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Application of seismic velocity analysis in determination of the geological structure of the western part of the Iwonicz Zdrój Fold (Polish Carpathians)

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Abstract. A seismically delineated exploration prospect was recognised in 1994 on a Polish Oil Company licence (Sobniów-Kombornia-Rogi - Polish Carpathians) (Fig. 1.) and the seismic data was reprocessed to reconstruct the geological structure. The area in the western part of the Iwonicz Zdrój Fold was chosen, to carry out detailed velocity analyses, by methods worked out by Probulski, (1998). The velocity analysis suggested a prospect existed in one part of the licence and the Draganowa-1 well was drilled. This well discovered a gas accumulation in Cieżkowice sandstones in an anticlinal structure. To further delineate the newly discovered gas field POGC plan to acquire a 3D seismic survey in this area.

The seismic reprocessing is based on very detailed velocity analyses, time to depth conversion modelling and final stack model, which resulted in a considerably better image of the geological structure of the Iwonicz Zdrój Fold and the neighbouring area. The better seismic data supports detailed structural analysis and sequence stratigraphic analysis methods, which suggest the presence of additional traps for hydrocarbon accumulations.

Key words: Carpathian flysch,seismic processing, velocity analysis, seismic modelling

Introduction

The seismic survey made in 1994 on Sobniów – Kombornia - Rogi area (eastern Polish Carpathians - Fig. 1) was processed in a standard manner according to currently used processing routines. Results obtained (in 1998) have allowed us to identify reflex flattening ("flats") in central parts of overthrust structures on some profiles. These „flats" may suggest and are interpreted as gas-water contact (e.g. Berg & Woolverton - 1986, Brown - 1986, Hardage - 1987, Lindsey - 1973).

These anomalies are clearest on Iwonicz Zdrój fold in Draganowa area. As a result of seismic and structural analysis an object has been interpreted where then in 1999 Draganowa-1 well was drilled (Fig. 1)
The litostratigraphic profile elaborated in the project has been confirmed: Menilite beds to 1013 m, Eocene with 4 Ciężkowice sandstone beds to 1685 m, Istebna upper and lower beds to final depth of 2200 m. The gas deposit has been discovered in I Ciężkowice sandstone (Fig. 8).

Method description

To evaluate a spatial range of the deposit and location of new wells it has been proposed to carry out seismic reprocessing with new processing routines:

- Static corrections from refraction
- Routines of surface concordant deconvolution
- f-x deconvolution pre and post stack
- optimisation of kinematic corrections DMO
- new velocity model.

By using new means of processing a far better quality of seismic data was reached. The obtained structural image on seismic sections is more real and continuous.

A new velocity model has been used, based on average velocity data from Carpathian area and gravity data, elaborated using previously tested method (Probulski 1998) and interval velocities have been computed eliminating various measurement errors. Thank to this analysis it has been stated that on Iwonicz Zdrój fold velocity inversion occurs, i.e. velocity decreases from 5200 m/s to about 3000 m/s.

On the basis of velocity analysis a number of 2-D model analyses along one seismic section (33-13-96K) has been performed, (Fig. 1). This is a profile located perpendicularly to Iwonicz Zdrój fold structure. The seismic modelling has been performed to:

a) determining layer velocity structure of geological medium
b) recognising time-depth relations of the structural element
c) generating a synthetic initial sum and set it against a field section
d) determining a percent of stack velocity reduction rms in time migration
e) determining the best velocity model for depth migration.

The seismic modelling has been conducted simultaneously with seismic reprocessing. It has been also noted that during velocity analysis proper velocity cannot be set univocally. On analysed records diffraction field is visible and very strong noise field appears.

