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# STUDY IN THE DEVELOPMENT OF ROTLIEGENDES BASIN IN WESTERN POLAND IN THE ASPECT OF NEW GAS PLAY DISCOVERIES.

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The area in question is being intensively explored in seismic and geological respects. It is located in the northern part of Fore-Sudetic Monocline within Poznań Trough. In the south it adjoins regional Wolsztyn Ridge formed of carbon layers creased with basement in Variscan orogen. In the north it borders and partly includes the southern part of Szczecin Synclinorium. The present-day structure plan of Upper Rotliegend (Saxonian) surface was formed as a result of the last significant tectonic folding connected with laramide phase movements. It was then that the whole Fore-Sudetic area inclined towards north – east and some hydrocarbon traps were partly or totally destructed. As far as hydrocarbon search is concerned the analysed area can be divided into two parts because of differences in geological structure. In the southern part, adjoining Wolsztyn Ridge, deposits connected with pinch-out of sediment forms of Upper Rotliegend are to be found (Paproć, Ujazd). Several dislocations, often taking part in creating structural – tectonic traps, can be seen here on the NW – SE line. The northern part (Poznań Trough) is, in turn, characterized by regular geological structure, without significant fault zones. In this part of Polish Rotliegend Basin, within top, several deposits of gas have been found. They have a form of domes, with the amplitude of 30 to 100 meters *[99 to 330 feet]*.

High prospectivity of the area is proved by the presence of hydrocarbons in each well there. The purpose of this presentation is to analyse the main geological and sedimentological factors leading to such high prospectivity of the area in question. Moreover, some new geological ideas, allowing to discover big fields of hydrocarbons in Upper Rotliegend forms, will be presented.

**Rotliegend Basin Lithofacial Formation**

**LOWER ROTLIEGEND (AUTUN):** represented by volcanic effusion rock of high diversity. It can be assumed that in the area adjoining Wolsztyn Ridge volcanic forms such as rhyolite, dacite and trachybasalt dominate. Towards NE (the center of Rotliegend Basin) alternating packets of volcanic breccia and volcanic effusion rocks of melaphyre character have been found. Within volcanic breccia thin, strongly metamorphosed sandstone inserts occur. The range of these forms is limited and their thickness is highest in the neighbourhood of elevations.

**UPPER ROTLIEGEND (SAXON):** a detailed sedimentological analysis profiles allows a division into four subenvironmental deposition parts connected with desert sedimentation environment:

**ALLUVIAL CONES COMPLEX**: sediments here are mainly fine and medium clastic conglomerate of dissipated skeleton rocks represented by poorly sorted fragments of volcanic rock, fragments of volcanic glass and, occasionally fine granular clastic rocks in sandy – claystone filling mass.

**AEOLIAN SEDIMENT COMPLEX:** consists manly of sand dunes of high thickness and forms deposited between the dunes. In sandstone series interpreted as dune sediments, diagonal layers with variable lamina gradient (10 to 30º) dominate. Within aeolian group of strata gradient and fraction changes occur quite often. Futhermore, boarders are emphasised by thin lamina enriched with loamy substance or chemical cement.

**FLUVIAL SEDIMENT COMPLEX:** the forms here are sediments of periodic braided rivers, typical of desert areas. In some sandstone layers thin inserts of coarse granular sandstone occur, which may indicate the presence of bed river forms representing channel-lag. They are usually to be found on erosion surfaces. The base inclined bedding can be seen, whereas above ripplemark stratification occurs. Overbank deposits were formed during floods covering the area outside the bed river. They consist mainly of material brought in suspension and their thickness grew towards the center of the sedimentation basin. A detailed analysis of the range of these forms enables to define areas lowered during Upper Rotliegend forms sedimentation.

**PLAYA SEDIMENT COMPLEX:** these are sandstone mudstone and claystone regularly or irregularly horizontally laminated, sometimes with periodical strata sequence. They were formed in not effluent lakes in the conditions of intensive evaporation. These forms appear at the close of Upper Rotliegend sedimentation, their high thickness proved in the central part of the basin.

**Development of Upper Rotliegend Forms**
Sedimentological – facial analysis proved meshing of aeolian complex sediments with other deposition forms. The direct reason for this was the existence of vast dune field in Poznań Trough between the area dominated by fluvial deposition complex in the W and S of Wolsztyn Ridge and the area dominated by lake deposition complex towards N, in the center of Upper Rotliegend Basin.

