



Processing Issue at Moderately Shallow Depth

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Summary

Processing of moderately shallow target is a little different story from the usual experiences of processing of targets of the order of 2 km or more. While processing for targets of about 300m, slight adjustments in processing strategy is required when using the existing software. Here some basic aspects for moderately shallow depth are discussed. This discussion is based on processing of seismic data specially acquired for shallow target and is aimed at understanding various issues related to processing of data at these depths.

The seismic data under investigation (for moderately shallow depth target) is rich in high frequencies as attenuation losses are less. At shallow depths secondary reflection activities is more or less absent. So de-convolution is not required. However ground roll is expectedly very strong and need to be addressed. For structural imaging, single window spectral balancing is sufficiently effective because a wide bandwidth of frequency is available. For attributes, sections can be generated without spectral balancing. Stacking velocity estimates also get effected at shallower target. This depends on elevation of shot and receiver w.r.t. seismic reference datum. If migration is required, particularly for interval velocity probing through PSDM then it is reasonable to take 1st layer of thickness half of the shot depth and velocity driven from up hole data and shifting the datum to midway between shot and receiver elevations the same (half the shot depth). Thin layers can be modeled because the data is rich in high frequencies.

Introduction

Seismic data taken for this study was acquired with the aim of establishing surface gas seepage. The objective of survey was to find braided channels, define faults for target depths up to 500m (TWT 500ms). Expected dips are up to 10 degrees. Processing was to produce output image with the high frequencies preserved.

Data acquisition:

Data was acquired by recording with 256 channels using symmetric split spread, with spread length of 635m resulting in 2x8 fold. Geophones of 30Hz natural frequency were used in the field. Shot-hole depth was of the order of 45m. Datum elevation was MSL and general surface elevation (receiver) ranged from 0 -10m. Record length and sampling interval of the data were 2 sec and 0.25ms respectively.

Table 1: Acquisition Parameter in brief

Spread configuration	Split spread 2x8 fold
Natural freq. of geophone	30hz
No. of channels	256
Near/Far offset	10m /640m
Rec/Shot interval	5m/ 40m
Shot depth	~ 45 m
Seismic datum	MSL
Record length / SI	2sec / 0.25 ms

Processing of data:

Shot records were studied for the frequency content. Strong ground roll dominated the near traces. (Fig. 1a). To begin with, strong ground roll and the first break activities were muted and a first hand estimate of the frequency content was made in the noise free target zone. This shows presence of frequencies up to 150 hertz. The strong ground



roll does get arrested by using spectral balancing because fairly wide frequency band is available (Fig 1b). Optimum frequency was found to be up to 120 Hz which gives a good S/N ratio. Data was also re sampled at 1 msec. There is a need to mention here that some of the existing algorithms did not perform well with the data sampled at 250 micro-seconds, for example, random noise attenuation, surface consistent amplitude correction. De convolution was tested but spectral balancing was found to be more effective.

Stacking velocity estimates at shallow levels are affected by sizeable shot depth and selection of seismic reference datum. These were found to be lower in the case under study. For example, up-hole studies suggest sub weathering layer is having velocities of the order of 2000 m/s. This appeared as comparatively less (~ 1700 m/s). This can be explained from the equation

$$V = x / \sqrt{(t_0' * NMO)}$$

(Where symbols have their usual meaning)

Time t_0' is the zero offset two-way-time corrected to reference datum, i.e., $t_0' = t_0 + FS$ where FS is signed total shot and receiver correction and t_0 is time taken by the disturbance from shot to reflector and to the receiver. At small t_0 times, this term FS becomes significant. For $t_0 \sim 160$ ms and FS ~ 40 ms, velocity will be 10% lesser. This consideration is not significant at deeper levels as $t_0 \gg FS$.