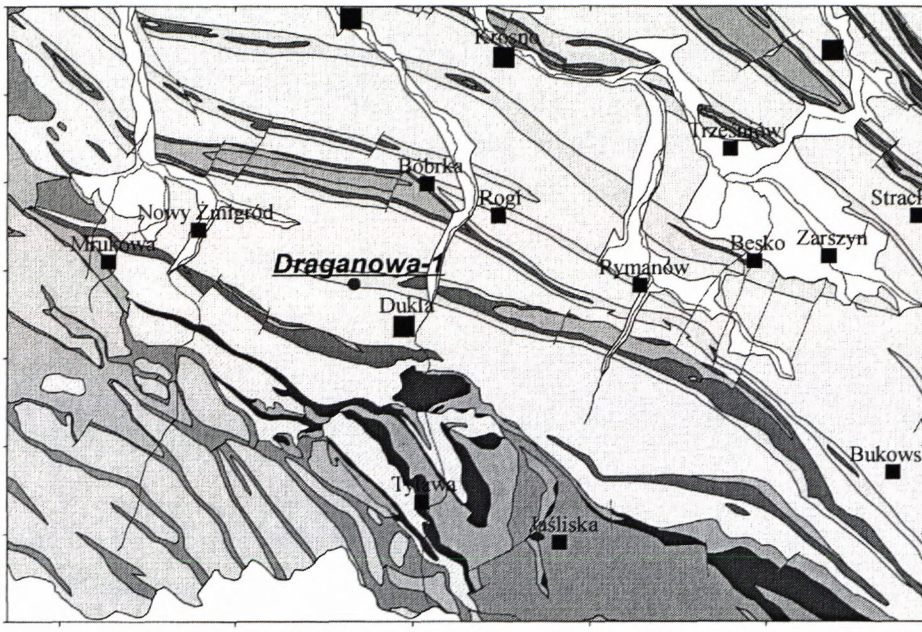

Fig. 1. Location map of study area

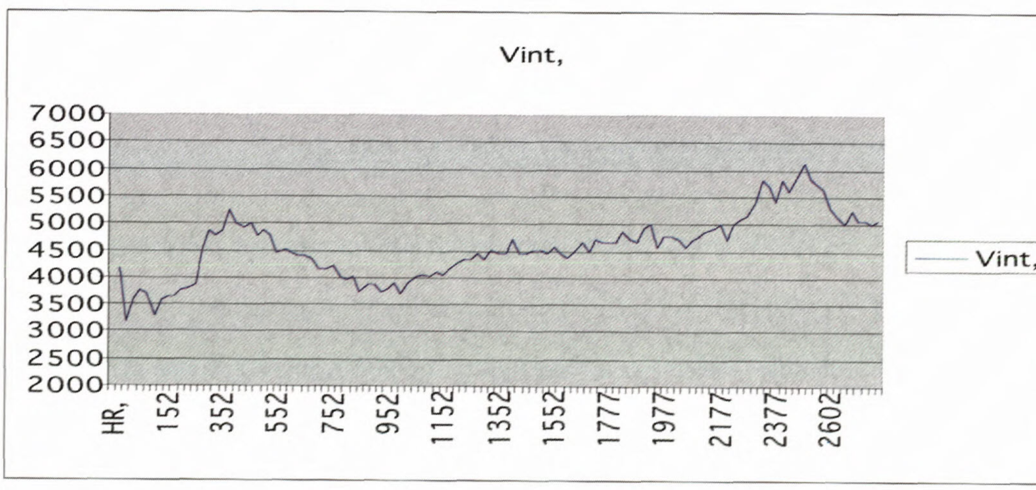

Fig. 2. An example of interval velocity calculation for Iwonicz-4 well.

