NEW TECHNIQUES IN THE SEISMIC DATA PROCESSING
NOVÉ TECHNOLOGIE VE ZPRACOVÁNÍ SEIZMICKÝCH DAT

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Abstract

MND, a.s. is the biggest oil company in the Czech Republic. There are 21 production fields with daily exploitation of 5,000 oil barrels and 250,000 m^3 of gas. The MND group operates also underground gas storage Uhřice with the capacity of 180 million m^3 gas. The exploration area is: south-east slopes of Bohemian massif, Vienna basin VIII and Vizovice hills I.

Seismic Data Processing Centre in Brno is part of MND a.s. New methods in seismic data processing as Prestack Time Migration (PreSTM) or Prestack Depth Migration (PreSDM) are now required outputs in the seismic data processing. The new trends in seismic data processing proved that reprocessing can bring more accurate imaging of seismic events.

Abstrakt

Moravské naftové doly, a.s. (MND, a.s.) jsou největší ropnou společností v Ceské republice. Vlastní 21 těžebních polí s denní těžbou 5000 barelů ropy a 250 000 m^3 plynu. Skupina MND provádí také řízení provozu podzemního zásobníku plynu na Uhřicích s kapacitou 180 000 000 m^3 plynu. Oblasti těžby jsou jihovýchodní svahy Ceského masívu, Vídenská pánev VIII a Vizovické vrchy I.

Středisko zpracování seizmických dat je součástí MND a.s. Nové metody jako předsoučtová časová migrace (PreSTM) nebo předsoučtová hloubková migrace (PreSDM) jsou nyní žádanými výstupy zpracování seizmických dat. Nové trendy zpracování seizmických dat prokázaly, že zpracování dat novým způsobem může přinést přesnější obraz seizmických rozhraní.

Keywords

prestack time migration, prestack depth migration, velocity analyses, amplitude versus offset analyses

1 Introduction

MND, a.s. is the biggest oil company in the Czech Republic. There are 21 production fields with daily exploitation of 5,000 oil barrels and 250,000 m^3 of gas. The MND group operates also underground gas storage Uhřice with the capacity of 180 million m^3 gas.

MND, a.s. is recently concentred on the exploitation of the existing deposits and exploration of new reservoirs with the new technologies that are environmental friendly. The company operates in 3 exploration areas: south-east slopes of Bohemian massif, Vienna basin and Vizovice hills I. The prospecting requires not only reliable geological interpretation but also good quality of seismic data processing.

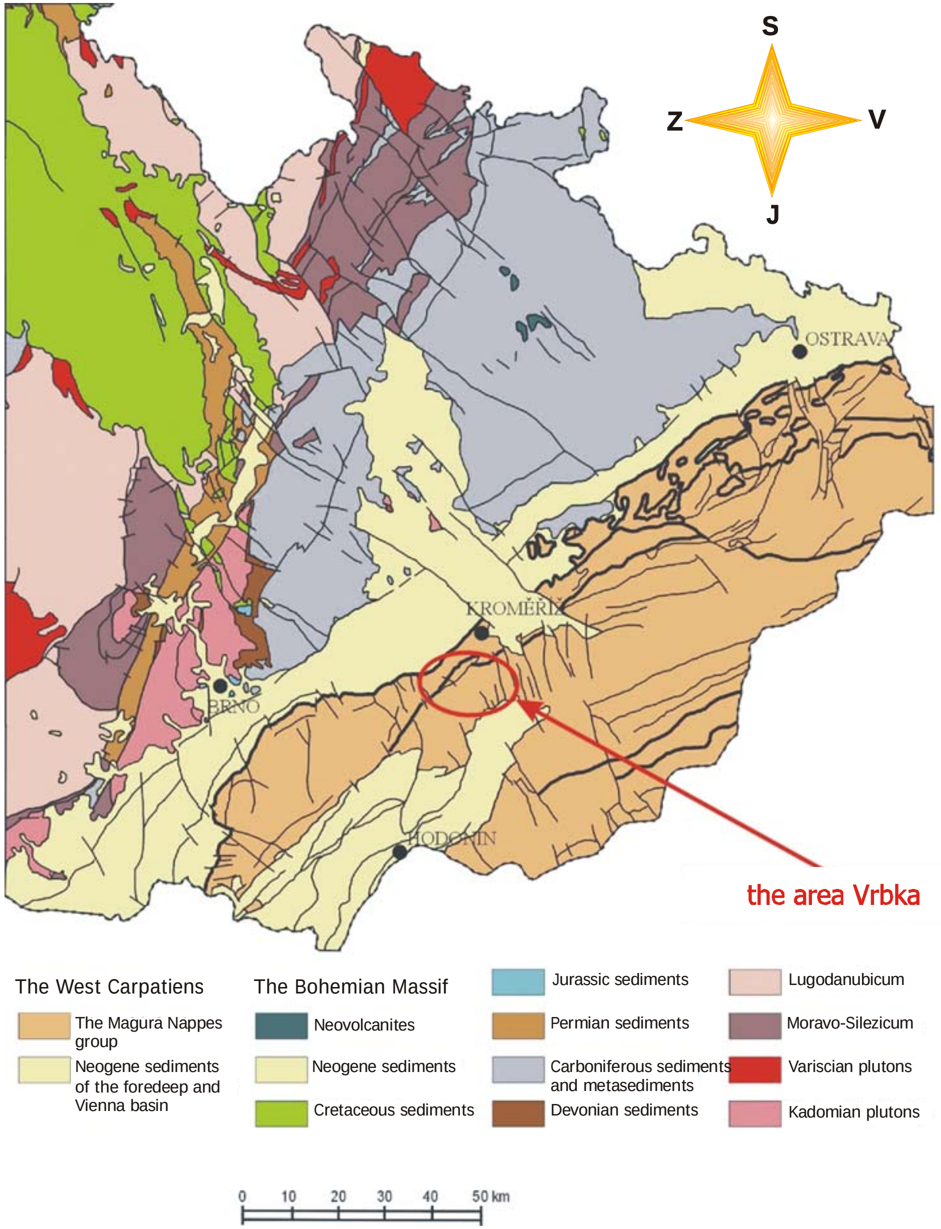

Fig.1 Geological map of eastern part of Bohemian massif - the target area Vrbka

The geological interpretation of seismic data in MND went through the major progress. The interpretation of seismic lines having been on paper was replaced by interactive software Charisma, Kingdom and lately system Petrel which is used most recently. The advantage of interactivity is the faster geological interpretation but the older seismic data needs to be reprocessed.

