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Title of PhD thesis: ***Improved methodology for interpretation of resistivity well logs data affected by the Groningen effect***

Summary

Resistivity logging, as one of the main measurements of boreholes, is necessary to determine of reservoir formation hydrocarbons / water saturation. Over the years, electrical logging methods have been perfected and new solutions have produced better results. With time, however, numerous imperfections of the proposed solutions became apparent, resulting from the specific geological nature of the deposits. An example is the so-called screening effect, which is met in the literature under different names, depending on the resistivity methods used and the hydrocarbon fields on which was observed. Recognized erroneously high reading resistivity from the early Laterolog tools like LL3 or LL7 was called the Delaware effect, and those identified on logs of Dual Laterolog tools was called the Groningen effect. In both of these cases, the deep resistivity was gradually increased in formations with low resistivity, approaching to formations of high resistivity, such as anhydrite or salt. While the Delaware effect has now only a historical aspect, the Groningen effect still occurs in modern measurements made with Dual Laterolog tools. In Polish geological conditions it is observed within the most important hydrocarbon fields in the Polish Lowlands (in reservoir deposits of the Rotliegend Sandstone, Zechstein Limestone and Main Dolomite).

The aim of the Ph.D. thesis was to develop a measurement and interpretation methodology for resistivity logs affected by the Groningen effect in the Polish geological conditions. The use of the latest technology solutions does not always turn out to be the most effective solution, as it is usually burdened with significant costs. The Geofizyka Toruń S.A.'s own solution, used from the mid-1970s (with various modifications) to the first decade of the 21st century goes to expire. The significant costs of acquiring the latest solutions like Array Laterolog tools, resulted in the need to search for effective alternative solutions. Techniques based on mathematical modelling of resistivity responses of Laterolog in various geological conditions, developed by a team from the Department of Geophysics of AGH University of Science and Technology, Faculty of Geology Geophysics and Environmental Protection (in cooperation with Geofizyka Toruń S.A. and Polskie Górnictwo Naftowe i Gazownictwo S.A.) and improved in this work was helpful. Additionally, statistical methods using multidimensional cluster analysis and artificial neural networks as well.

The author analysed the data from the largest Polish oil and gas field BMB (Barnówko-Mostno-Buszewo), where the Groningen effect was observed on resistivity logs in the Main Dolomite. The long-term exploitation of the hydrocarbons from the field allows to draw conclusions about the correctness of the formation saturation assessment at the exploration stage using own GT solution. The results of resistivity measurements in the Rotliegend Sandstone were similarly examined. The work carried out showed under which conditions of water saturation the

formation resistivity is artificially increased due to the Groningen effect. The author performed log analyses from the Array Laterolog and Array Induction tools in similar geological conditions (Main Dolomite water saturated and industrial hydrocarbons saturated) in order to verify the correctness of the log analysis made using his own solutions. All currently available resistivity logging measurements (Array Laterolog, Array Induction and Dual Laterolog) were performed in one of the well in the Rotliegend Sandstone formation. The author confronted the measurement results with each other and, based on the analyses, formulated conclusions and developed a measurement and interpretation methodology in the conditions of the Groningen effect with the minimization of logging costs.

Changes in the energy policy, aimed at reducing the use of fossil fuels to a large extent limit the activity related to the exploration of hydrocarbons. Restrictions on exploration expenditures particularly affect the service companies of the oil sector. The developed program Poprawki_LLD_LLS_2021 as well as machine learning and multi-dimensional statistical methods allow for the reinterpretation of archived data. Thanks to this, it is possible to integrate already existing data and reduce the costs of exploration work in partially explored areas. The prepared methodology is in line with the oil exploration market trends related to the reduction of exploration costs and environment protection and is a desirable direction.