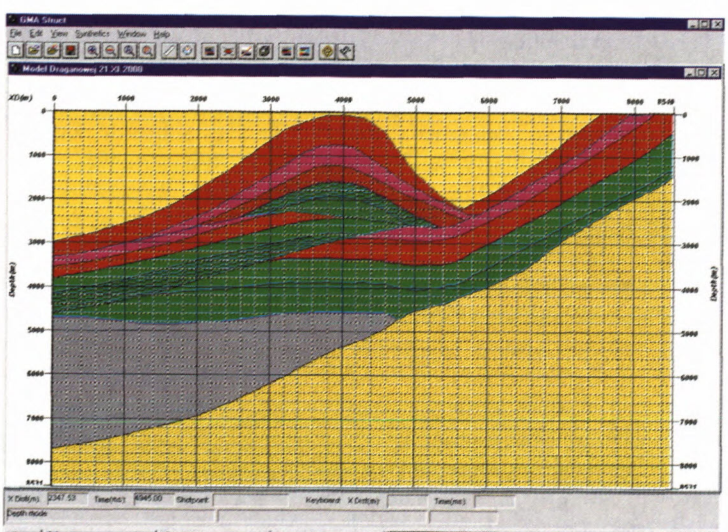

Fig. 3. An example of conducted modelling. Structural image is in depth domain

Analysing results of modelling (Fig. 3, 4, 5) it has been noted that in central part of the structure in time domain a time low appears and the amplitude increases. This phenomenon originated from a very high focusing the seismic rays and additionally velocity inversion appears. Because of these relations the velocity analysis process has to be conducted several times keeping conditions confirmed by the modelling. After seismic section stack and migration in new velocity conditions (Fig. 6) high-amplitude flattenings have been eliminated. But the structural element has been enhanced and low-amplitude flattening has been revealed.

The processing of succeeding seismic lines has been set down. The multiple waves appearing on sections have been eliminated using predictive deconvolution of 48 ms step.

The next problem, considered and implemented in reprocessing process was a percentage selection of stack velocity in time migration.

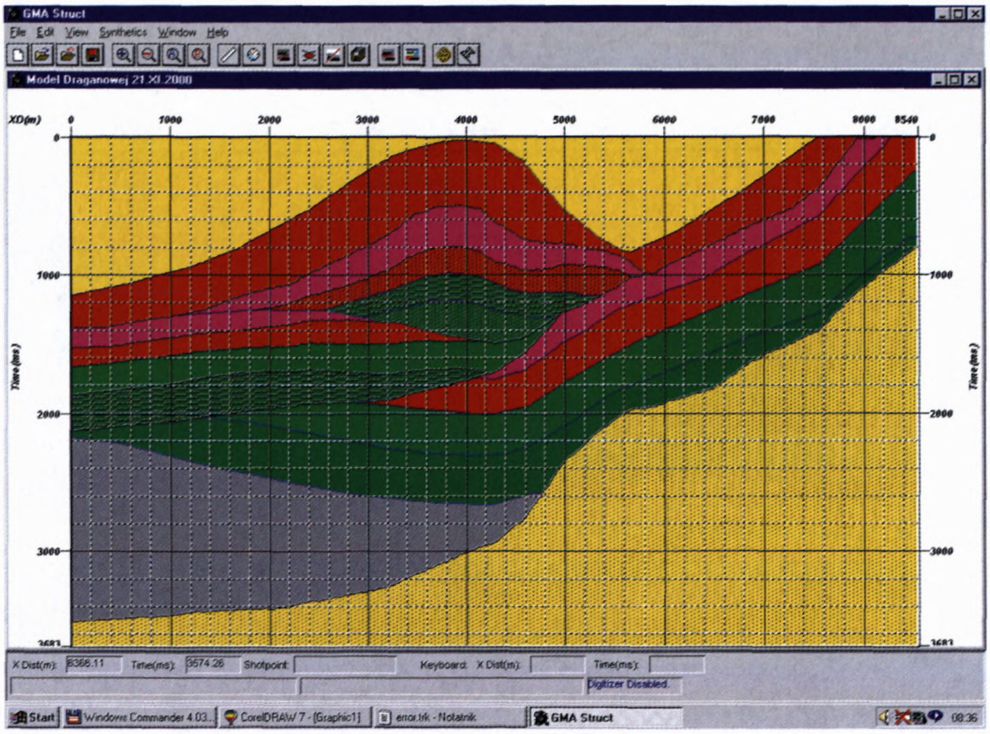

Fig. 4. An example of conducted modelling. Structural image is in time domain.