3D data from Vrbka area was reprocessed in 2007 (exploration area Vizovice hills I) which is situated southwest of the town Kroměříž. The reprocessing was carried out in MND processing centre in Brno and there were used the new techniques.

2 Processing of Seismic Data

Seismic Data Processing Centre in Brno is part of MND a.s.; follows in the tradition of seismic data processing in Geofyzika Brno. The centre recently dispose of the cluster Dell under the system LINUX with 7 workstation and seismic system Geocluster supported by CGGVeritas. Seismic data processing experience fast progress and it is difficult to keep up with the worldwide trends.

The information technology development enables more complicated computation and processing of large amount of 3D data in relatively short time. The current interpretation systems allow more detailed interpretation of seismic data and put together the necessity of feed back between geologist and processor. This type of cooperation between these two specialists was not used too much in the processing routine before. However with new techniques in seismic data processing as prestack time migration (PreSTM) or prestack depth migration (PreSDM) being recently required products in oil and gas exploration industry appears this cooperation as very useful and can bring the improvement of final results. These new trends we can see also in big companies as Shell which branch the in-house processing centres and exploit from the cooperation of geologist and geophysics.

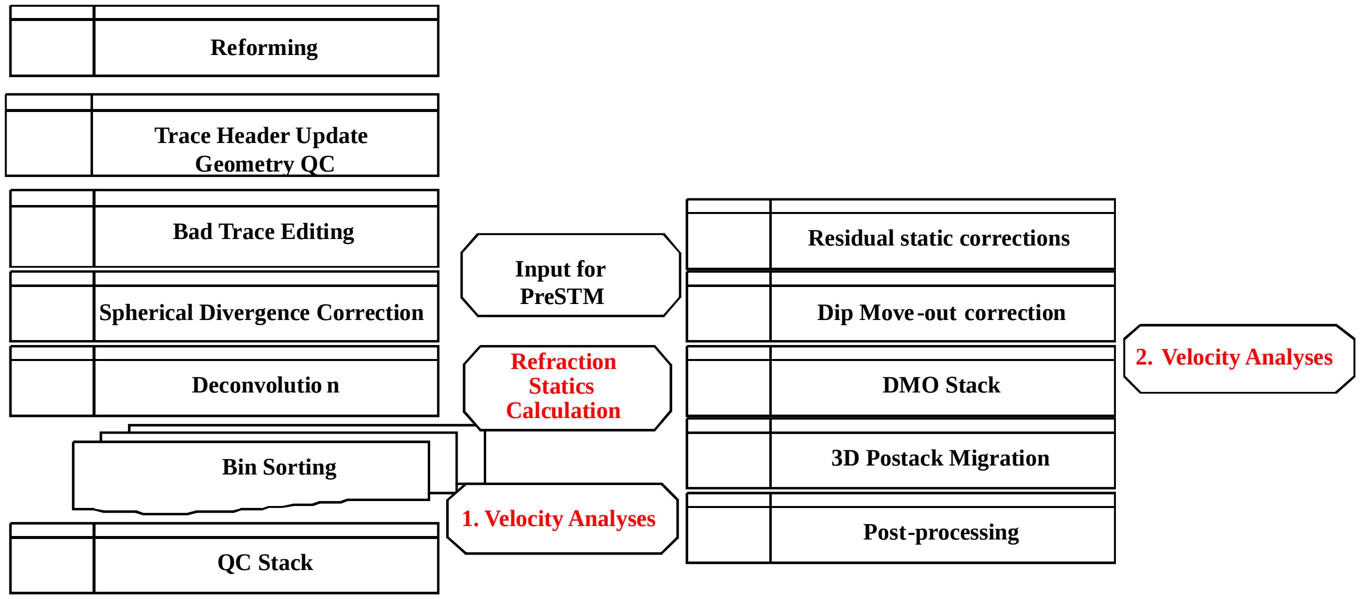

Fig. 2 Block Diagram -3DPoSTM Processing

2.1 Glossary

- ***Velocity analysis*** veloscan - constant velocity stack or spectral velocity analyses
- ***AVO analysis*** amplitude versus offset analyses
- ***Bin*** common reflection point in 3D
- ***CDP gather*** common depth point
- ***Deconvolution*** the process of undoing the effect of the earth filter
- ***DMO*** dip move out correction
- ***QC stack*** stack of traces belonging to the same CDP or Bins
- ***Migration*** plotting of dipping reflections in their true spatial position:
  - PoSTM - Postack Time Migration
  - PreSTM - Prestack Time Migration
- ***Spherical divergence*** the decrease in wave strength with distance as a result of geometric spreading
- ***Static correction*** time shift applied on seismic data to eliminate the effects of variation in elevation, weathering thickness or weathering velocity
- ***RMO*** residual move out - a small amount of normal move out which remains after velocity smoothing.

