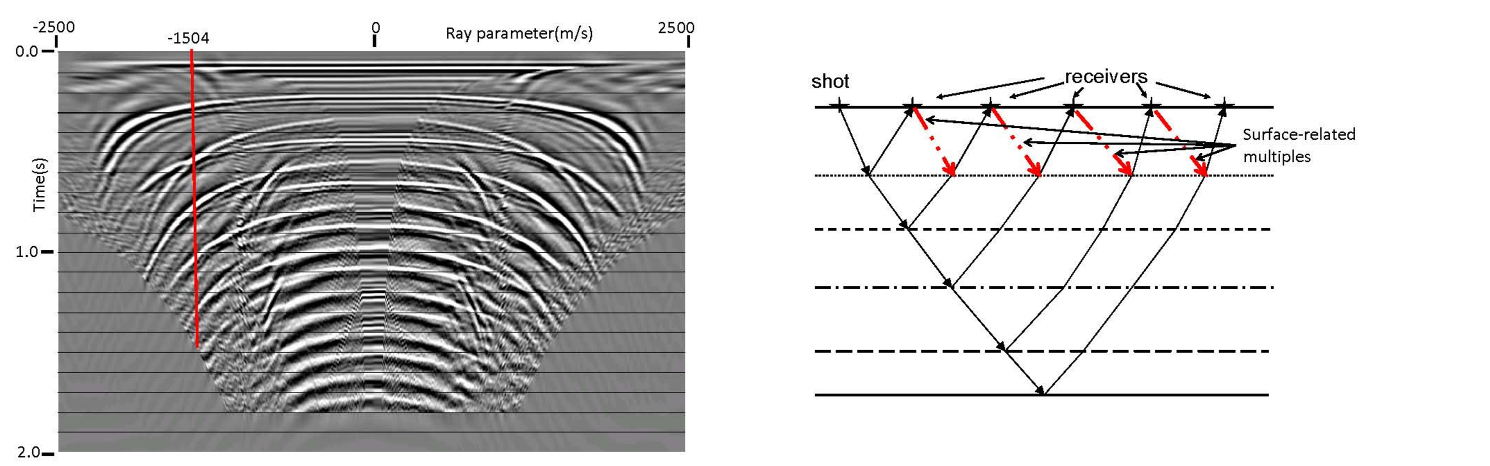

FIG. 3. (left) Radial trace transform of trace gather for model B. Radial trace at ray parameter -1504m/s is flagged. Many orders of surface-related multiples are visible—periodicity is preserved because of raypath geometry of radial trace transform (right)

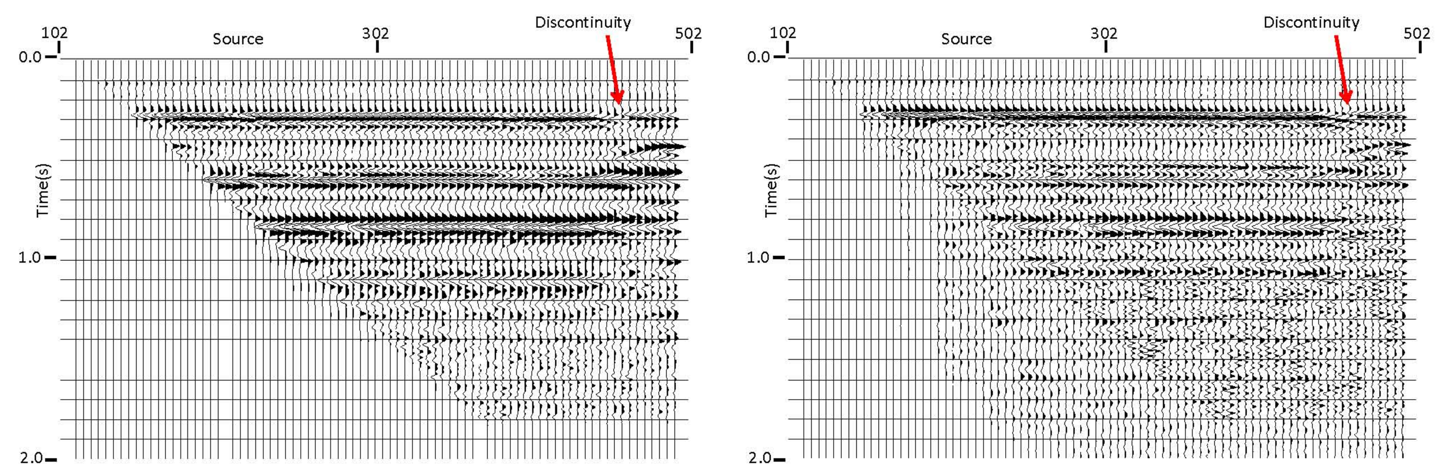

FIG. 4. Radial traces sorted by common ray parameter = -1504m/s. (left) input panel, (right) same panel after autocorrelation and spiking deconvolution. Surface-related multiples are greatly diminished.