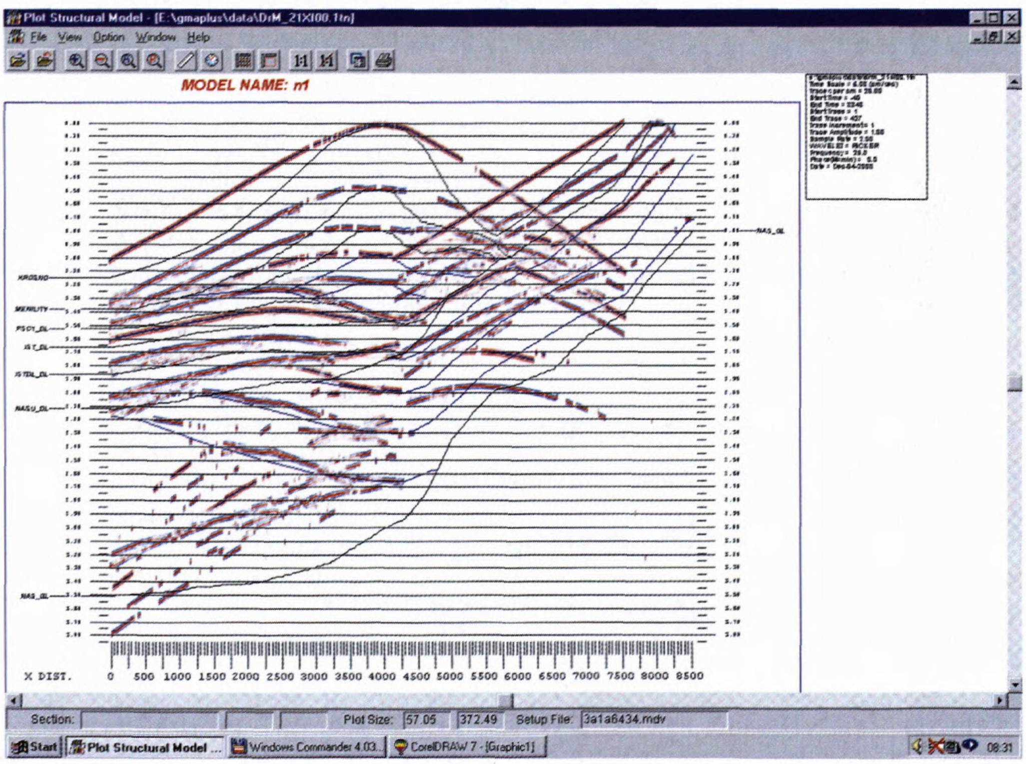

Fig. 5. An example of modelling the synthetic sum for the structural image.

The next problem, considered and implemented in reprocessing process was a percentage selection of stack velocity in time migration.

To determine a percentage share of velocity in time migration, test time migrations on profile 33-13-96K for 100, 90, 80, 75, 70 % of stack velocity have been performed. It has been noted that on northern wing of the structure at 900 ms depth migration focusing phenomenon appears, i.e., a migration fan emerges. This phenomenon remigrates the seismic image.

For the velocity of 75 % reflection correlation is stabilising and appears clearly. After studying additional aspects of migration it has been set down the time migration has to be conducted for velocities of 80-75 % range (Fig. 7).