At shallow levels, the CMP traces for non zero angles actually get shifted because of different elevation of shot and receiver (Fig. 3). For large offsets this shift is a few CMPs because CMP interval is also very small. For split spread geometry, this smearing will be on both sides of CMP. As the shallow beds are uniform and flat this shifting was accepted. This can not be addressed with existing software. This, however, does not affect if NMO stretch is further reduced. The hyperbola anyway gets flatten with lesser velocity also.

Two pass residuals were estimated and applied to avoid loss of higher frequencies in stack (due to residual mismatch). NMO stretch is also restricted to 20%. Subsequently, post stack frequencies fall to about 100Hz (because of NMO stretch). A mild FX treatment for random noise attenuation was also applied.

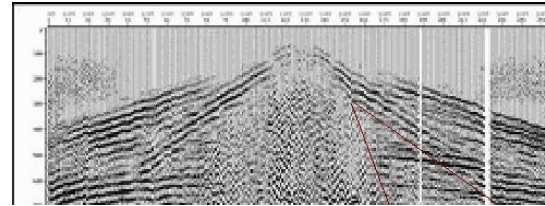


Fig 1(a) Shot gather (spherical div applied)

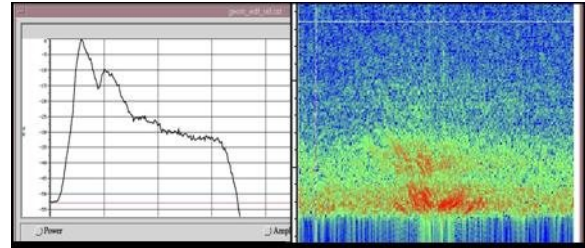


Fig 1(b) Frequency and F-K Spectrum of noise free zone

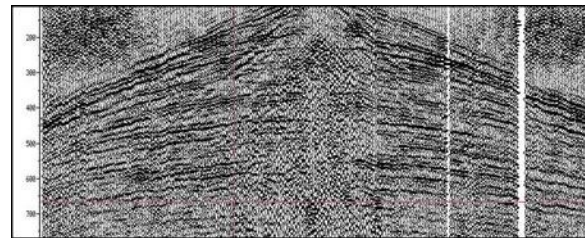


Fig. 1(c) Spectral balancing up to 120 Hz

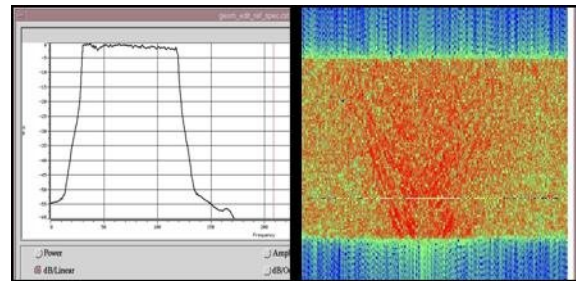


Fig 1(d) Frequency and F-K Spectrum after spectral balancing

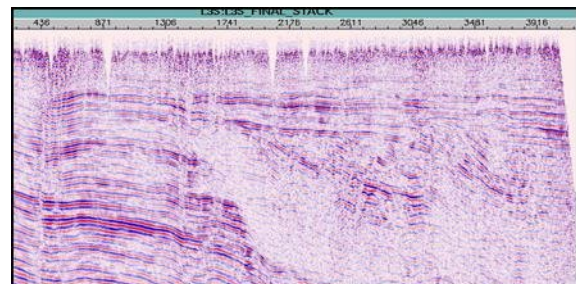


Fig 2. Stack shows sharp feature which require migration

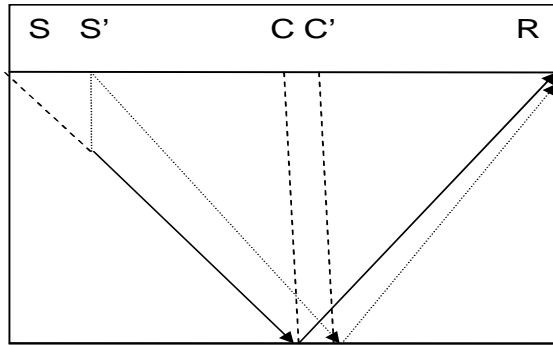


Fig. 3 The reflecting point moves away from CMP as the angle of incidence increases.