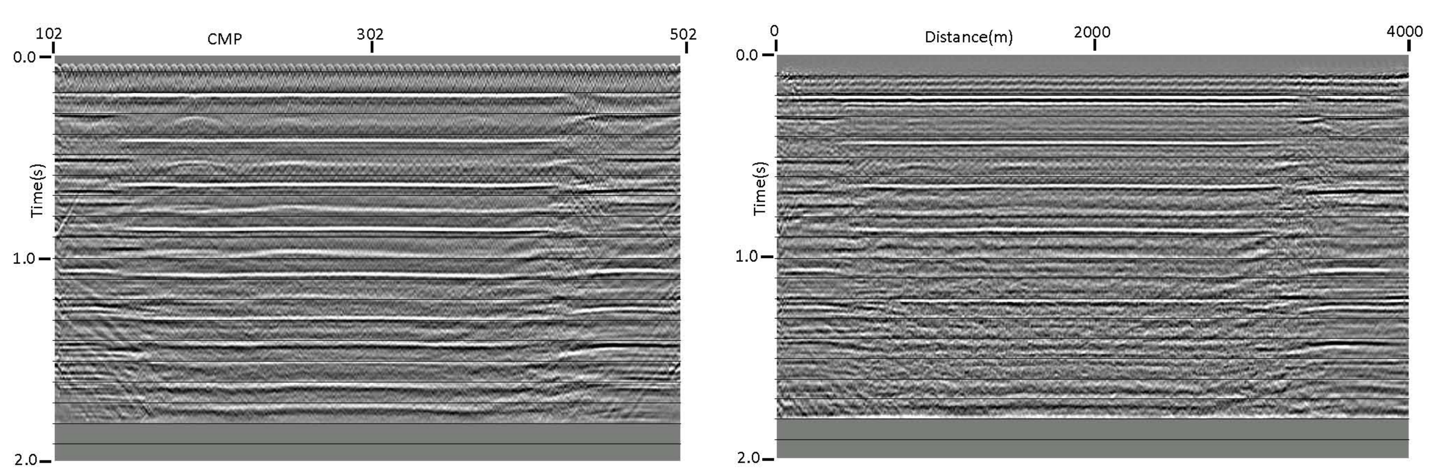

FIG. 5. CMP stack of model B before (left) and after (right) after de-multiple operation. Note the discontinuities near both ends of the image, beginning at the very shallowest reflection

The interpretation—*Processor ultimately vindicated!*

In spite of minimal (and misleading!) information conveyed to the Processor by the Modeller, careful attention to all details of the processing and imaging led to the correct model.

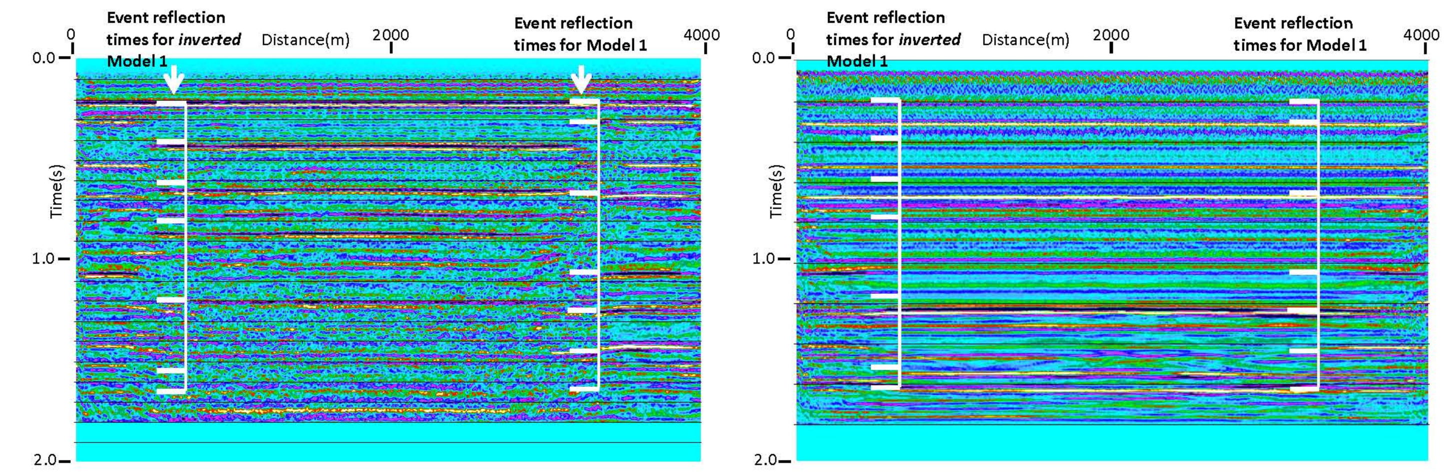

FIG. 6. CMP stack of model B (left) and model E (right) after coherent noise attenuation and de-multiple. Superimposed are zero-offset reflection traveltimes computed from Model 1, the first proposed physical model. Also superimposed are the zero-offset traveltimes that would result if the model had been inverted before survey.