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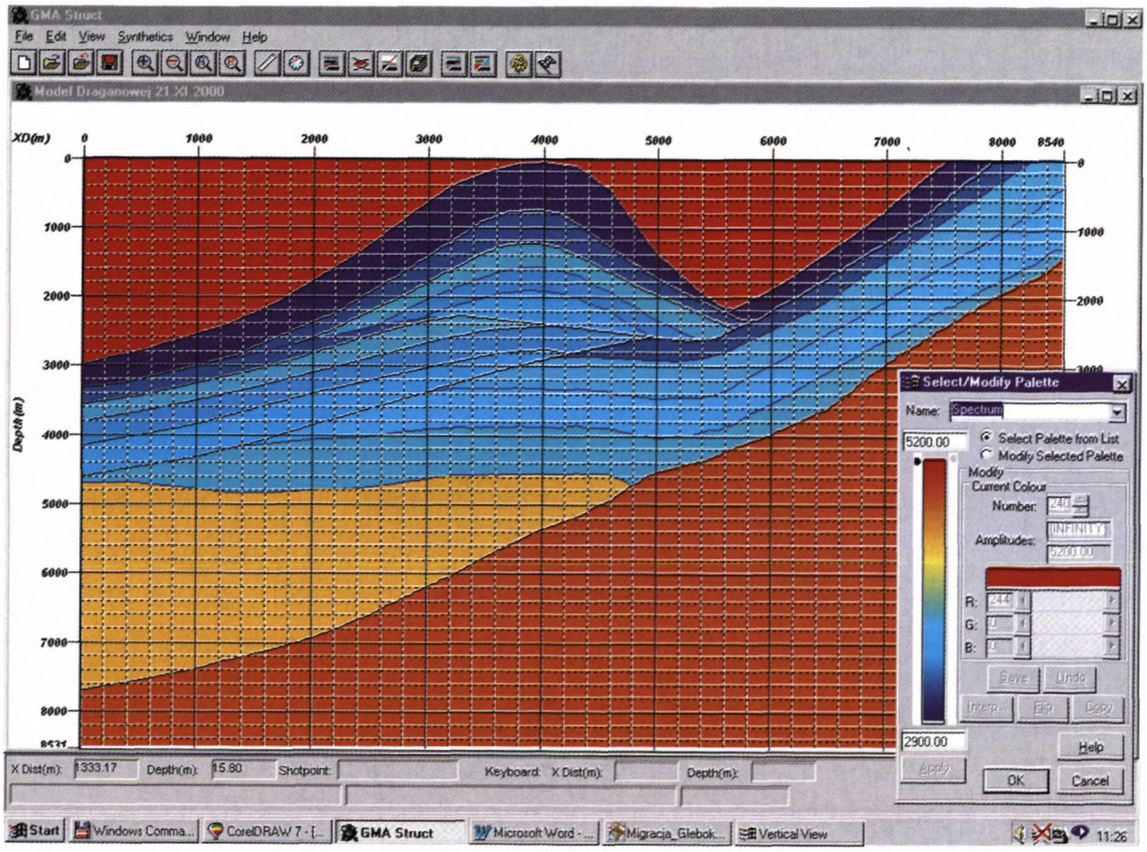

Fig. 6. A synthetic model of interval velocity in depth domain

Then depth pre-stack migration has been performed. This is the most difficult method of seismic processing on profiles in Carpathians. A very important element of the method is a velocity model. Thus in Geofizyka Kraków a number of processing routines of 33-13-96K profile for following velocity models has been conducted:

1. velocity for sum AV velocity for migration of 70% synthetic model
2. velocity for synt. mod. sum velocity for migration of 85 % synt. mod.
3. velocity for synt. mod. sum velocity for migration of 100 % synt. mod.
4. velocity for AV sum velocity for migration of 75 % AV
5. velocity for AV sum velocity for migration of 85 % synt. mod.
6. velocity for AV sum velocity for migration of 75 % synt. mod.

This processing scope has allowed us to determine the behaviour of migration in a reflection aspect. On the recent level of geological recognition we can assume the result of depth migration is the best when using a synthetic velocity model.

These complicated and very time-consuming analyses have allowed us to perform seismic processing and obtain a very reliable geological mapping on the whole seismic survey: Sobniów – Kombornia – Rogi. A very important interpretation fact is a possibility to delineate and interpret seismic facies correlating on each profile.

The analysis of seismic facies together with sedimentological analysis and separating depositional sequences (sensu Vail 1987) has allowed us additionally (mainly in Istebna beds) (Fig. 8) to delineate depositional sequences (Systems Tract).

Conducted simultaneously analysis of reservoir properties and their link with elements of depositional architecture within depositional sequences has shown the best reservoir properties are connected with series of low relative sea level (LST) that creates new possibilities to discover hydrocarbon traps.

The data elaborated in this way are the base of designing 3-D seismic survey in this area to determine the deposit range and detailise its structural build-up.

