EVOLUTION OF KEROGEN CARBON ISOTOPES DURING EARLY CAMBRIAN TO ORDOVICIAN IN EASTERN TARIM BASIN, CHINA

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Introduction

At present, there are mainly two kinds of opinions about the primary source rocks in Paleozoic marine cratonic region of the Tarim Basin. Most geochemical researchers believe that the vast majority of oils in the cratonic region are derived from the $O_{2–3}$ source rocks (Zhang et al., 2000; Ma et al., 2008; Li et al., 2010; Zhu et al., 2012; Li et al., 2015; Xiao et al., 2016), while more and more geologists and geochemists believe the majority oils are $Є–O_1$ origin (Sun et al., 2003; Cai et al., 2015). The carbon isotopic value ($\delta^{13}C$) is widely used in the oil–source correlation. Because the TD2 well oil is situated in Cambrian strata and has the most enriched $\delta^{13}C$ value (−28.5‰), it is commonly regarded as the end-member for the $Є–O_1$ derived oils. While the oils with the most ^{13}C depleted values (about −34‰) from the Lower Ordovician in YM2 area are automatically regarded as the $O_{2–3}$ sourced end-member (Li et al., 2010, 2015). However, a set of high quality source rocks in Lower Cambrian with depleted $\delta^{13}C$ values (about from −34‰ to −38‰) were widely developed in Oman, Russia, Australia, South China as well as in XH1 well (Cai et al., 2015) and Akesu outcrops in Tarim Basin (Tao et al., 2016). The condensates from the Middle Cambrian in well ZS1 are ^{13}C depleted and sparked more controversy about their origin (Li et al., 2015; Cai et al., 2015).

However, there are no systematic $\delta^{13}C$ for the Palaeozoic source rocks in the Tarim Basin until now. In order to define the occurrence horizon and $\delta^{13}C$ characteristics of the main source rocks of Cambrian–Ordovician, 90 cutting and core samples of YD2 well were selected systematically to analyse the total organic carbon (TOC), total sulfur (TS) and isotopic composition of kerogen ($\delta^{13}C_{ker}$).

Results

The TOC content of the Lower Cambrian to Ordovician samples from YD2 well vary generally between 0.05% and 3.29%, while the TS abundance varies between 0.03% and 4.16%. TOC values show an obvious positive correlation with the TS content. Their trends may be subdivided into five parts. The Lower–Middle Cambrian is the first part and shows a TOC ranging from 0.05% to 3.29%. The black shales contain the highest content of TOC and TS. The second one is Tuershaketage Fm. ($Є_3$-O_1) with the lowest TOC content ranging from 0.05% to 0.83%. The third part is Heituao Fm. (O_{1-2h}) with a TOC range between 0.62% and 1.38%, average of 1.00%. The fourth one is the lower member of Queerqueke Fm. (O_{2-3q}) with a TOC range between 0.80% and 1.37%. The Last one is the upper member of Queerqueke Fm. with a TOC range between 0.08% and 0.74%, averaging 0.43%.

The $\delta^{13}C_{ker}$ data for Early Cambrian to Late Ordovician display a total range between −27.3‰ and −34.2‰. The ^{13}C depleted values (−32.0‰ to −34.2‰) were only found in the black shales of the Lower Cambrian. The Moheershan Fm. ($Є_2$) and Heituao Fm. (O_{1-2}) show much stabile isotopic ranges from −30.7‰ to −31.6‰ and from −31.0‰ to −31.5‰, respectively. The Tuershaketage Fm. ($Є_3$-O_1) shows the most enriched $\delta^{13}C$ values, from

−27.3‰ to −30.2‰, averting −28.6‰. The lower member of Queerquek Fm. shows a range of $\delta^{13}C_{ker}$ from −29.2‰ to −31.3‰.

Conclusions

The best source rocks in Eastern Tarim Basin are the Lower Cambrian black shales, followed by the Middle Cambrian black shales and lime mudstones. The black shales of Heituao Fm. and lower member of Queerqueke Fm. are also active source rocks. The Tuershaketage Fm. as well as the Upper Queerquek Fm. are not effective source rocks.

Carbon isotope values of the kerogen are obviously controlled by both the geologic time and sedimentary environment. The Lower Cambrian has the most depleted $\delta^{13}C$ value source rocks, while the Upper Cambrian to Ordovician is characterized by much more enriched $\delta^{13}C$ values. The black shales are obviously enriched in $\delta^{13}C$ values than that of dolomite and grey mudstone during the same geological time.

The oils with the carbon isotope values less than −33‰ must be derived from the Lower Cambrian source rocks, while oils with the carbon isotope values more than −32‰ can be originated from the Middle Cambrian source rocks, or Lower-upper Ordovician source rocks, or both of them.

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