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Characteristics and Implications Significance for Carbon and Oxygen Isotope Continuous Change of Zhenjia1 Well in The Northern Shaanxi Salt Basin

XING Enyuan, ZHANG Yongsheng*, ZHENG Mianping, WANG Zhuozhuo, PAN Wei, ZHAI Daxing and WU Feimeng

*MLR Key Laboratory of Saline Lake Resources and Environments, Institute of Mineral Resources, CAGS,
Beijing 100037, China*

Zhenjia1 well located in the 2nd salt depression of the Northern Shaanxi Salt Basin (Zhang et al, 2013), is the basis potash exploration wells, and its main purpose is marine potash prospection, combining with gas exploration. Drilling completion depth is 3443.6m, continuous coring 900m. Lithology characteristics of this well from top to bottom is briefly described as follows: Ma 5 Member: having the largest thickness of halite, with accumulated thickness 116.65m, other lithology are mainly powder crystal limestone, brecciated limestone, dolomitic limestone, argillaceous limestone, karstenites, gypseous dolomite, micritic dolomite and so on. Ma 4 Member: thickness is 106.88m, main lithology are limestone, dolomitic limestone and calcareous dolomite, generally porphyritic structure. Ma 3 Member: thickness is 112.88m, main lithology are halite, karstenites and dolomite. Ma 2 Member: thickness is 81.94m, main lithology are limestone, calcareous dolomite, with salt interlayers, thin-bedded karstenites and micritic dolomite. Ma 1 Member: thickness is 60.4m, main lithology are karstenites, argillaceous dolomite and halite, and underburden Cambrian Zhangxia Formation is contacted unconformably.

The analysis of the Zhenjia1 well was continuously sampled for test carbon and oxygen isotope test analysis, carbon and oxygen isotope data were obtained 328 groups (PDB standard). Correlation Criterion (Qing and Veizer, 1994) shows that most of the data which characteristics can represent the original marine environment have little or no alteration by the late diagenesis.

The carbon and oxygen isotopes of Ma 4 Member and the 4th to the 10th Ma 5 sub-member shows positive correlation. Although these data may be subject to a late

diagenetic effects, the analysis shows that this phenomenon is indeed closely related to the halite and potash bedding effects. At the middle and lower section of Ma 5 member is mainly deposited a thick layer of halite (Zhang et al., 2014), characterized by deposition response of isotopic variation; protogenesis halite inclusions analysis shows that the ancient salt formation temperature is 27 ~ 36.9 °C (Hu B, 2014), which reflect the hot, arid climate favorable halite and potassium deposition ancient environment. This phenomenon shows that the causal link exists between the positive correlation of the carbon and oxygen isotopes of the 4th to the 10th Ma 5 sub-member carbonatite and the extreme paleo-environment of that period. Therefore, this feature shows the potash bedding potential of the middle and lower section of Ma 5 member in the Northern Shaanxi Salt Basin, which proved in some east part boreholes already confirmed (Liu et al, 1997; Zheng et al, 2010; Yuan et al., 2010; Chen et al., 2010; Zhang et al, 2014). Analysis shows that amount of brine formed from the strong evaporation of seawater during the early-to-mid Ma 5 sub-stage probably influence the underlayers. Dolomitization analysis in Ma 4 Member^[7] (Zhang, 2000) shows that the bury diagenesis is most likely to be related to the brine, which reflects the strong evaporation of seawater. Therefore, the test data of carbon and oxygen isotope with positive correlation still reflects paleo-environmental characteristics of the seawater in a certain extent.

Carbon isotope usually vulnerable under the impact of biological fractionation, a positive correlation exists between carbonate isotope and organic carbon values of pyrolytic carbon in each fases of the well (Fig. 1). In addition, mutations in different species of paleontology have some response at the carbon and oxygen isotope trends (Wang et al, 2002). In Ma 2 member, when the *Scolopodus flexills* appears, the $\delta^{14}\text{C}$ of this section