References

Berg, O., & Woolverton, D., 1986: Seismic Stratigraphy II, An Integrated Approach To Hydracarbon Exploration, AAPG Memoir 39, Tulsa.

Brown, A., 1986: Interpretation of Three-Dimensional Seismic Data, AAPG Memoir 42, Tulsa.

Hardageb, B.,1987: Seismic Stratigraphy Volume 9, Geophysical Press Limited, London

Lindsey, J. P., 1973: How hydrocarbon reserves are estimated from seismic data.[In:] Beaumont E. and Foster N., 1989 - Geophysics III Geologic Interpretation of Seismic Data, Treatise Petroleum Geology Reprint Series, No.14, AAPG, Tulsa.

Probuskij, J. 1998: Interpretation of 2D seismic line from SE part of the Polish Carpathian XVI[th] Carpathian-Balkan Geological Associacion Congress, Vienna, Austria, Abstracts: 493.

Vail, P.R. 1987: Seismic stratigraphy interpretation using sequence stratigraphy, part I: seismic stratigraohy interpretation procedure, [In:] A.W. Bally, ed. Atlas of seismic stratigraphy: AAPG Studies in Geology 27, v.1: 1-10.

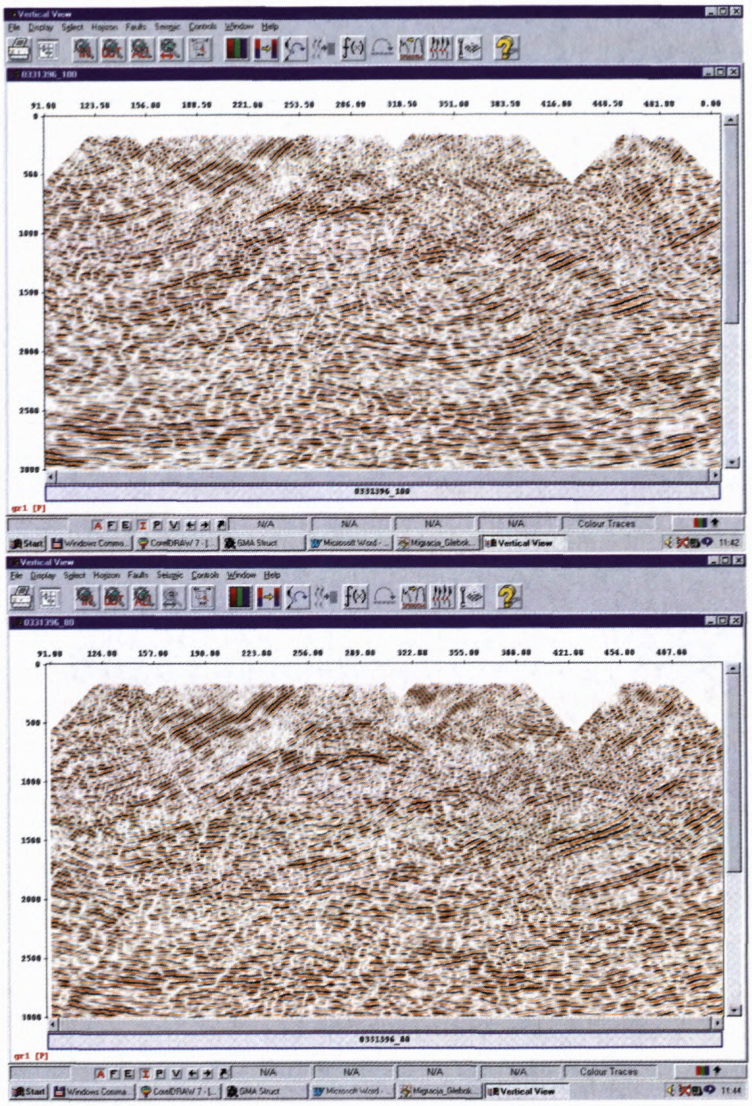

Fig. 7. Time migrations of profile 33-13-96K using finite difference algorithm (upper part 100 % , lower 80 % of stack velocity)

