Society indoor meetings
Abstracts of papers

Cracow Branch
April 15, 1996

Regional seismostratigraphic profiles in the area of Polish Carpathian Foredeep

Piotr KRZYWIEC and Kaja PIETSCH

The Polish Carpathian Foredeep (PCF) basin developed in Miocene times in front of the advancing Carpathian thrust belt. It formed the northernmost part of the Paratethys sea and belonged to the Neogene late- and post- orogenic system of the Alpine-Carpathian basins.

Recently completed structural and seismostratigraphic interpretation of four regional, basin-wide seismic profiles located between Kraków and Przemyśl together with selected wells provide information on large-scale framework of Miocene tectonic development of this part of the PCF, the distribution of major seismic facies and its depositional history. These profiles are generally oriented south-north and extend from the thrust front to the northernmost limits of the PCF.

For the western part of the study area located between Kraków and Rzeszów it is concluded that only minor tectonic deformation of Miocene age can be observed within the PCFs' Mesozoic basement. This developed in the form of a natural fault located NW-SE. Immediately in front of the Carpathians, particulary between Bochnia and Tarnów, a series of frontal thrusts developed within the foredeep sediments. General seismic stratigraphic pattern suggests dominant direction of sediment supply from the south towards the north and north-east. The gentle flexure of basement in this part of the PCF suggests that bending of the lithosphere below the thrust belt was the dominant process that created the present-day large-scale architecture of the PCF.

Very different results were obtained for the eastern part of the study area located between Rzeszów and Przemyśl. Seismic data revealed a large amount of tectonic deformation within the Palaeozoic and Precambrian basement of the PCF. These consist of either horst - and - graben structures related probably to strike - slip movements or systems of large normal faults and rotated blocks located NW - SE. Also, it was concluded that normal faults present in the easternmost part of PCF developed partly as a synsedimentary features and were slightly inverted during the Late Sarmatian. Moreover, the maximum of extension controlled by these faults was located not immediately in front of the thrust belt but significantly further towards the north. This implies that this extension was not only related to the lithosphere fracturing due to its flexure below the Carpathians but also was controlled by intense faulting related to Miocene reactivation of the Tornquist-Teisseyre tectonic line. Inferred sediment transport was from the south towards north-east, and also, sub-ordinarily, from the north and north-east.

It can be concluded that formation of PCF was controlled by very different tectonic processes in different parts of this basin. Also, the depositional pattern differs along the strike of the basin. This implies that, although PCF clearly belongs to the class of foreland/foredeep basins, its development was also controlled by some possible strike-slip movements and significant extension active within the foreland plate and not directly related to the flexural processes in front of the Carpathian thrust belt.

The completed interpretation reported above constitutes the first stage of a research project whose goal is a detailed tectonic and sequence/seismic stratigraphic study of the Miocene evolution of the PCF and its hydrocarbon habitat, in particular the distribution of subtle stratigraphic traps for gas accumulations.

This project was completed in collaboration with the Polish Oil and Gas Company and the Polish Geological Institute. Numerous stimulating discussions with collegues from these institutions and also from the Jagiellonian University and the Polish Academy of Sciences are gratefully acknowledged.

April 22, 1996

Possibilities of identification of vertical gas migration zones using seismic data

Kaja PIETSCH

Direct seismic survey and surface geochemical investigation play an important role in prospecting for oil and gas. As a result of hydrocarbons diffusing from a deposit to the surface, an anomalous wave field is observed over some hydrocarbon deposits what is confirmed by surface geochemical anomalies. Hence, hydrocarbon leakage zones identified on seismic sections and correlated with surface geochemical anomalies may be an additional indicator of hydrocarbon deposits.

This research problem was considered during prospecting for hydrocarbon deposits in the Palaeozoic (Carboniferous and Devonian) formations in Western Pomerania (NW Poland). The Mesozoic and Zechstein reflecting horizons were exactly located by seismic survey made by Geophysical Company "Zakład Geofizyka - Toruń". The sub-Zechstein reflections were observed occasionally. Therefore detecting seismic anomalies caused by the vertical gas diffusion might help locate hydrocarbon accumulation.

