Overpressure Genesis of the Tight Gas Sandstone Reservoirs of the Southwestern Ordos Basin in the Upper Paleozoic*

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Search and Discovery Article #51029 (2014)
Posted September 22, 2014

*Adapted from poster presentation given at AAPG International Conference & Exhibition, Istanbul, Turkey, September 14-17, 2014, AAPG © 2014

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Abstract

In recent years with the discovery of natural gas in the first member of the Shanxi Formation and the eighth member of Shihezi Formation of the upper Paleozoic, the southwestern area of the Ordos Basin has become a new exploration area, covering an area of 20000 km^2. Now in the exploration, 5 commercial gas wells have been found, which shows a good exploration prospect.

Discussion

Former scholars believe the Shihezi Formation and Shanxi Formation of the upper Paleozoic in the Ordos Basin had a widespread overpressure in ancient times. We also confirm this point of view by analyzing the paleopressure of the target layer with fluid-inclusions (Shan et al., 2007; Wang et al., 2007; Liu et al., 2008). The formers considered the main mechanism for generating the overpressure is disequilibrium compaction, while as for this problem we hold different views. Aiming at this question, we have made a study, and we suppose that in this area the main reason for generating the overpressure is not disequilibrium but gas generation. The reasons for this point of view are as follows:

1. The deposition rate of the target layer is low. The disequilibrium compaction is mainly developed in the Cenozoic sedimentary basins, which had a higher deposition rate and filled with fine-grained lithology. As we calculated in this

area, the target layers in the upper Paleozoic all have a low deposition rate, as well as its overlying stratum. The highest deposition rate of the upper Paleozoic occurs in the member of Shiqianfeng Formation, which is about 45.2 m/Ma, and the average is around 27.01 m/Ma (Figure 1). As for the overlying strata from the Cretaceous to the Permian, the deposition rate in the Triassic appears to increase, but the largest value is only 42.96 m/Ma. Comparing with a high deposition rate mostly over 100 m/Ma of the other typical overpressure basins of China, we consider that the low deposition rate is not enough to cause the disequilibrium compaction.

2. The logging response characteristics are not obvious. Generally, the disequilibrium compaction will make the porosity values significantly greater than the porosity values in the normal compaction curve, and make the density values smaller than that in the normal compaction curve. By making a series of curves, including the AC-Depth, DEN-Depth, RT-Depth, and CNL-Depth curves of random wells in this area, we find no obviously abnormal tendency of these four logging curves in the overpressure section (Figure 2) and more similar to the logging response characteristics of overpressure caused by hydrocarbon generation that is summarized by Hunt (1994).

3. According to the recent studies (Zhao et al., 2013), overpressure has a good positive correlation with the hydrocarbon generation in this area, with the increase of hydrocarbon generation intensity, the pressure coefficient showed a trend of obvious increase (Figure 3).

4. With the analysis of fluid-inclusions and basin modeling by Petro-Mod, we know that the main formation time of the gas pool was from late Jurassic to early Cretaceous. While in this time the stratum of the upper Paleozoic have already reached a depth of 3000 km, which has become tight to a large extent and the disequilibrium cannot exist. Moreover, the densification of sandstone will make it harder for the gas to migrate and diffuse, so the large generation of gas will cause the expansion of pore fluid volume and generate overpressure.

Selected References

Hunt, J.M., J.K. Whelan, L.B. Eglington, and L.M. Cathles III, 1994, Gas Generation - A Major Cause of Deep Gulf Coast Overpressures: Oil and Gas Journal, July 18, p. 59-63.

Fertl, W.H., and D.J. Timko, 1972, How downhole temperature, pressure affects drilling, Part 1, Origin of abnormal formation pressures: World Oil, 174.7, p. 67-70.