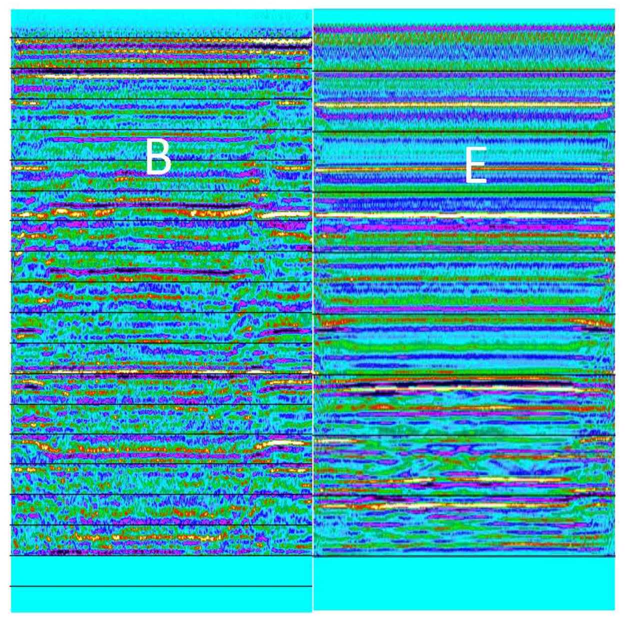

FIG. 7. Models B and E compared side by side to show potential common events. The edge of model B matches the edge of model E quite well.

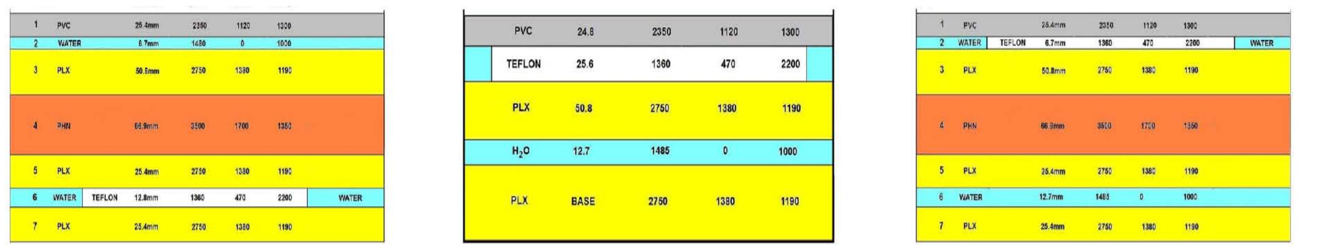

FIG. 8. The three models proposed to fit the two seismic surveys. In each case, the presence of the teflon block would correspond to model B, and the absence would correspond to model E. Ultimately, reflection time ties and the presence of surface-related multiples eliminated all but the model on the extreme right.

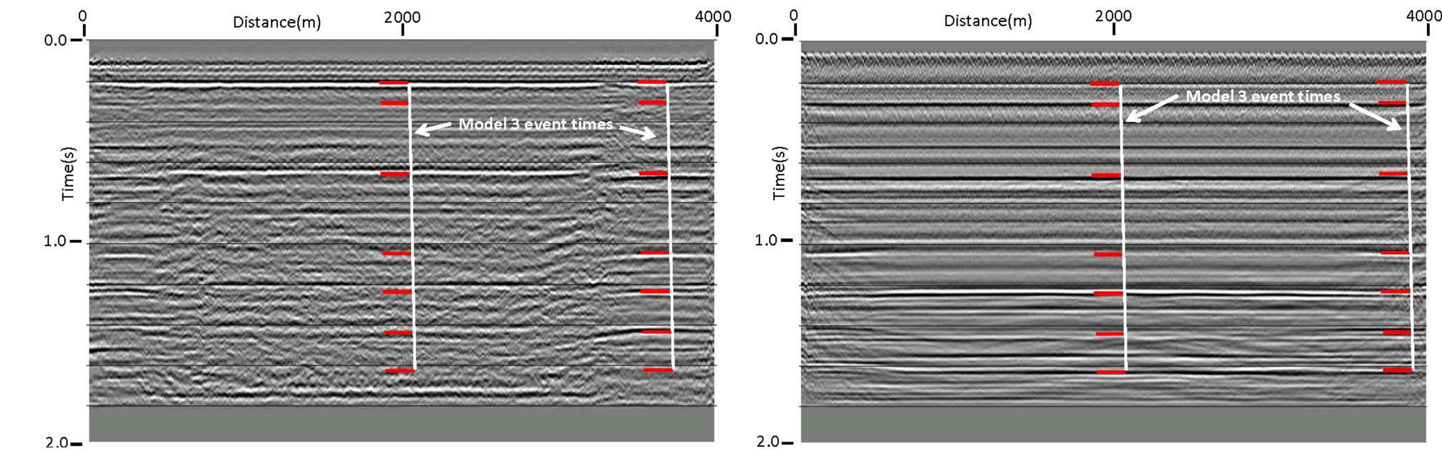

FIG. 9. Model B (left) and model E (right) showing the reflection time ties with the model on the extreme right in Figure 8. The ties in the centre of model B are shifted slightly up, due to the faster velocity of teflon relative to the water it replaces in model E.