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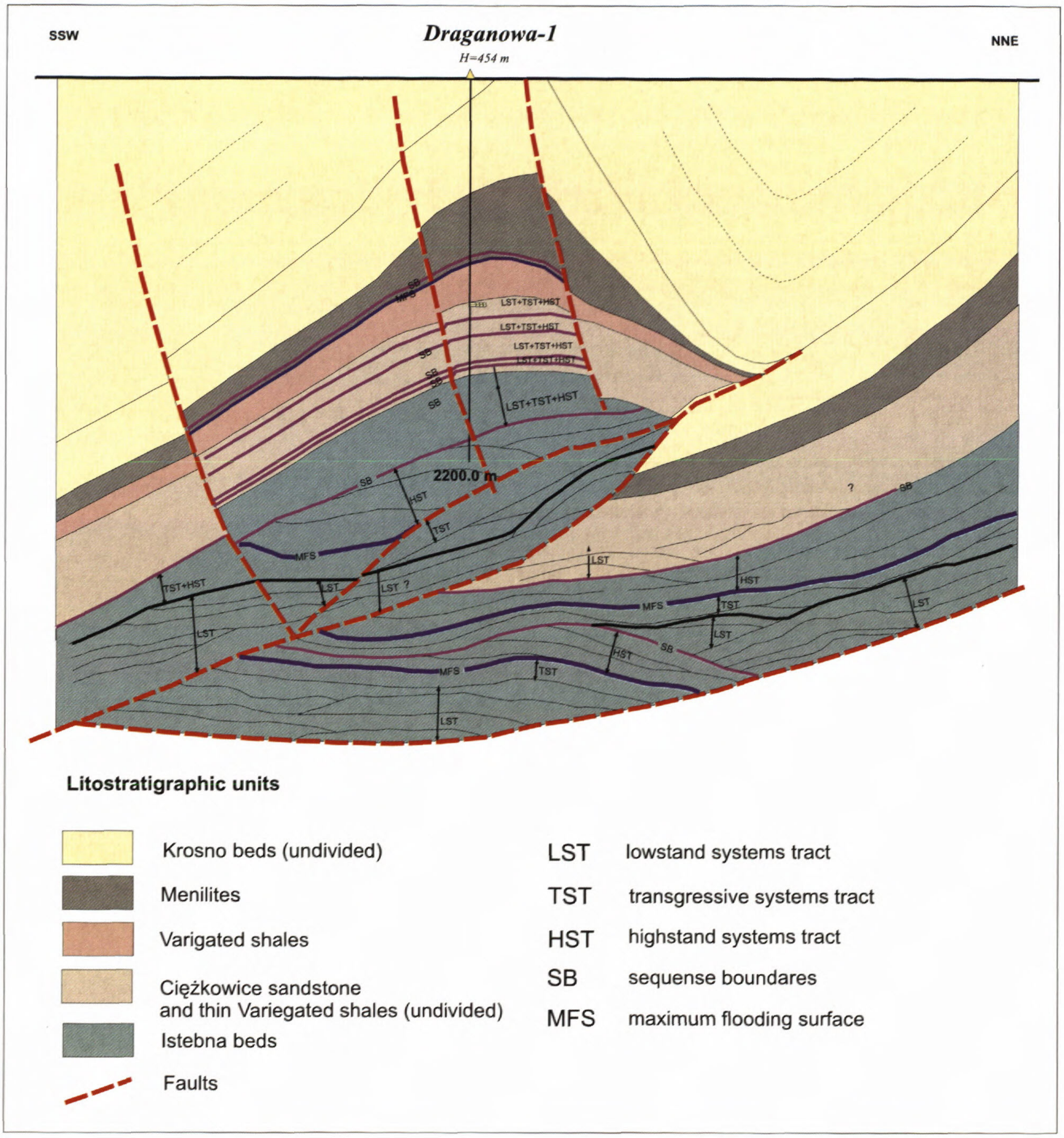

Fig. 8. Interpretation of depositional sequences on seismic time section 33-13-96K