Table 2 : Processing parameters in brief

Spherical divergence	T**1
Spectral balance	30 -120 hz
Two pass residual	
NMO stretch	20 %
Random noise attenuation	Mild
Migration aperture	800m

Migration:

In the area under study, stack section shows some channel cuts with sharp dips (Fig. 2).

To precisely define the structure and to study the interval velocity variations, migration issues were considered for shallow depths. The aperture requirement for shallow depth is small, which is also desirable (as more noise moves up during the migration process). An aperture of 800m seemed sufficient for PSTM and PSDM with stronger stretch filter. This aperture also sufficiently accounts for Fresnel Zone. (PSTM section Fig. 6).

Building 1st layer through seismic is difficult as remnants of ground roll still remains in the data. So it is best to use up-hole model for depth and Vint for this layer. (Fig 7)

Again to overcome problem related to sizeable shot depth compared to the target depth, it is useful to use 1st layer of thickness half the shot depth and use the up-hole modeled velocity for this layer (Fig. 4) The velocity estimates at shallow level were more accurate using this approach. Only depth gets a constant shift (equal to half the shot depth which can be adjusted).

As the data is rich in higher frequency, thinner layers (of thickness less than the normally accepted restriction of 200ms) were chosen. Layer based tomography was used. Grid based tomography was not used as the software does not allow modification for less than 400m (as these have

been designed to avoid instability for the normal target depths). Reasonable lateral variation of interval velocity was captured (Fig. 5) with the model based approach, which can be of significance depending upon other attributes.

Remarks on Fig4 ; (Upper diagram) FS(datum at receiver plane) applied data used for velocity model building. Top line is receiver plane which is also the SRD. Red line is the chosen 1st layer of depth equal to the shot hole FS applied data used for velocity model building runs into difficulty as it deviates from the actual travel time calculations and ends up underestimating the velocity of the 2nd layer. (Subsequently errors would also propagate down). (Lower diagram) Here the datum is shifted by half the shot depth and 1st layer thickness is reduced to half (thus adjusting the travel in 1st layer equal to actual travel in this layer) Therefore further computations are made using the actual travel time. Orange color arrows show actual ray path as recorded in field. In both the figures, thick vertical line show shot hole Top line is the receiver plane. Ray diagram is for max offset = 90m (1st layer velocity = 1200 m/s /time=36 ms/depth 44m) For v2=1800 m/s critical angle is about 40 0 .