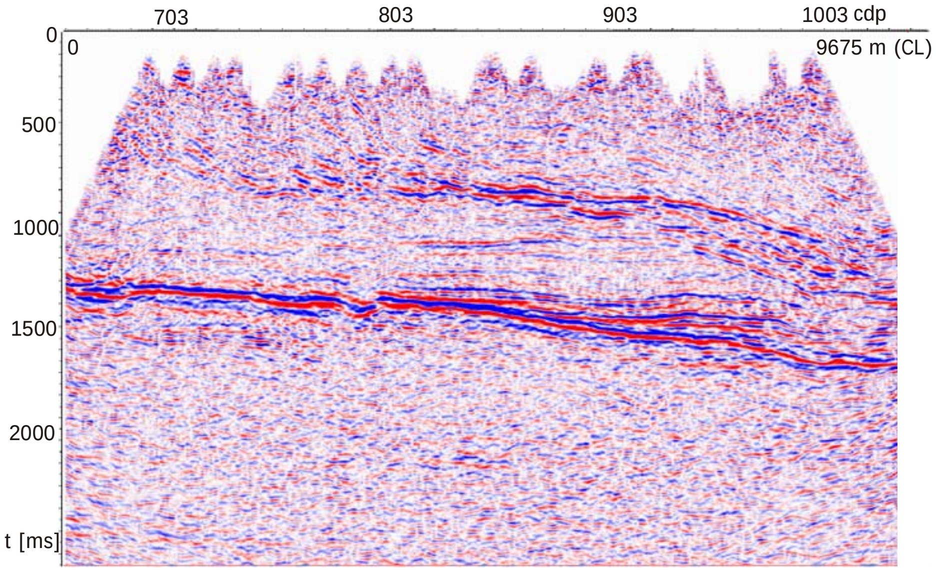

Fig. 4 PoSTM processing 1997 IL 535

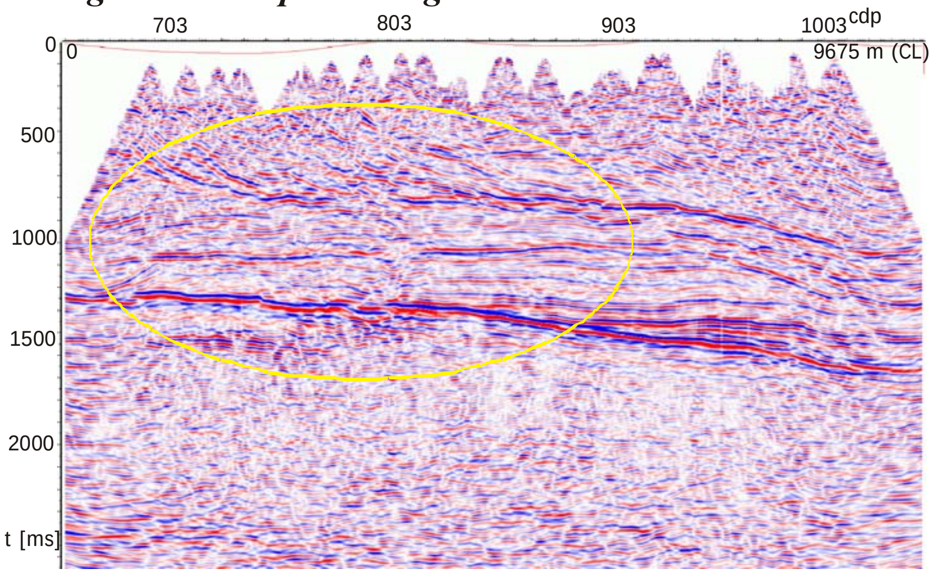

Fig. 5 PoSTM reprocessing 2006 IL 535

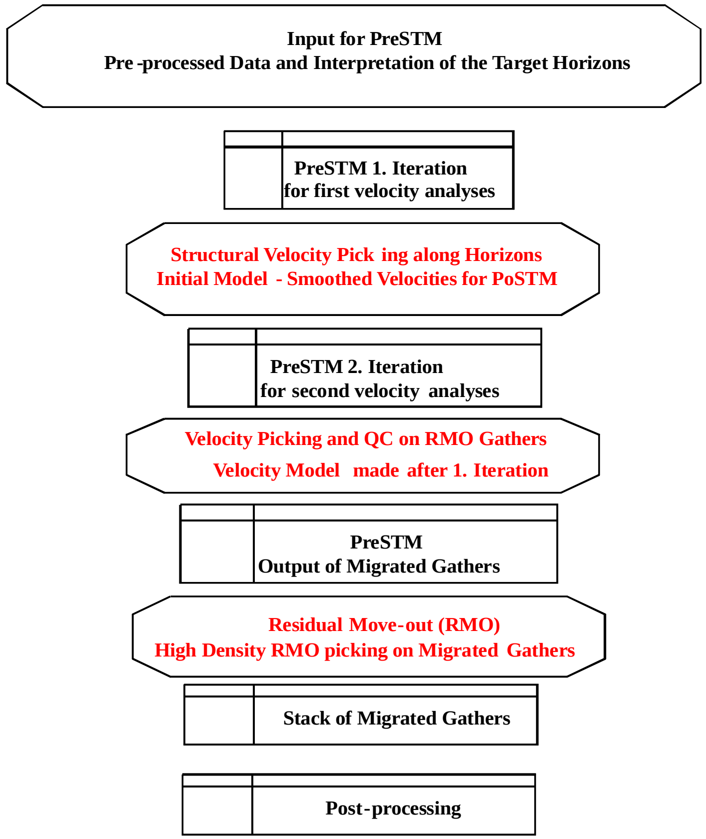

Fig. 3 Block Diagram 3D PreSTM Processing

2.2 Standard Seismic Data Processing

The relatively new techniques in seismic data processing are Prestack Time Migration (PreSTM) or Prestack Depth Migration (PreSDM). The advantage of PreSTM is that the seismic events are better focussed at the faulted areas and in the areas with strong velocity contrast for example in the areas with salt diapirs. The disadvantage is not very accurate position of the seismic events in very complicated geological areas with large degree of horizons incline and with the horizontally variable velocity field. The PreSDM can help to image the data correctly if we have the accurate velocity model. The special software for velocity model building and for PreSDM is needed. This software is not available in MND Processing Centre nowadays.

