Integrative Reservoir Prediction in Duzhai sub-depression Bohaiwan Basin North China

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The $Es_3^{3\text{-}4}$ unit of the Lower Tertiary Shahejie Formation in Duzhai sub-depression of Bohaiwan Basin (North China) consists of 500-900m of lacustrine shales with sandstone interbeds. The current burial depth of $Es_3^{3\text{-}4}$ range from 3500 to 6300m.The Duzhai sub-depression extends 30km in NNE direction and 6-10 km wide from the eastern escarpment margin to western hinged margin (Figs.1,2). According to basin model calculation 602×10^8 m^3 of gas have generated in the sub-depression, and the sandstones that sandwiched in these shales should have good prospect for hydrocarbon accumulation. Zhongyuan Petroleum Exploration Bureau has been searching hydrocarbon in this area for many years. By 1999, 0.5km × 1km high resolution seismic lines were shot, and three deep wells, PS4, PS5, PS12 drilled. No large-scale commercial pool was discovered due to absence of thick amalgamated sand-bodies. The individual sand-bodies consist of typically lenticular thin bed less than 3 meters. The maximum cumulative sandstone thickness is less than 80m, and

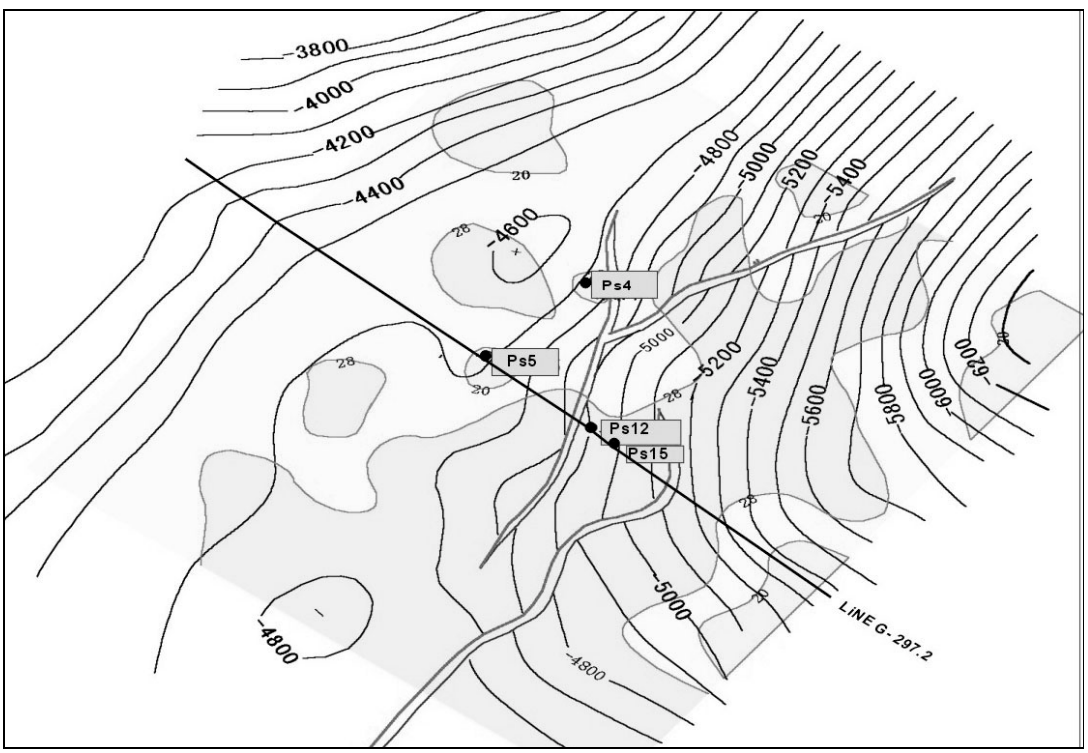

Fig.1 Structural map of upper boundary of the sandstone of Duzhai sub-depression. Sandstone isopach of 20m and 28m is based on 2D seismic inversion.

normally 10-30m. They are largely made up of siltstone and fine sandstone, with low porosity (10-19%), low permeability ($<10^{-3}\mu m^2$) and high residual water saturation (up to 40%). The prediction of good reservoir sandstone is most important for gas exploration in the region.