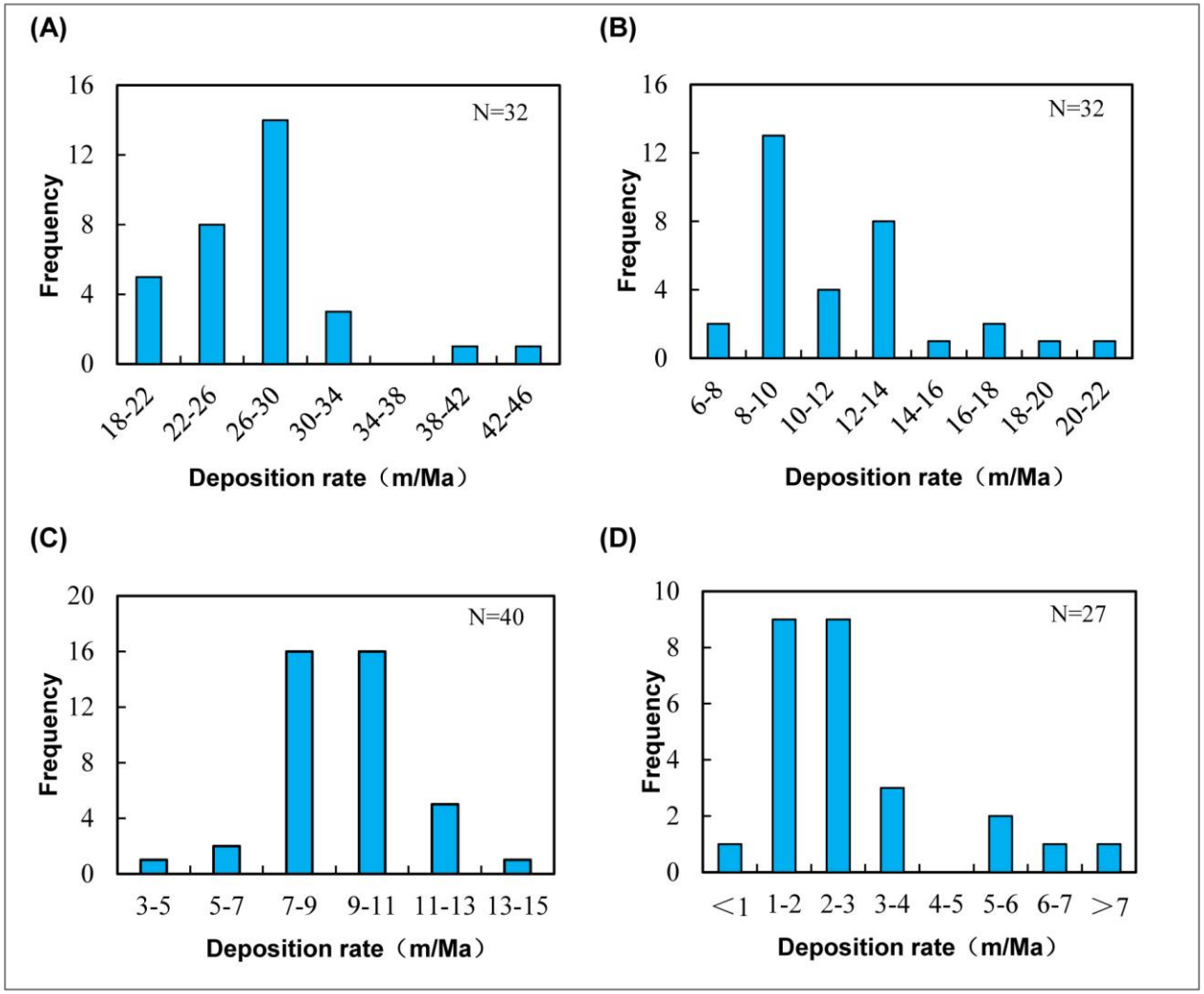

Figure 1. The frequency distribution characteristics of deposition rate for the strata of the Shiqianfeng Formation (A), Shihezi Formation (B), Shanxi Formation (C), and Taiyuan Formation (D) in the upper Paleozoic.

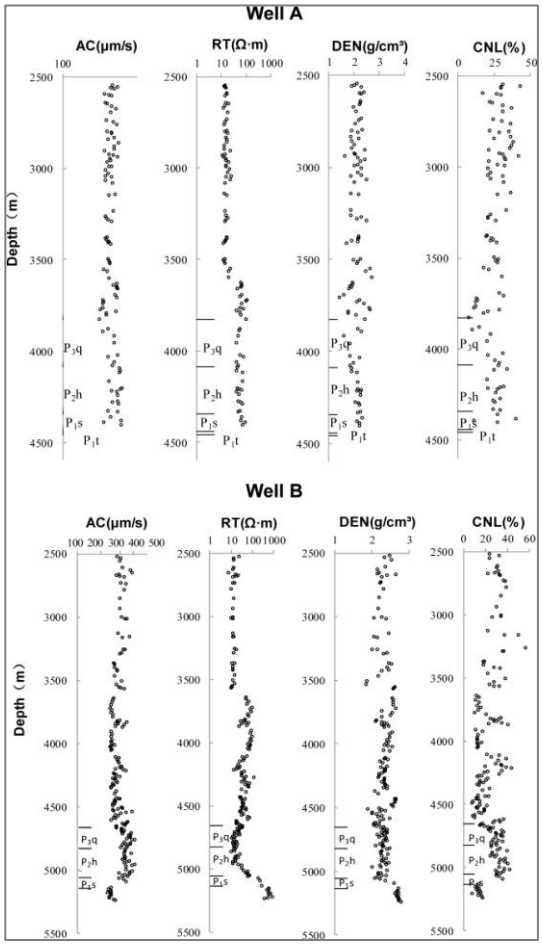

Figure 2. Logging parameters-depth profiles (including AC-Depth, DEN-Depth, RT-Depth, and CNL-Depth) of well A and B in the southwestern area of the Ordos Basin. The logging response characteristics from well A and B display that it is not obvious compared with the typical response of well logging parameters to normal compaction and overpressure by disequilibrium (Fertl and Timko, 1972).

