Wave Inversion Technology, Report No. 2, pages 51-56

Spatial Positioning of Reflectors Using the τ-p Transform (Cross-Section Processing)

Kai-Uwe Vieth[1]

keywords: *imaging, migration, τ-p transform, 2.5D-processing, side-swipes*

ABSTRACT

In 2.5D seismic it is possible to calculate dip and strike if the same event has been picked in in- and cross-line sections. In my diploma thesis I use the entire wave field of common-shot gathers to calculate the correct position of a reflector in 3D space. This knowledge is of interest when migrating 2D data as errors occur but are not recognized if side-swipes have been recorded.

SUMMARY

One aim in reflection seismic is, of course, to create an image where all reflectors are in the correct position in 3D space. In principle, it is no problem to reach this goal if one has 3D data. But for 2D data one has to consider that migration is fulfilled correctly only if the line is in dip direction. Outcrops and geologic knowledge help to avoid deviations of this restriction at least for flat interfaces but their geometry might change dramatically with depth. Therefore, so-called side-swipes are recorded and make the reflector appear at the wrong position.

This master thesis focuses on in-line registration accompanied by cross-line registration, i.e. 2.5D data are provided. Identifying and picking on both datasets an event, it is possible to calculate its dip and strike. The new feature in this thesis is not to use only picked values but to make use of the complete wave field!

The spatial location of a reflector is determined uniquely if two angles, dip and strike, and one point of it is known. For that purpose, common shot gathers of both lines, corresponding to the same shot, are transformed into the well known (τ,p)-space, where every ray parameter is associated with plane waves (Phinney et al. (1981)). The coherency measure semblance (Neidell and Taner (1971)) is an appropriate tool to

[1] **email:** kuvieth@gpirs1.physik.uni-karlsruhe.de

discriminate between significant and insignificant data in slant stacks accompanied by a threshold (Stoffa et al. (1981)). For synthetic and real data it is shown in the thesis that an event does not have to be continuous along the complete aperture in order to be detected and therefore is taken into account for further processing. The synthetic datasets have been successfully processed, i.e. the results coincide very well with the model input. For signal-to-noise ratios of 0 dB the results are excellent and it is very easy to handle the small amount of noise. For -10 dB the noise cannot be suppressed as good as for 0 dB, therefore the results are of more interest concerning applicability hence an example is shown below. Because it is intended to use the results for interpreting migrated or to be migrated data, respectively, it is necessary to display them in a zero-offset section. Geometric considerations yield that the zero-offset section is bounded by the shot position and the location of the common geophone of in- and cross-line.

One example is presented in this summary. In Figure 1 the model used for generating

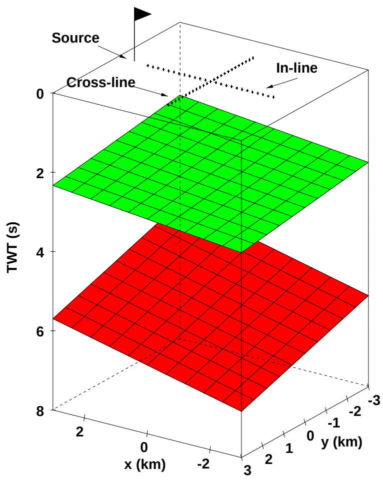
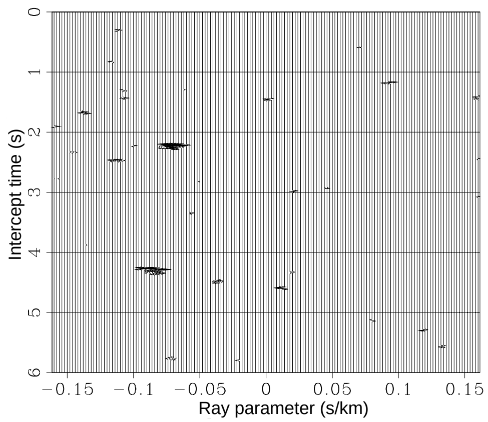


Figure 1: *Both reflectors strike with* 135^o *corresponding to in-line. The upper one has got a dip of* 20^o *, the lower one a dip of* 40^o*.*

synthetic data is shown. Corresponding to the in-line both reflectors have a strike of 135^o. The upper interface dips with 20^o, the lower one with 40^o. The zero-offset time at source location is 2 s and 4 s for the interfaces, respectively. The synthetic seismograms are not displayed here, as the events cannot be observed by eye because of the signal-to-noise ratio of -10 dB. But in Figure 2 τ-p transforms of both lines (left: in-line, right: cross-line) are shown. The events are represented by a small range of ray parameters. The incident angle is different for both lines, hence the events appear in different (τ,p)-regions.

Grey-scale values represent average values as a lot of data of the slant stack contribute to each sample in the zero-offset section. Hence, \`events\` in the zero-offset



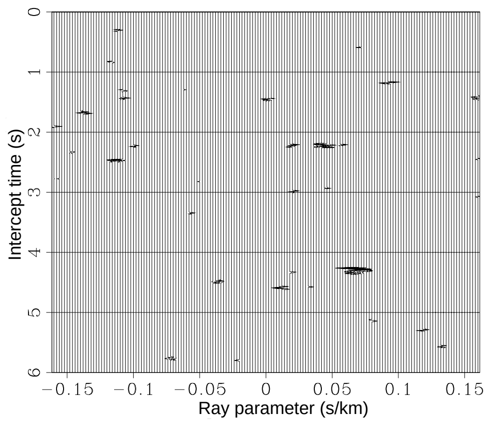


Figure 2: *τ-p transform of shot-gather of in-line at the left and of cross-line at the right side.*

section which have high standard deviation values are considered as a product of noisy (τ,p)-data, whereas real events have low values. In my diploma thesis I extensively used colormaps for displaying attributes which makes interpretation easier than in grey-scaled mode. Despite the low signal-to-noise ratio the strike of the reflector at 2 and 4 s two-way-traveltime (TWT) at an offset of 2.5 km is reconstructed exactly. The dip of the upper reflector is about 10^o bigger than in the model whereas the dip of the lower interface coincides with the model.