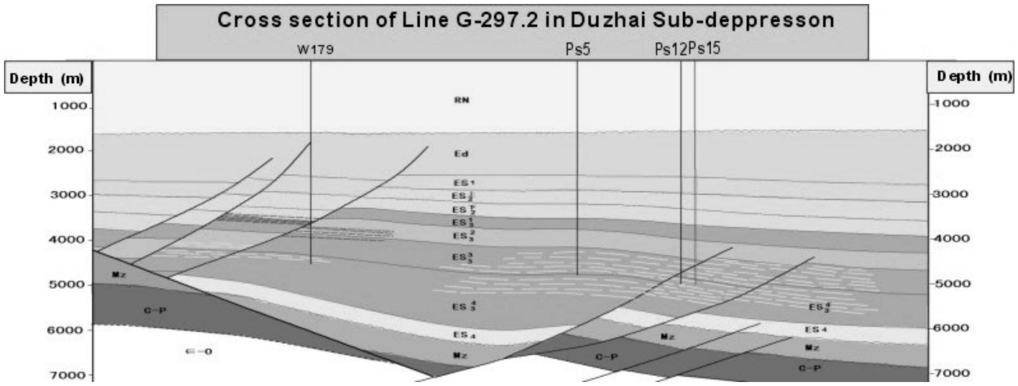

Fig. 2 Structural cross section along the seismic line G-297.2 in Duzhai Sub- depression.

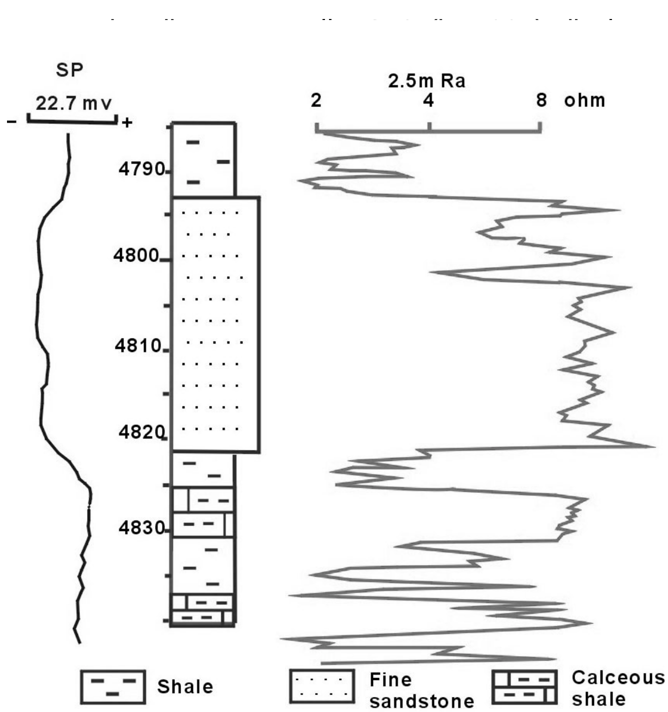

Fig.3 The well log section of the 28 m sandstone of Well PS12

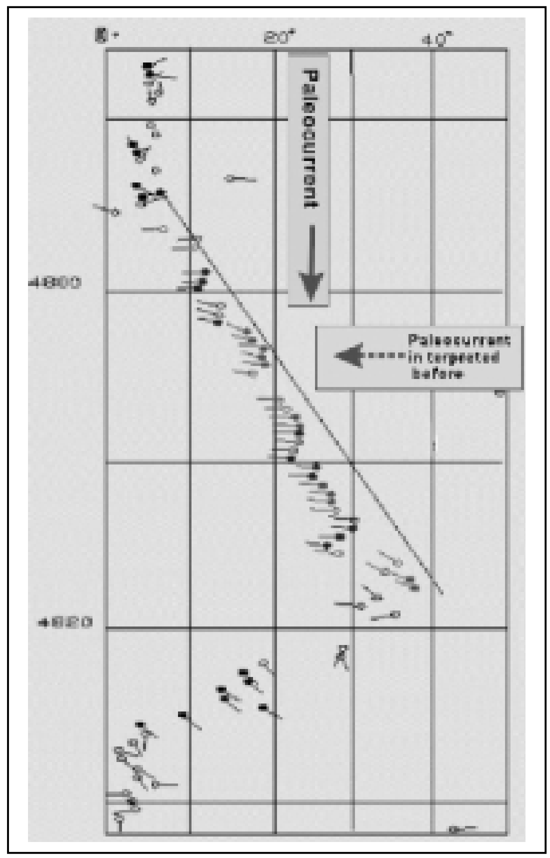

Fig. 4 Dip log of the 28 m sandstone of Well PS12

The discovery well PS12 (in 1991) disclosed 28m (4793-4821m) of sandstones in Es_3^{3-4} with initial 35000 m^3/d of gas production(Fig.3). Based on earlier geologic study and 2D seismic inversion these sandstone were then interpreted to be delta front facies sourced from east escarpment margin (Fig. 1). The next exploration well PS15 was drilled 250 m east of PS12 in early 2000 hoping to find thick sandstones close to the source area. Unfortunately PS15 was failed due to missing the thick reservoir target.