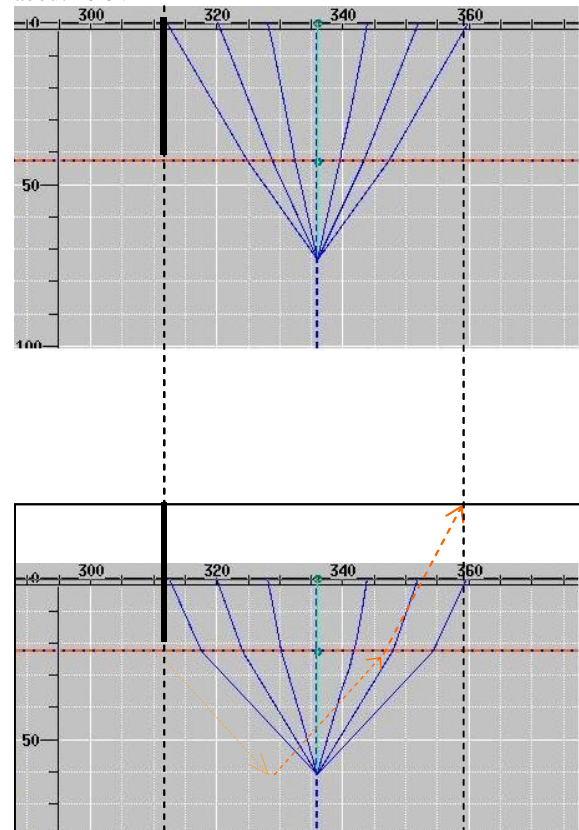


Fig4. Ray tracing gets affected by the choice of SRD



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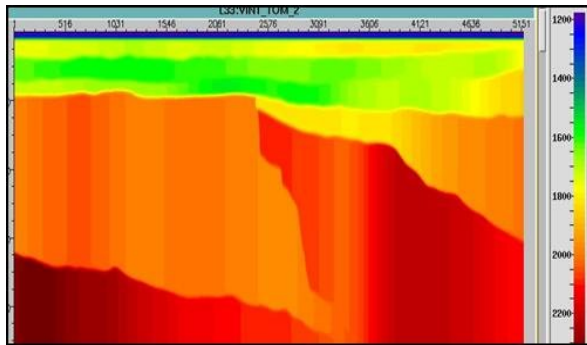


Fig. 5 Interval velocity model to capture lateral velocity variation (1st layer using UH model)

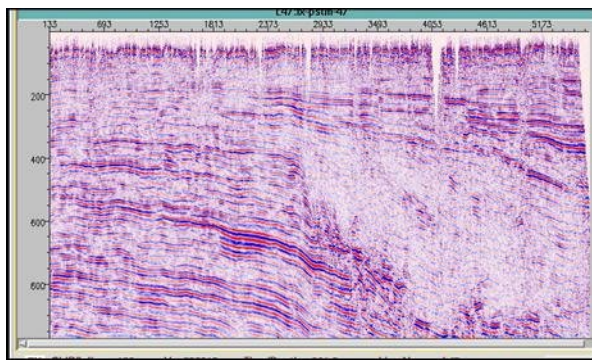


Fig. 6 PSTM section

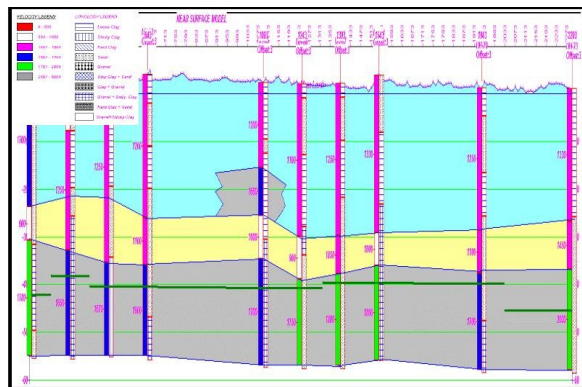


Fig 7. U H model along the line For shot depth of 45m up hole time is of the order of 40ms.i.e. average velocity is of the order of 1100 m/s . Below this is sub-weathering velocity of the order of 1700 m/s.

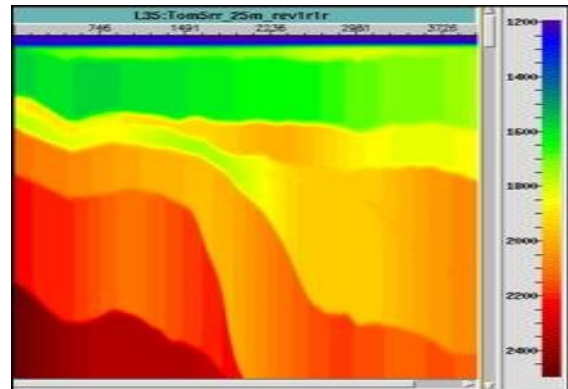


Fig. 8 Interval velocity model created after shifting the SRD as suggested in Fig4

Conclusion

To process data at moderately shallower depth, existing processing tools should be used carefully as some of the usual approximation may not be valid at these depths.

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