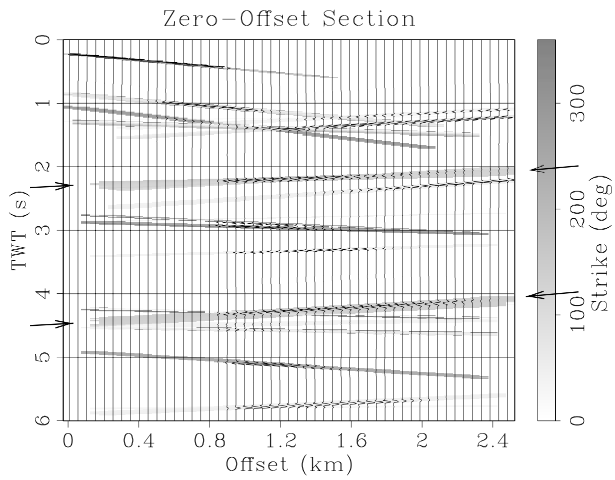


Figure 3: *Zero-offset section overlain by the attribute strike. Observe the good correlation with the model for the reflectors which are at 2 and 4 s TWT at 2.5 km offset.*

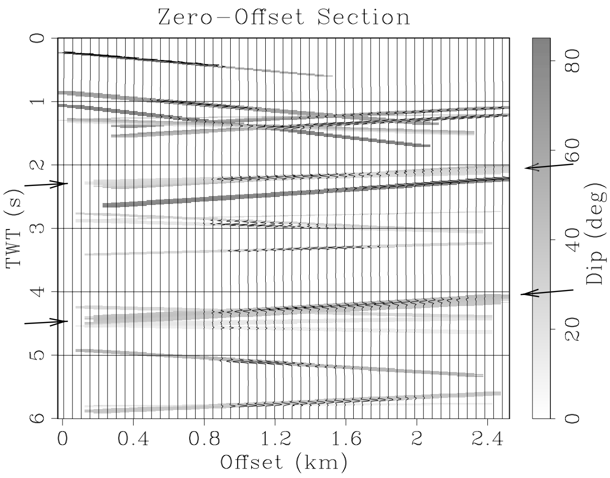


Figure 4: *Zero-offset section overlain by the dip attribute. The dip of the upper reflector is about* 10^o *higher compared to the model. For the lower interface the correct dip has been evaluated.*

It is notifiable that the results for a symmetric, i.e. an X-shaped, array is much better than for an asymmetric, i.e. a T-shaped, array. In Fig. 3 it is depicted that not only the half but the whole first Fresnel-zone contributes constructively to that certain (τ,p)-value if the arrays cross half-way at point C. If the configuration is asymmetric the region of tangency with a diameter of the first Fresnel-zone shifts to higher ray parameters which results in increasing dips.

Although not displayed here, the processing scheme has been applied successfully to real data recorded during the URSEIS' 95-project.

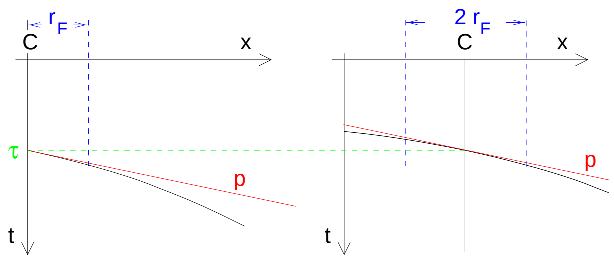


Figure 5: *For the symmetric arrangement (right side) the main contribution for (*τ*,p)-values stems from both sides of the crossing point.*

CONCLUSION

Not only picked data but the whole wave field is processed succesfully in order to find the correct spatial position of interfaces. Whenever possible the lines should cross half-way. Even for bad signal-to-noise ratios the algorithm yields good results. This important knowledge has to be considered when 2D migrated data are interpreted as the migration might be incorrect because of side-swipes.

REFERENCES

Neidell, N., and Taner, M. T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, **36**, no. 3, 482–497.

Phinney, R. A., Chowdhury, K. R., and Frazer, L. N., 1981, Transformation and analysis of record sections: Journal of Geophysical Research, **86**, no. B1, 359–377.

Stoffa, P. L., Buhl, P., Diebold, J. B., and Wenzel, F., 1981, Direct mapping of seismic data to the domain of intercept time and ray parameter - A plane-wave decomposition: Geophysics, **46**, no. 3, 255–267.

Vieth, K.-U., and Wenzel, F., 1997a, Systematische Auswertung von Querlinien: 57. Jahrestagung d. Deut. Geophys. Ges., Abstracts.

Vieth, K.-U., and Wenzel, F., 1997b, Wellenfeldrekonstruktion zur Berechnung von Seiteneinstreuungen: 14. DEKORP-Kolloquium, Potsdam, Abstracts.

Vieth, K.-U., 1998, Räumliche Einordnung von Reflektoren mit Hilfe der τ-p Transformation (Querlinienauswertung): Master's thesis, Geophysikalisches Institut der Universität Karlsruhe.

PUBLICATIONS

Detailed results were published by Vieth (1998), Vieth and Wenzel (1997a), Vieth and Wenzel (1997b).