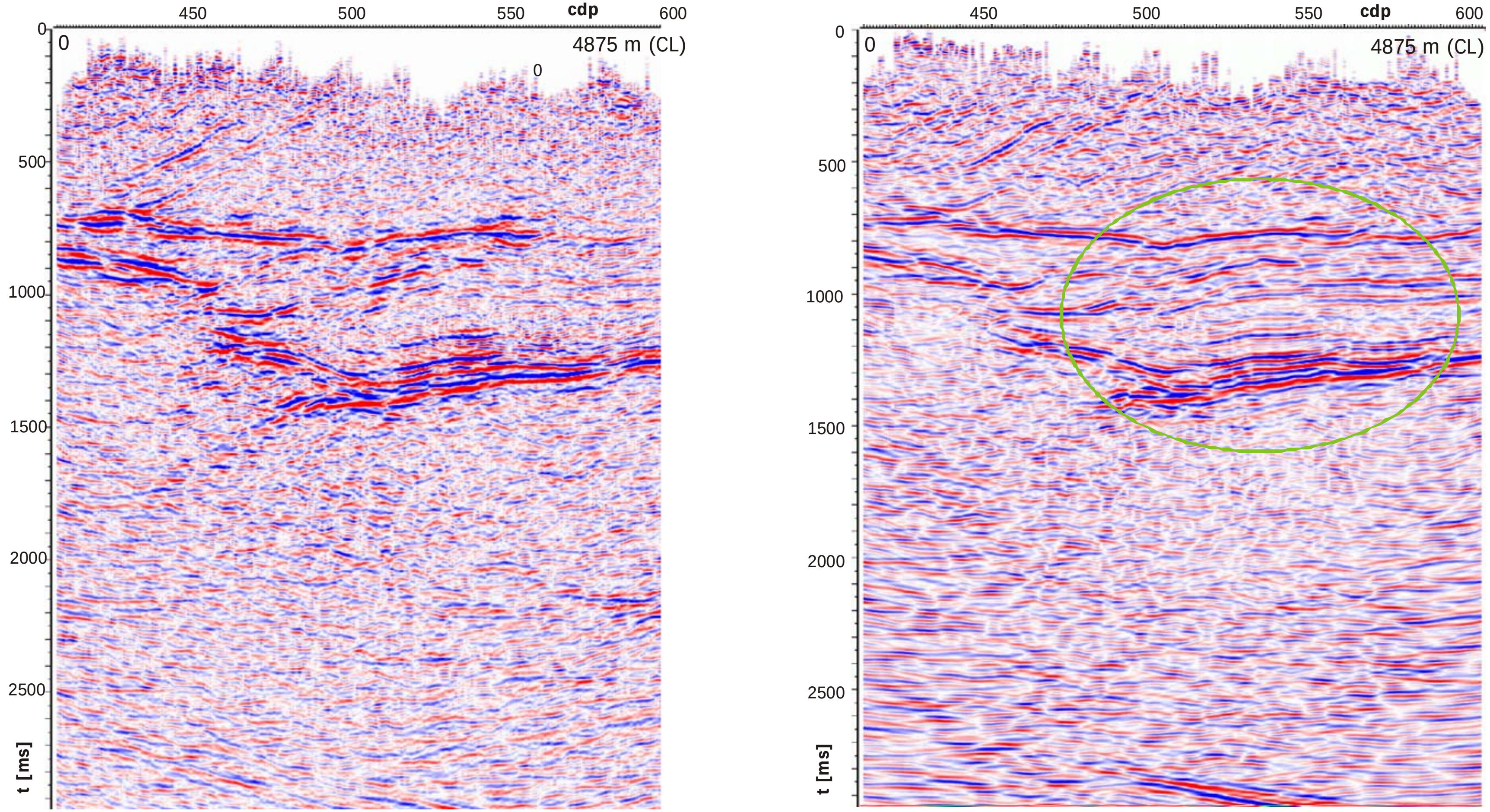

Fig. 6 PoSTM comparison processing 1997 and reprocessing 2006

3 Reprocessing of Seismic Data

One of the most exploited procedures how to improve the data for geological interpretation is reprocessing of the existing data. There is a good chance that together with processing software development, new interactive applications and also with cheaper hardware offers new and more detailed look of the target areas.

There is an example of comparison the old seismic data processed in Geofyzika Brno 1996 and reprocessed data in MND Hodonin 2006. New module for 3D FK filtering developed by CGGVeritas was used for better attenuation of linear noise then 2D FK filter used in 1996. Control phase processing was chosen to prepare the data for AVO analyses and eventual seismic inversion. New program for acquisition footprint attenuation was used after DMO stack. 3D Kirchhoff postack time migration was accomplished (Yilmaz, 1987).

