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Deeply Buried Sandstones - Diagenesis and Reservoir Quality

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SUMMARY

During development of sedimentary basin, pore space of sandstones undergo transformations related to diagenetic stages. These processes include compaction, cementation, dissolution, replacement and recrystallisation, and become more and more advanced with depth. This interactions amends primary porosity, leading to deterioration of reservoir properties. The paper presents diagenetical changes occurred within deeply buried tight Rotliegend sandstones from Polish part of Southern Permian Basin and its impact on reservoir properties

Introduction

Diagenesis is a dynamic process involving physical and chemical changes taking place in a sediment or in a sedimentary rock after deposition, during burial history and a development of a sedimentary basin (Boggs 2009). Eo- and mesogenetic changes play an important role in postdepositional modification of reservoir parameters such as porosity and permeability. Primary porosity may be reduced by mechanical compaction, cements precipitation, mineral reactions or pressure solutions, and moreover increased (secondary porosity) during burial, as a result of grains and cement dissolution, mineral reactions or fracturing (Bjørlykke 1983). Permeability is controlled mainly by pore – throat size (Pittman 1992) and its loss corresponds to the decreasing volume of primary porosity (Pittman 1992, Dutton and Loucks 2010). Presented work aims to investigate diagenetic changes within deeply buried tight Rotliegend sandstones from Polish Part of Southern Permian Basin and its impact on reservoir properties.

Methods

Research was based on core samples analysis - qualitative and quantitative petrographic and petrophysical studies. Petrographic examination included analysis of thin sections in polarizing microscope with transmitted light and scanning electron microscopy.

For investigation were selected 21 sandstone samples from 4 wells, deposited in aeolian conditions in the central part of Polish Permian Basin, where deeply buried Rotliegend sandstones may be a reservoir rock for unconventional tight gas accumulations. Samples were represented by fine and medium – grained sandstones, chiefly quartz arenites and wackes, from depth 4016,5 - 4284,7 m. In addition were performed porosimetric and permeability analysis on 11 samples, which allowed numerical characteristics of pore space.

Reservoir parameters were altered by the diagenesis. Mechanical compaction had the greater impact on decrease of primary porosity. It contributed as well the development of long grain contacts (Figure 1A). As the main cement components were observed illite dominant clay minerals, with subordinate amount of ferruginous, anhydrite and carbonate cements. Occurrence of primary porosity were confirmed in each sample. Evidence of chemical compaction, dissolution of minerals and recrystallisation were also present very common (Figure 1B, Figure 2). Results of porosimetric studies revealed poor reservoir quality of deeply buried sandstones. Permeability in most cases does not exceeded 0,1 mD.

Figure 1 Polarizing microscope image showing diagenetic changes in deeply buried Rotliegend sandstones from depth 4184,7 m (A) compaction; grayscale; (B) cementation, dissolution and replacement; sample impregnated with blue resin.

Figure 2 Scanning electron microscope image (Rotliegend sandstone) from depth 4184,7 m (1- clay grain coating, 2 – quartz grain, 3 – pore filling clay-cement, 4 – grain dissolution).

Conclusions

Burial depth and associated temperature and pressure growth forced diagenetic processes affecting petrophysical properties of deeply buried Rotliegend sandstones:

- 1) Primary porosity was chiefly decreased by mechanical compaction and precipitation of cements. As the main cement components illite was recognized.
- 2) Secondary porosity increased slightly due to dissolution of less stable minerals.
- 3) Permeability was highly reduced even below 0,1 mD, in relation to precipitation of autigenic clay minerals, mostly by illite.

References

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