Pre-Stack Simultaneous Inversion in the Marine Carbonate Reservoir Prediction of the South Yellow Sea Basin, China

WU Shuyu1,2,*, LIU Jun1,2,3, CHEN Jianwen1,2, YUAN Yong1,2, LIANG Jie1,2, ZHANG Yinguo1,2 and SHI Jian1,2

1 The Key Laboratory of Marine Hydrocarbon Resources and Environment Geology, Ministry of Land and Resource, Qingdao Institute of Marine Geology, Qingdao 266071, Shandong, China
2 Laboratory for Marine Mineral Resources, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266061, Shandong, China
3 Faculty of Earth Resource, China University of Geosciences, Wuhan 430074, Hubei, China

Abstract: Lower Yangtze plate is an important area of Marine carbonate distribution in the southern China. Extensive and thick Marine sediments were formed from late of sinian to end of Triassic, which lasted for 700 million years. South Yellow Sea Basin (SYSB) is the main body of the lower Yangtze plate in the eastward extension area(Chen et al., 2016). After a series of tectonic movements, such as Caledonian movement, Indosinian movement, Yanshan movement and Himalayan movement, etc., present tectonic structure of the basin is bounded by the QianyiUplift in the north and the WunastraUplift in the south. From north to south, the basin can be divided into three secondary tectonic units: Yantai Depression, Laoshan Uplift and Qingdao Depression(Wu et al., 2016) (Fig.1a). The basin mainly developed several sets of carbonate rocks in Mesopaleozoic strata. From bottom to up, including dolomite of tidal flat faciesand restricted platform facies in the upper Sinian series (Z2d), pelitic rocks of basin facies and platform-margin slope facies, dolomitemand dolomitic limestone of platform facies in the Mid-Upper Cambrianseries (Є2-3), carbonate rocks of shelf sea facies in the Ordovician series(Oi), carbonate rocks of tidal flat facies and platform facies from Carboniferousseries to Lower Permian series (C - P1q) , carbonate rocks in the Upper Triassic (Т1к) (Zhang et al., 2014, Yuan et al., 2016)(Fig.1b).Carbonate strata in the Upper and Middle Yangtze region have been achieving oil &gas breakthrough, while there has not yet beenool & gas breakthroughs in the SYSB so far. It is found that carbonate reservoir has strong heterogeneity, poor reservoir performance and serious adverse factors in the later reconstruction, resulting in a large difference in seismic response. Therefore, the prediction of carbonate reservoir is the key and difficult point in oil & gas exploration in the SYSB at present(Liu et al., 2016).According to rock physics analysis in this paper, property indicator factor is sensitive to the porosity, which can judge the carbonate rock property. According to different angle, acquired far, middle and near angle stack seismic and the low-frequency models, using pre-stack simultaneous inversion, according the modified Fatti formula (Formula.1),Zs, Z5 and dp are obtained by pre-stack inversion, and property indicator factors obtained by using the petrophysical relations (Formula.2), then we can explain the favorable carbonate reservoir.

It can be seen from the Fig.1c, the physical properties of carbonate rocks are relatively well developed in general, especially the local weathering crust, leaching belt and dolomite located in the ancient highlands, pores, cavities and fractures are relatively developed. It can improve the pore condition of carbonate reservoir and form favorable reservoir easily. Dolostone in the Upper Sinian series (Z2d) is located in the evaporative tidal flat facies, reservoir space types are dissolution pore, intergranular pore and intergranular pore, whichare well developed and with better physical proper. Limestonefrom Mid-Upper Cambrianseries and Lower Permian series(C - P1q) developed weathering crust, seam and corrosion holes and hole reservoir types, fractures and cavities are the main reservoir space types, distributed in layers which wascaused by the tectonic fractures in the later period. Carbonate reservoir including weathering crust and beach facies are relatively developed from Carboniferousseries to Lower Permian series(C - P1q) with nodular limestone and bioclastic limestone, and top of the Carboniferous seriesformation is eroded by weathering due to the Hercynian movement. We can concluded that the distribution of favorable marine carbonate reservoir in SYSB can be prediction accurately, by pre-stack simultaneous inversion, which can provide reliable geophysical parameters of well drilling technical support in the next step of oil & gas exploration.

Key words: South Yellow Sea Basin, marine carbonate reservoir, pre-stack simultaneous inversion, property

Acknowledgments: This research has been funded by the South districts of Qingdao city science and technology development project “Pre-inversion study of Middle Paleozoic marine carbonate reservoirs in the South Yellow Sea basin” (2016-3-009 -ZH), China geological survey project “Investigation of oil & gas resources in the South Yellow Sea Basin” (DD2016015).

References


About the first author

WU Shuyu, female; born in 1984 in Wanning city, Hainan province, graduated from China University of Geosciences in Beijing, associate professor of Qingdao Institute of Marine Geology. She is mainly engaged in the field of marine regional oil & gas exploration. Her research interests include seismic data interpretation and inversion. E-mail: hnwushuyu@163.com; phone: 0532-85755322, 13792885753.

Formula 1. The modified Fatti formula

\[ T(\theta) = \bar{c}_W(\theta)D\Delta L_M + \bar{c}_2 W(\theta)D\Delta L_S + c_1 W(\theta)D\Delta L_D \]

\[ \bar{c}_1 = \frac{1}{2} \bar{c}_1 + \frac{1}{2} \bar{c}_2 + mc_3 \]

\[ \bar{c}_2 = \frac{1}{2} \bar{c}_2 \]

Formula 2. Property indicator factor formula

\[ Y = Z_r \cdot \cos(\theta) + Z_s \cdot \sin(\theta) \]