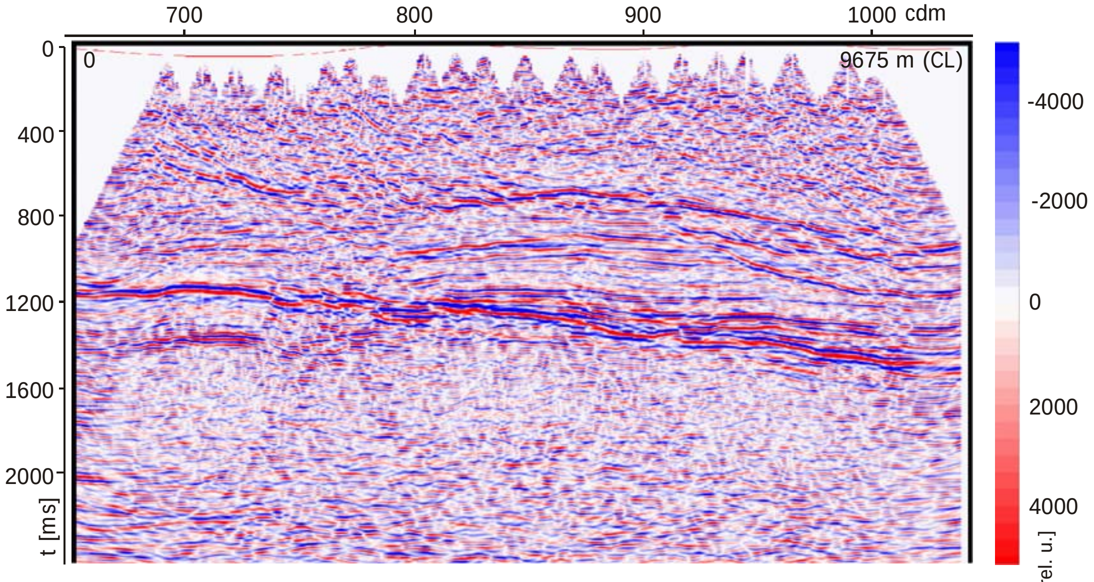

Fig. 7 PoSTM reprocessing 2006 IL 520

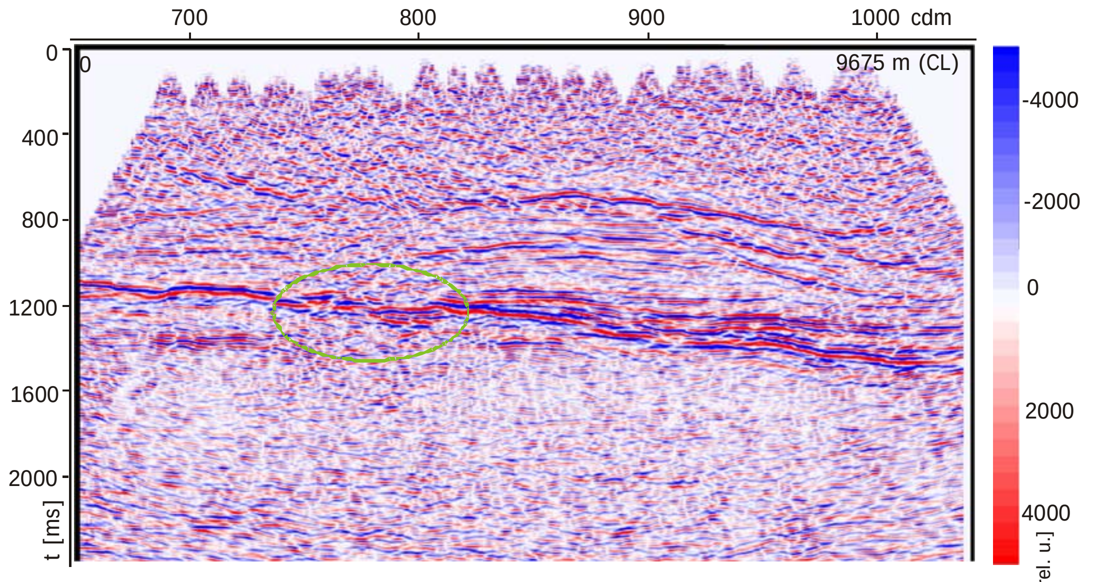

Fig. 8 PreSTM reprocessing 2006 IL 520

Spectral balancing after migration was used to increase the frequency content. The higher resolution of the seismic was achieved at the target area but at the deeper part of the block was slightly increased level of noise.

The comparison of PoSTM 1997 and 2006 shows on the slides 4, 5, 6 that reprocessing dramatically improved signal to noise ratio and the reflections at target area around 1 s were better enhanced.

3.1 Comparison PoSTM 2006 - PreSTM 2006

The objective of PreSTM was to improve the seismic image and brought the more detailed look into the structural geology of the pretertiary basement under the Tertiary layers. The comparison of PoSTM and PreSTM from 2006 shows on slides 7, 8, and 9 that PreSTM gave better correlation in the fault's areas.

4 Geological Interpretations of Seismic Data

Geological structure of the area of interest is relatively monotonous. Characteristic feature of the geological structure is general inclination of the platform with enormous increasing of the flysch nappes to the SE direction (Thonová, H. et al., 1996). Carpathian fore-deep is filled by Miocene sediments, which are spread faraway to the east in the basement of the flysch nappes. In the area of interest, more coarse-grained parts of sandstones pinch out on the base of Carpathian sediments. These basal more coarse-grained parts of sandstones were the main target for numerical processing of the seismic data. It goes about 200 m thick part of rhythmic sedimentation, characterized by changing of thin layers and plates of psammites, aleurits and rarely parts of pelites. Individual sands are a few meters thick; their maximum is reaching about first tenths of meters. Pretertiary basement consists of Devonian sediments and crystalline fundament, which is made of volcanics, in western part covered by metamorphic rocks (Thonová, H. et al., 1998).

