geoconvention
Virtual Event
September 21-23
2020
CSPG • CSEG • CWLS • GAC • MAC • IAH

Origin of a Tight Oil Sandstone Reservoir in The Third Member of Shahejie Formation, Dongpu Depression, China

Hui Li[1,2], Xiongqi Pang[2], Nicholas Harris[1]

1-University of Alberta; 2-China University of Petroleum – Beijing

Summary

As an important unconventional hydrocarbon resource, tight sandstone oil has become one of the most important replacement fields for oil and gas production worldwide. The formation of tight sandstone oil is determined by the diagenetic evolution and oil accumulation process. Research into relationships between porosity loss and hydrocarbon accumulation in tight sandstone reservoirs is important for accurate prediction, of producibility in tight oil exploration. We investigate diagenesis and oil migration in the Wenliu Area, Dongpu Depression, Bohai Bay, China.

Theory / Method / Workflow

Samples selected in this study were collected from the third member of Shahejie Formation (Es_3) that cover a range of structural location and depth. 1538 reservoir porosity and permeability data of 36 wells were collected from the Research Institute of Petroleum Exploration and Development, Zhongyuan Oilfield Company, Sinopec Group. A total of 36 samples were subject to analysis.

Blue epoxy resin impregnated thin section were analyzed for petrographic and diagenesis analyses. The thin sections were partly stained by alizarin red for carbonate mineral determination. Samples were analyzed by scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS) to identify pore geometry, cement morphology and textual relationships between minerals. Fluid inclusion petrographic analyses and homogenization temperature were conducted to study the stage of oil filling and accumulation time.

Results, Observations, Conclusions

According to the results of petrological and physical property analysis, the reservoir is mainly composed of feldspathic quartz sandstone and feldspar lithic quartz sandstone. Porosity is between 2% and 27%, with the average of 11% and the permeability is between 0.002mD and 71mD, with the average of 4.5mD, which indicate reservoir is generally tight. Sweet spots are present, with porosity between 12% and 27% and permeability between 5.245mD and 71.364mD.

Thin section and scanning electron microscope observations show the type of diagenesis. Diagenetic process is shown in Figure 1. Porosity decreased by 15% from original values 35% due to compaction during early diagenesis. Porosity was reduced by an additional 8% by early

carbonate cementation, prior to filling by hydrocarbons that inhibiting the cementation and compaction. At the same time, organic acids associated with hydrocarbon generation dissolved carbonate cement and feldspar, increasing porosity by 5%. Porosity continued to decrease where dissolutions were absent. Following hydrocarbon emplacement, compaction continued, accompanied by secondary enlargement of quartz, late ferriferous carbonate cementation and carbonate replacement of earlier carbonate, feldspar and quartz, resulting in additional porosity loss of 9%. Observation of two stages of cementation is consistent with homogenization temperature of inclusions in carbonate cements. At about 16Ma, the porosity was less than 12%, which indicated that the reservoir was tight.

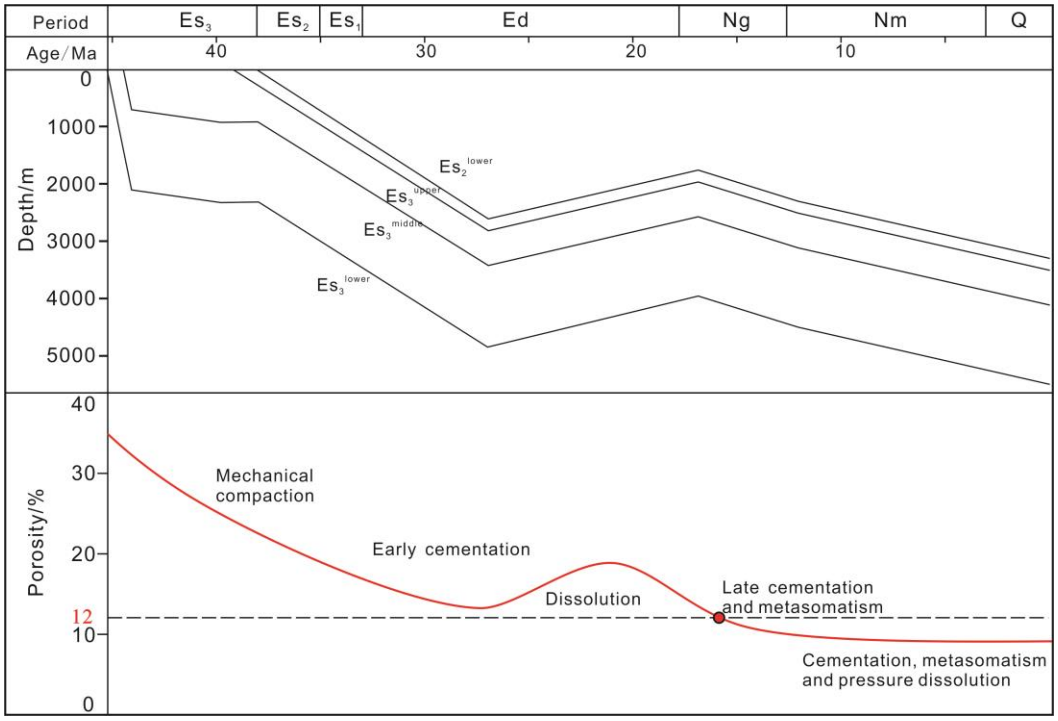

Figure 1. Es_3 reservoir quality evolution and diagenetic process in Wenliu area

Petrographic features and homogenization temperature of inclusions illustrate that there were two stages of oil filling. The first one happened at about 30Ma-27Ma, with large volumes of oil accumulating in conventional reservoirs. With continued porosity loss, conventional oil reservoirs became tight at about 16Ma. A second period of hydrocarbon accumulation took place from about 5Ma until present day, when the sandstone reservoir was tight near the sag.

Acknowledgements

This study is funded by the Major Scientific and Technological Projects of SINOPEC (P15022). We also grateful to the Zhongyuan Oilfield Company, Sinopec Group for providing the samples and database to support the study.

References

Beard D C, Weyl P K. Influence of texture on porosity and permeability of unconsolidated sand[J]. AAPG bulletin, 1973, 57(2): 349-369.

Xi K, Cao Y, Liu K, et al. Diagenesis of tight sandstone reservoirs in the Upper Triassic Yanchang Formation, southwestern Ordos Basin, China[J]. Marine and Petroleum Geology, 2019, 99: 548-562.

Dutton S P, Loucks R G. Diagenetic controls on evolution of porosity and permeability in lower Tertiary Wilcox sandstones from shallow to ultradeep (200–6700 m) burial, Gulf of Mexico Basin, USA[J]. Marine and Petroleum Geology, 2010, 27(1): 69-81.

Higgs K E, Zwingmann H, Reyes A G, et al. Diagenesis, porosity evolution, and petroleum emplacement in tight gas reservoirs, Taranaki Basin, New Zealand[J]. Journal of Sedimentary Research, 2007, 77(12): 1003-1025.

Lai J, Wang G, Ran Y, et al. Impact of diagenesis on the reservoir quality of tight oil sandstones: The case of Upper Triassic Yanchang Formation Chang 7 oil layers in Ordos Basin, China[J]. Journal of Petroleum Science and Engineering, 2016, 145: 54-65.