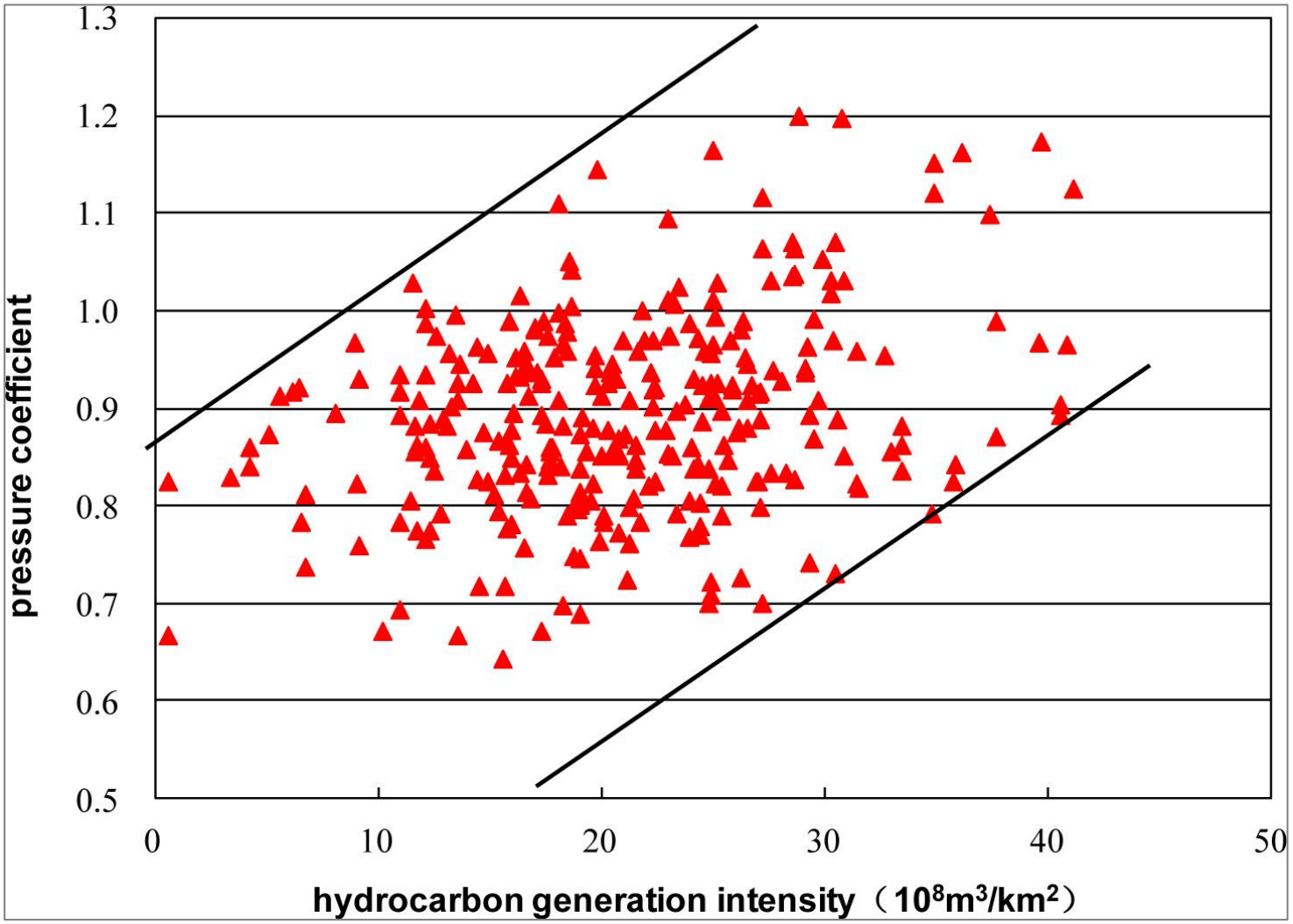

Figure 3. The relationship between hydrocarbon generation intensity and the pressure coefficient. It shows a good positive correlation between them.