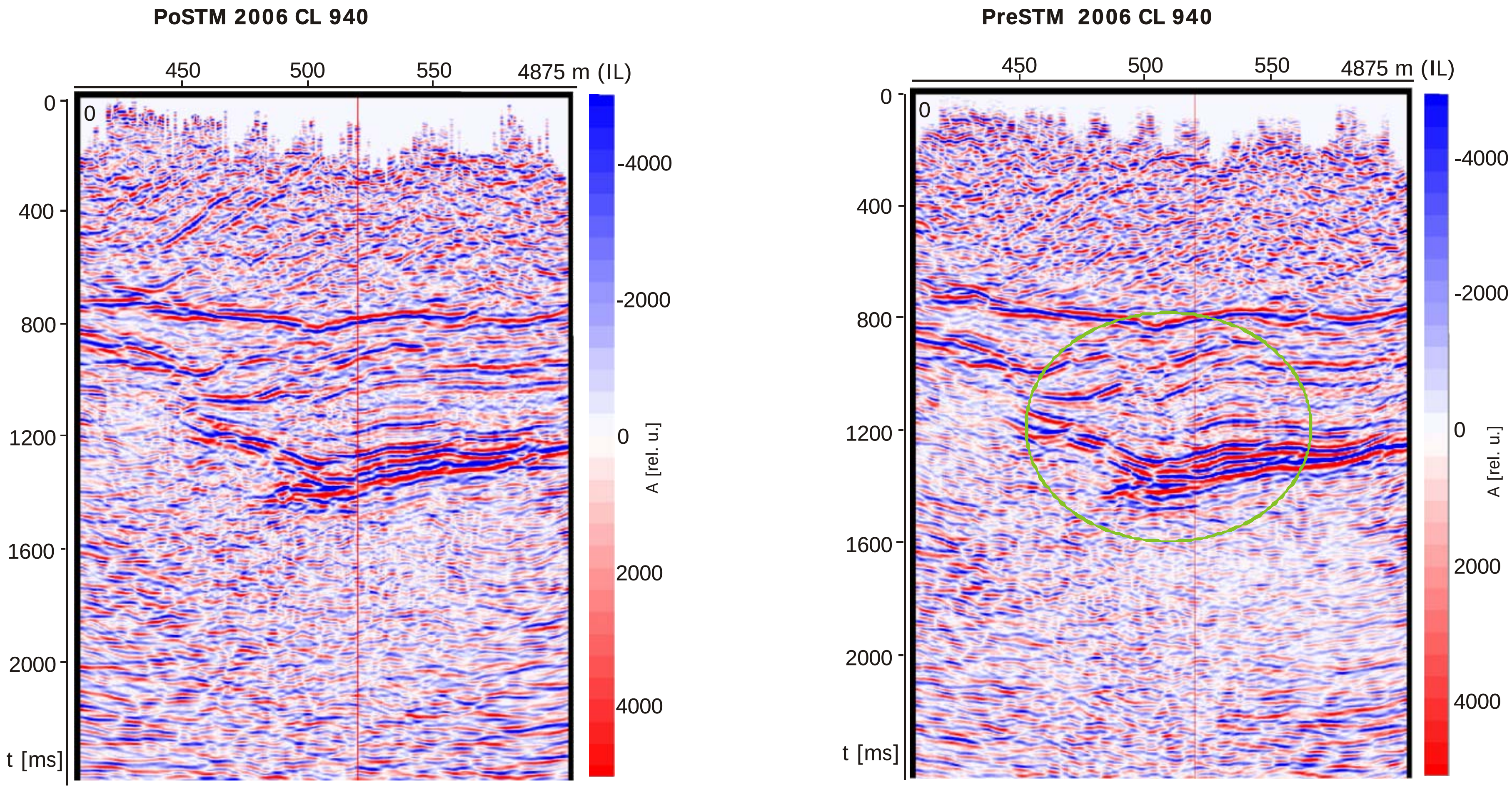

Fig. 9 PoSTM and PreSTM Comparison 2006 CL 940

The main target for processing of seismic data was to specify the global image of geological structure, to improve the quality of interpretation of tectonic lines and to enable more detailed interpretation of the interested horizons. Especially the basal sands requires very well reprocessed data catching as many details as possible, with regard to their more difficult identification and interpretation.

Interpreted seismic boundaries are in time seismic lines matched to the relevant litho-stratigraphic and facial boundaries verified by wells. Correlated seismic horizons were in the area of interest tied with results of the wells in the area of the oil field Lubná, wells in Vrbka area and the well Bařice-1 in the north part of area of interest. At mutual correlation of these horizons, the usage of the check shot at Vrbka - 1well was the most important. See fig.10.