At the early stage of Upper Rotliegend Basin development in the area in question alluvial cones formed. They developed most intensively in NE part of Wolsztyn Ridge which, at the beginning of Saxon sedimentation phase, formed a mountain massif over 1000 meters *[3300 feet]* high (Wolsztyn Ridge). Volcanic rocks coating formed along the deep tectonic in active dislocation zone underwent cracking and quick erosion. In this way paleoelevations about 300 m *[990 feet]* high were formed, their center being volcanic effusion Lower Rotliegend and Carboniferous rocks. Conglomerate and alluvial sandstone thickness may reach from 10 to 100 meters *[33 to 300 feet]*, depending on paleomorphological zone were the sedimentation took place. Coarse clastic material from Wolsztyn Ridge erosion was generally transported towards NE. The climate change into a more severe one above alluvial cone forms resulted in appearance of aeolian forms, their thickness up to 150 meters *[495 feet]*. The dune field had a considerable range and can be seen on almost all area discussed. Among aeolian dune forms not very thick aeolian inter-dune and fluvial sand forms occur. Another climate change in aeolian forms resulted in fluvial formation, sandstone and conglomerate mediumgrained clastics, mediumclastic dominating. More humid climate helped alluvial cones and braided rivers develop in a significant area. Fluvial forms represent distal (mediumgrained sandstone) and medial parts, with proximal alluvial cones (conglomerate mediumclastic) and braided rivers with the thickness of 30 – 50 meters *[99 to 165 feet]*. In some parts fluvial cycle formations are distinctly dual and divided by aeolian forms 20 – 30 meters *[66 to 99 feet]* thick.

In the top part of Upper Rotliegend on fluvial formation dune and inter-dune aeolian forms ending clastics sedimentation are to be found. The dune deposits field extended on a large area of Fore-Sudetic Monocline and aeolian formations occur transgressively on alluvial, fluvial and aeolian formations of older sedimentation cycle. The biggest Upper Rotliegend cycle forms are from 10 to 100 meters *[33 to 330 feet]* thick within sedimentation plain, whereas towards the center of the basin their thickness in up to 500 meters *[1650 feet]*. In many cases only sandstones of the last aeolian cycle were found because of low thickness of Upper Rotliegend formation. Top parts of Upper Rotliegend were destructed and redeposited by water of the entering Zechstein See. Weissliegende deposits are to be found practically on the whole analysed area they are a few meters thick.

**Structural Character of Upper Rotliegend Forms**
Carboniferous and Lower Rotliegend (Autun) forms create an extension of Autun Gorzów Block towards SE. The northern boundary of the complex on NW-SE line is extremely varied and numerous peninsulas and gulfs are to be found there. Paleomorphological elevation are surrounded by Upper Rotliegend sediment series represented by sandstone, conglomerate, mudstone and claystone mentioned before. Some wells show a few meters thick tuff, tuffite and volcanic breccia or sandstone and conglomerate series probably belonging to Upper Rotliegend. This indicates proximity of thick Upper Rotliegend sediment series pinch-out zones. Pinches of these forms are to be found along the Miedzychód Trough – Poznań Trough line that is between northern and southern zones of Variscan folding.

Cyclical forms of Saxon sediments found in all wells at this level allow the assumption that the area in question is located in the vicinity of elevated which zones, as a result of erosion, provided terrigene material. Owing to varied erosion rate and climatic processes thickness of sedimentation sequences is differentiated, usually starting with coarse clastic material changing into sandstone and then into mudstone or claystone. Such lithofacial variety and interrelation of

forms, together with the results of drilling work, allows the conclusion that numerous deposit traps characterized by terrigene series pinch-out may exist there.

Upper Rotliegend forms are to be found at different depths. The highest ones were drilled in elevation connected with the belt of Carboniferous and volcanic effusion Lower Rotliegend rock adhering NE border of Wolsztyn Ridge. They can be found here at the depth of 2500 *[8250 feet]* meters, whereas towards NE (Poznań Trough) at 3500 meters *[11550 feet]*. They move further NE towards the center of sedimentation bassin where they can be found at the depth of 5000 meters *[16500 feet]*. Therefore regional sinking of these forms towards north can be seen. That creates conditions for hydrocarbons migration towards numerous lithological traps. Deposit trap types likely to be discovered in Upper Rotliegend forms will be discussed further in this presentation.