* Corresponding author. E-mail: zys_601@126.com

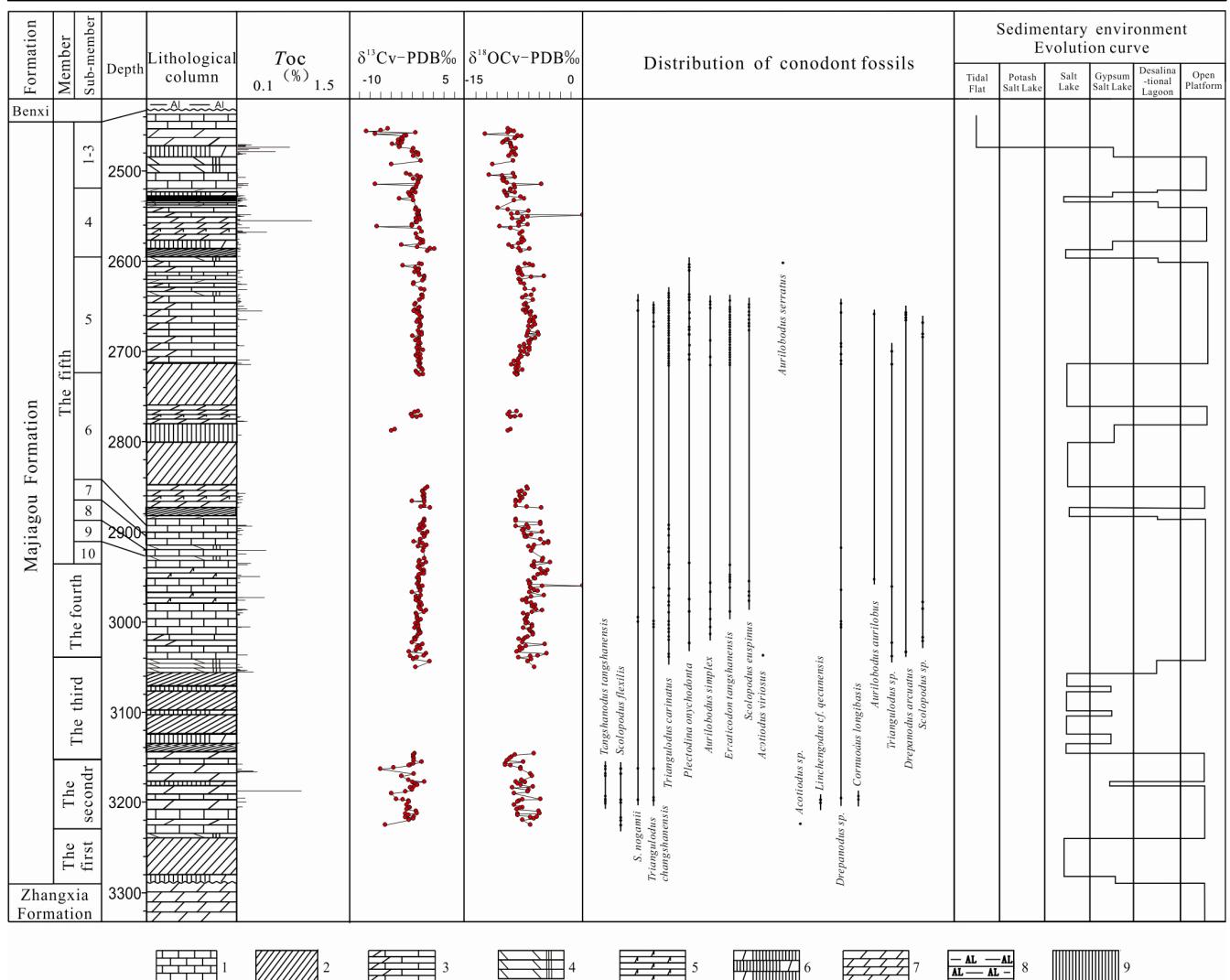


Fig. 1 Ordovician geochemical comprehensive column of Northern Shaanxi Salt Basin Zhenjia1 well, 1-Limestone; 2-Halite; 3-Dolomitic limestone; 4-Gypseous dolomite; 5-Calcareous dolomite; 6-Dolomitic karstenite; 7-Dolomite; 8-Bauxite; 9-Karstenite.

carbonate shows a positive drift and $\delta^{18}\text{O}$ shows a negative drift, which reflects the rise of the sea level and prosperous organism; in addition, when the *Lingnengodus cf. qecunensis*. and the *Cornuodus. Longibasis*. disappear in Ma 2 member, the $\delta^{14}\text{C}$ of this section carbonate shows a negative drift and $\delta^{18}\text{O}$ shows a positive drift, indicating relative fall of sea level, organic matter decline in productivity, the reduction of biological fractionation resulted in a relative increase in local water $\delta^{12}\text{C}$.

In the case of absence of post-secondary factors, the original oxygen isotopic composition of carbonate rocks are mainly reflected by the ancient climate, and also closely related to sea level changes(Tian et al, 1995; Luo et al, 2010). $\delta^{18}\text{O}$ variation of Zhenjia1 well in Majiagou Formation consistently corresponded with the characteristics of the lithofacies caused by sea-level fluctuation(Fig. 1): (1) Before the deposition of Ma 1 Member, $\delta^{18}\text{O}$ of Zhangxian Foamtion carbonates gradually increase gradually, and the representative deposits of

bottom of Ma 1 member are karstenites and large set of halite. (2) $\delta^{18}\text{O}$ of Ma 2 Member show a overall decreasing trend, and just at the end of Ma 2 stage $\delta^{18}\text{O}$ show positive shift. The representative deposits of bottom of Ma 3 member are karstenites, some halite and dolomite clips. (3) $\delta^{18}\text{O}$ of Ma 4 Member show a decreasing trend at the middle and lower section, and the representative deposits are large set of limestones at bottom and dolomites at middle section. The $\delta^{18}\text{O}$ variation trend in the upper part has a analogy trend with the upper part of Ma 2 member, the corresponding lithofacie changes at the bottom of Ma 5 Member are large set of limestones with dolomite interlayers, karstenites, and a pinch of halite deposition. (4) $\delta^{18}\text{O}$ of Ma 5 Member shows a increasing trend under the 6th Ma 5 sub-member, and the corresponding response are deposited a section of stable halite with karstenites and dolomites interlayers; in the 5th-1st Ma 5 sub-member $\delta^{18}\text{O}$ overall decrease, which represents the sea level rise in the final period of Ma 5 stage, as well as the potassium show

are weaken or disappeared in upper Ma 5 member and strong in mid-lower part. This lithology characteristic can be found in some salt exploration wells in the east part (the 10th to 6th Ma 5 sub-member) of Northern Shaanxi Salt Basin. Thus the longitudinal variation of $\delta^{18}\text{O}$ with the salt (with potassium) layer segments are in good agreement relationships.

Overall analysis showed that: the variation trends of the carbon and oxygen isotope of the carbonate rocks in Zhenjia1 well section have good relationship with the salt (with potassium) layer and organic matter enrichment segments, and can be corresponded with the ancient marine sedimentary environments. So that these data have a good significance to indicate the Natural Gas and potash mineral deposit in Majiagou Formation.

Key words: carbon and oxygen isotopes, ancient marine environments, Ordovician, Zhenjia1well

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