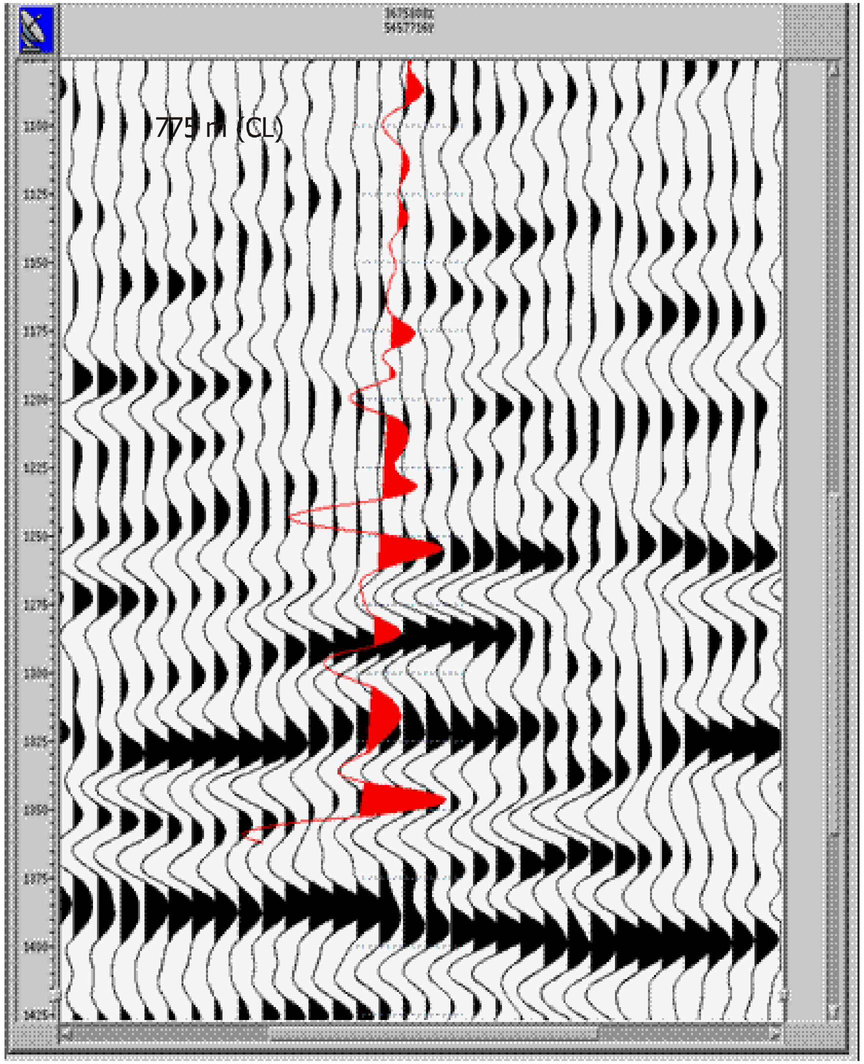

Fig. 10 Well-matching; the seismic data and synthetic seismogram obtained from acoustic impedance

After evaluation of processing of seismic data we can say, that the main goal of the task was carried out and that the results fully agreed to the primary requirements. Relation between signal and noise at postack time migration rapidly improved in comparison with the previous processing in 1997. The final seismic picture significantly contributed to the more accurate interpretation of the horizons of interest and allowed more detailed correlation of thin layers, especially in the area of basal Carpathian. Prestack time migration contributed to the better interpretation of geological structures of the area of interest and it gave us more accurate concept of tectonic system in the whole area. Generally, it rapidly increased the ability to interpret the tectonic and to interpret the horizons on the pretertiary fundament in a high quality. Individual seismic zones in the rhythmic sedimentation of basal Carpathian determined at Vrbka-1 well and correlated in the area of interest are thanks to the noticeable reflexes at processed seismic relatively well identifiable and interpretable. These zones are not under influence of some distinctive morphological changes in the space, and it makes the interpretation easier. More accurate correlation of basal Carpathian sands allowed their more detailed division and generally their more authentic mapping in comparison with previous processing of seismic data in 1997.

In attached slides are shown examples of interpretation in 1997 and 2006; fig. 11, 12, 13 and 14.

5 Conclusions

New trends in seismic data processing proved that reprocessing of seismic data can bring more accurate imaging of seismic events. The advantage of prestack time migration is better image of seismic events in comparison with postack time migration which was the routine result in the past. The disadvantage is not very accurate position at the very complex geological areas. In such case is advisable to use prestack depth migration that should solve the problem. The main condition for correct seismic imaging is accurate velocity model, which should be consulted between geologist and geophysicist. We believe that not only new techniques in the seismic data processing but also close cooperation between geophysicists and geologists contributed to the better quality of final results and higher reliability of geological interpretation.