To verify the hypothesis of seismic anomalies generated as a result of vertical gas migration in the overburden, wave fields for seismogeological models approximating the studied rockmass must be constructed first. Then the field calculations are made on the assumption that velocity changes are due to gas microinfiltration.

Construction of the theoretical wave field required information about the following seismic parameters of studied rock formation:

– succession of seismic boundaries derived from interpretation of seismic profiles,

– seismic parameters of individual layers, i.e. velocity of longitudinal wave and bulk density. The division of the rock formation to individual layers was the result of the comprehensive interpretation of all available logs. Interval velocity for rock formations of the same lithology and similar values of porosity were determined from the sonic log,

– changeability of seismic velocities as a result of the type of medium filling the pore space (gas, water), the changes of saturation as well as the changes of the distribution of liquid and gas phases in pore space. Velocity, porosity, and information about pore space geometry, taken from porosimeter measurements were the input data for the determination of velocity changes. Calculation of velocity, for the reservoir horizons, selected from logs, were made using Kuster and Toksoz model of porous formation, modified and adapted for numerical calculation by Bała. Calculations of velocity changes as a function of saturation of pore space with different media show that when media are not mixed (gas bubbles are created in water or separate pores are occupied by gas bubbles) even the lowest gas saturation can cause a great decrease in velocity (for instance a decrease in velocity of ca 90% may be observed when the gas saturation is on the order of 0.1 - 1%). The obtained relations are treated as base curves. The successive layers of seismic theoretical model have the velocities matched according to the base curves depending on the porosity, velocity and gas saturation.

Comparing theoretical fields calculated for models with and without gas one can see the extent of the phenomenon and obtain the basis for defining criteria enabling the identification in the seismic record of gas migration paths from the deposit to the overburden, and sometime to the earth's surface which can be manifested by surface geochemical anomalies.

The theoretical wave field was computed with the STRUCT GMA package (Geophysical MicroComputer Application Ltd.).

A seismic model used for the construction of the theoretical wave field was obtained based on the time section TO 070594 recorded in the Dobrzyca structure area. Fault zones (comprising Palaeozoic and Mesozoic formations and reaching subsurface layers) and faintly distinguished in seismic trace zones over faults cutting only Palaeozoic formations were assumed as possible gas migration paths.

Comparing the theoretical fields one can see that:

– the wave field computed for the model without gas unequivocally reproduces the arrangement of the main seismic boundaries, thus giving clear structural pattern. Fault zones present in the model are distinct and should be located in places where the continuity of seismic boundaries is broken;

– the wave field calculated for the model with assumed gas migration shows that the migration zones are displayed in seismic record as an abrupt discontinuity of seismic boundaries and chaotically arranged reflections with low and high amplitudes.

Since there are great differences in theoretical records for seismogeological models with and without gas, it is inferred that location of gas migration paths on the basis of seismic data is quite possible.

Due to good quality of seismic data from the Mesozoic formations an attempt of their interpretation was undertaken in order to locate possible gas migration paths. It was also advantageous that surface geochemical data, recorded by the group from the Fossil Fuel Department of Faculty of Geology, Geophysics and Environmental Protection, University of Mining and Metallurgy, Kraków, were available for most seismic lines. The observed surface geochemical anomalies give the possibility of verifying recorded seismic anomalies.

Interpretation and location of possible gas leakage zones was made for the TO 070594 line. The seismic anomaly observed in NE part of this line is connected with a regional fault zone. According to the modelling, records of this kind correspond to fault zones along which gas migrates. Zones of discontinuous seismic record which do not include the entire Mesozoic complex are also seen in the time section TO 070594. These may be attributed to diffusion chimneys over faults cutting only the Palaeozoic basement. Such interpretation is confirmed by the surface geochemical anomalies.

The results of the study – especially the agreement of seismic interpretation with geochemical anomalies – encourage the continuation of the research. It should be remembered that this investigation, and the modelling in particular, was made with accepting many assumptions simplifying both the gas migration process and its effect on the wave field.

The author wishes to thank colleagues of the Institute of Geophysics and the Institute of Fossil Fuels of University of Mining and Metallurgy, Cracow, for their assistance in this work.

This study was sponsored by the State Committee for Scientific Research as project No 99 311 93c/1564.