In June 2000, 300 km^2 of 3D seismic survey was conducted. According to integrated interpretation of the new 3D seismic and log data, and core examination, the 28m sandstone is now reinterpreted as incised valley fills that extended from north to south. The evidences included:

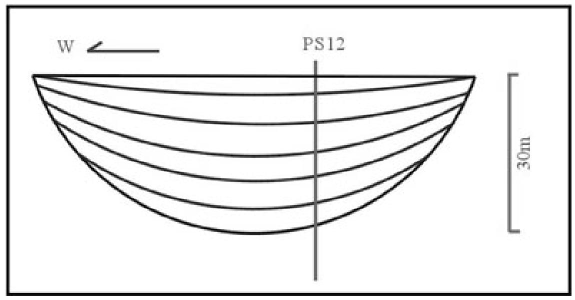

Fig. 5 Interpretation of the dip variation of 28m sandstone on dip log.

(1) The dip angles of the sandstones on dip log decrease upward should reflect incised valley fill (Figs. 4,5) and west diping directions were related to the bedding plane instead of foreset of tabular cross bedded sandstones. Therefore the paleo-current should be in a north-south direction perpendicular to the direction indicated by the dip log (Figs. 4,5). The borehole PS12 was drilled right on the east of the incised valley.

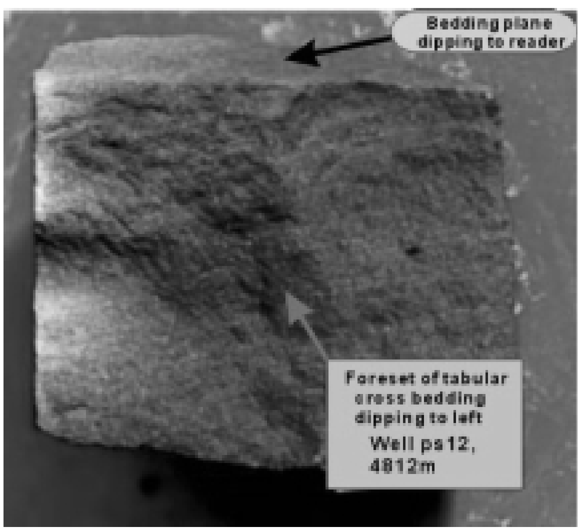

Fig. 6 Tabular cross bedded sandstone at the core of 4812m of the well ps12.

(2) Based on core examination the dip direction of foreset of tabular cross bedded sandstones is perpendicular to dip direction of the bounding plane (Fig. 6). The structural map also shows that upper boundary of sandstones dips toward east (Figs.1,2). So it can be inferred that the paleocurrent should be from north to south.

(3) 3D seismic horizon amplitude maps extracted from pure wave tapes show that the narrow belts of sandstones occur along the sub-depression axis in north-south direction. In addition, these narrow belts of amplitude anomalies tend to branch out southward. These characteristics also define north to south channels and deltaic tributary channels.

During the deposition of deep lacustrine shale, the lake became shallow or even dried up several times. This is indicated by 1-2m red mudstones and four intervals of evaporites interbedded with thick black shales. Unconformity reflections corresponding to the incised valleys, red beds and evaporites can also be identified in seismic profiles. Axial channel and delta are most important coarse deposits because both high stand and low stand coarse sediments are preserved on these fields. Combining the reservoir prediction with structural map, it can be seen that of the large scale incised valley fill sandstones identified in this research, only those located on nose rise and/or slope less than 5000m have the potential to form hydrocarbon traps.

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in1998. He worked in Sinopec Star Petroleum Co. Lid from 1983 to 1987. Since 1990 he has been working on the research of petroleum geology of North and Northwest China and teaching the course of seismic interpretation in Northwest University China. Now he is a visiting scholar in University of Regina Canada. His research interests include integrated reservoir characterization and seismic interpretation.