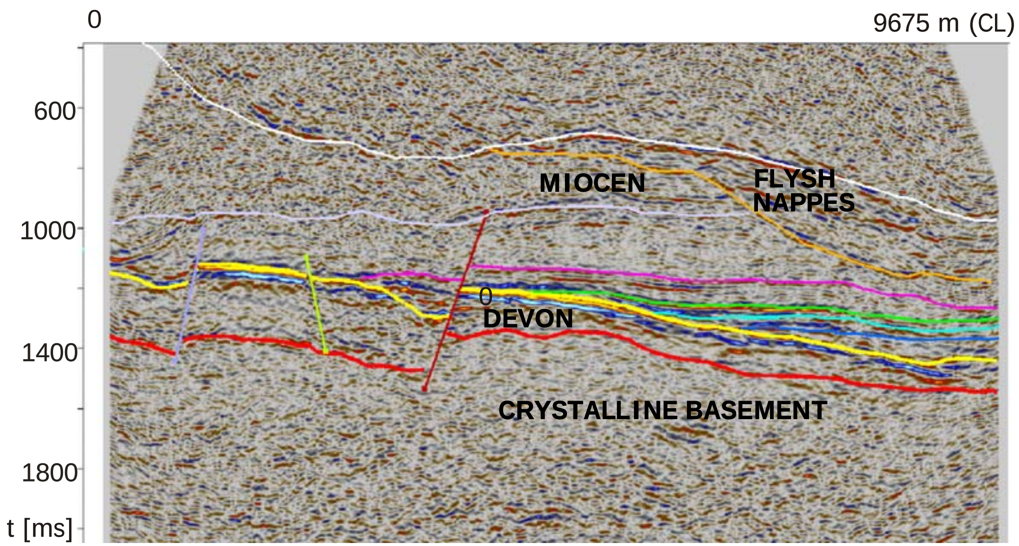

Fig. 11 Seismic data interpretation 1997 inline 523

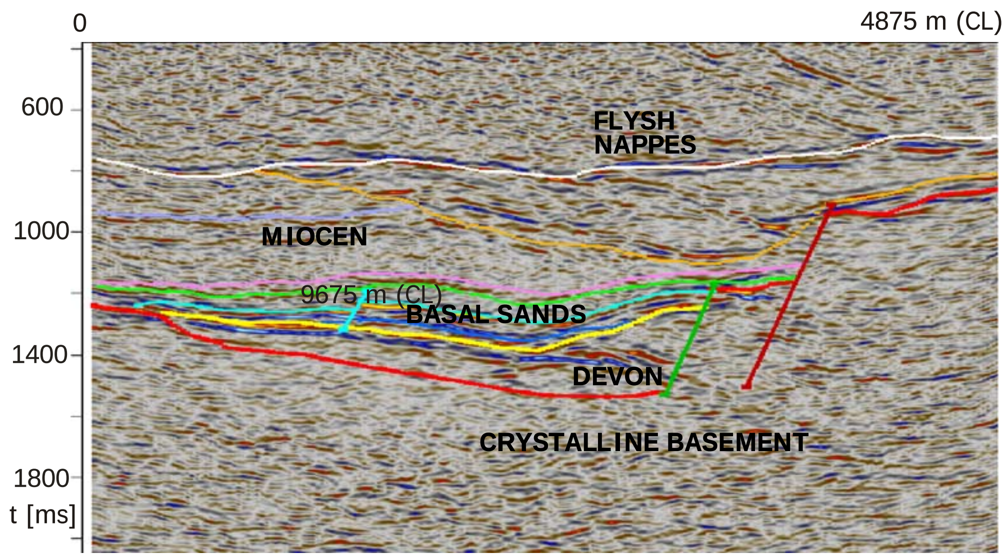

Fig. 13 Seismic data interpretation 1997 xline 940

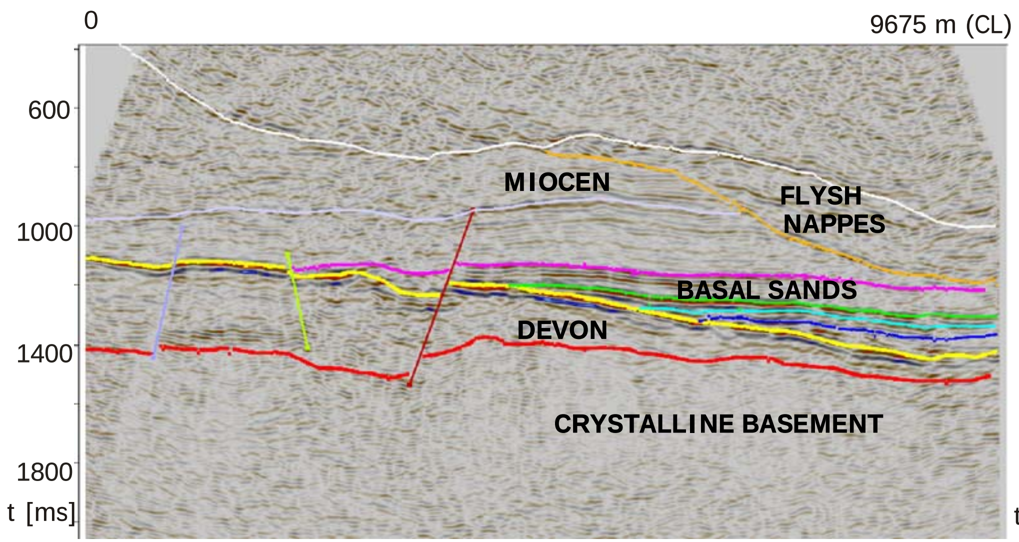

Fig. 12 Seismic data interpretation 2006 inline 523

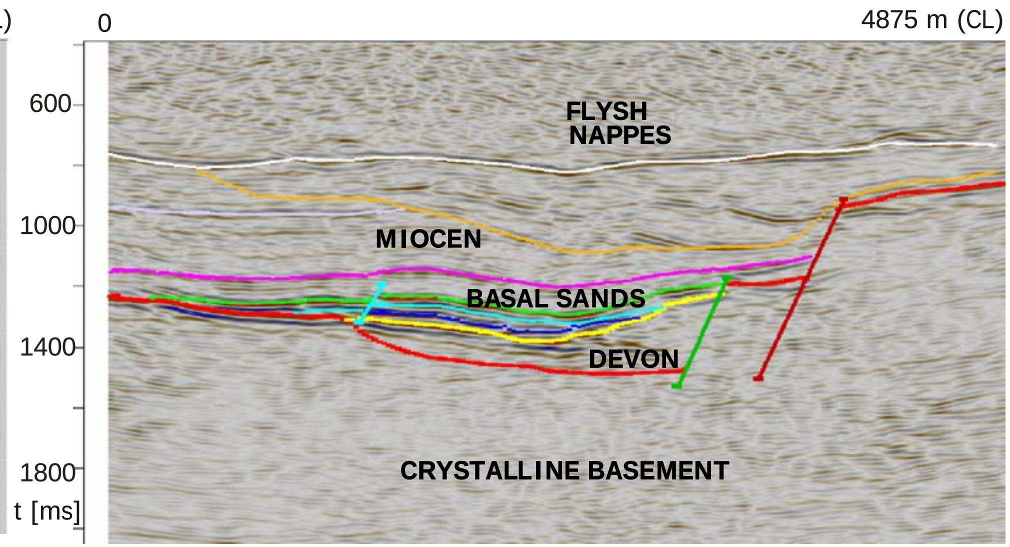

Fig. 14 Seismic data interpretation 2006 xline 940

References

JONES I.F. *An Introduction ti Velocity Model Building*, EAGE, Houten, 2010

NEHYBA S. *Sedimentologické a sekvenčně-stratigrafické zhodnocení neogenních sedimentů zastižených ve vrtech Vrbka 1, Vrbka 2 a Lubná 2*, MS archiv MND, Hodonín, 2008

ROBEIN E. *Velocities, Time-imaging and Depth-imaging in Reflection Seismic*, EAGE, Houten, 2005

THONOVÁ H. ET AL. *Závěrečná zpráva o vyhledávacím vrtu Vrbka-1*, MS archív MND, Hodonín, 1996

THONOVÁ H. ET AL. *Projekt geologických prací - vrt Vrbka -2*, MS archív MND, Hodonín, 1998

TRASON T. ET AL. *Závěrečná zpráva vrtu Vrbka-2*, MS archív MND, Hodonín, 2006

ZILMAY O. *Seismic Data Processing, Society of Exploration Geophysics*, Tulsa, 1987

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