**The Types of Deposit Traps Likely to Be Discovered**

**LITHOLOGICAL TRAPS OF PINCH-OUT TYPE IN SAXON TOP:** the existence of that type of deposit traps is limited to by-pleoelevation areas, since these are the only places wherethey can be formed. The examples are Ujazd and Paproć fields. Sandy-conglomeratic forms laterally adjoin impermeable folded Variscan formations or from a pinch within Upper Rotliegend. They are surrounded by alluvial- fluvial forms creating a side shielding for migrating hydrocarbons. Such traps are interesting in research respect as they can have large surface size, relatively big deposit zone thickness and, what is most important, they were continuously fed with hydrocarbons migrating from SW (consistent with local Upper Rotliegend slant). Using the proper 3D seismic research methodology allows to follow the changes in the amplitude of seismic impulse record which marks the range of potential hydrocarbon deposits credibly.

**INTERSAXONIAN LITHOLOGICAL TRAPS:** in several wells inflows of hydrocarbons from aeolian sandstone levels located at the depth of 50 meters *[165 feet]* below Upper Rotliegend top were found. The traps of this kind can be discovered in any of the previously described sedimentation zones. Their presence is possible owing to the existence of at least one impermeable alluvial, fluvial or playa complexes screening the below aeolian reservoir sediments from above. Such lihofacial disposition is common within Poznań Trough. In numerous periodic rivers lithological traps of aeolian or river sandstone lens character may exist. They may have the shape of locally formed sandy dune limited by impermeable formations. Interpretation of this kind of deposit traps is difficult and based on thorough geological analysis only, since seismic impulse select is so low that it cannot be seismically followed. Minor anomalies in 3D seismic research may only initially suggest the areas for future geological – sedimentological analysis.

**INTERSAXONIAN STRUCTURAL TRAPS:** so far only occasional occurance of hydrocarbons in intersaxonian levels has been stated. As in the case of intersaxonian lithological traps, the presence of deposits here depends on the existence of aeolian sandstone covered with impermeable fluvial or playa formations. The search for this kind of deposits in Poland has been abandoned as limitations of seismic methodology make it difficult. At present it does not allow the interpretation of intersaxonian levels (specificity Polish Rotliegend Basin). In the light of this presentation the existence of big field of this type is not unsound. Moreover, innovatory approach to the search may soon result in spectacular success.

**TOP STRUCTURAL AND STRUCTURAL – TECTONIC TRAPS:** that type of deposit is likely to be discovered in the area, especially within sedimentation plain (Poznań Trough). The deposits of that type constitute 99 % of all documented ones in the area. Their genesis is connected with the existence of aeolian sediment with good reservoir properties in top parts of Upper Rotliegend formations. Their area and amplitude depend on the size of dunes building them. The biggest deposits can be 40 $km^2$ big, with deposit series amplitude of over 100 m *[330 feet]*, whereas the smallest ones can be smaller than 2 $km^2$, with deposit series amplitude of 20 m. Such a serious divergence results from paleomorphology left by Upper Rotliegend reservoir at the close of that complex sedimentation. Such deposits are relatively easy to find and future success here depends on improvement of seismic methods and correct data interpretation.

**Conclusions**

The authors of this presentation have tried to present a complex analysis of Upper Rotliegend with the view to suggesting new search areas at this level. The seismic analysis, supported with geological – sedimentological data allows the following conclusions to be drawn:

• Upper Rotliegend formation sedimented in three main deposition zones: pinch-out area, sedimentation plain area, the central part of sedimentation basin;

• Upper Rotliegend forms show local slant towards NE, which is conducive to the existence of deposits in lithological traps in the vicinity of after Variscan folding elevations;
• Upper Rotliegend forms display cyclical structure which makes sediment analysis easier;
• Defining the extent of individual sedimentation environments such as: alluvial cones complex, aeolian sediment complex, fluvial and playa sediment complexes is crucial to the presented analysis of chances of discovering hydrocarbon deposits in this level;
• The analysis of the age of hydrocarbon traps pointed out the areas where primary hydrocarbon deposits were destroyed as a result of subsequent processes connected with geological changes of the area in question. Thanks to it some areas could be eliminated from hydrocarbon search;
• The types of deposit traps likely to be discovered have been analysed. The possible areas of their existence have been defined giving the chance to discover deposits within Upper Rotliegend levels where search work has not been done yet.