NITROGEN ISOTOPIC COMPOSITIONS OF THE PERMIAN AND TRIASSIC SOLID BITUMEN AND ITS POTENTIAL SOURCE ROCKS IN NORTH SICHUAN BASIN

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Introduction

The ocean nitrogen cycle include N_2 fixation, denitrification, nitrification and anammox and NH_4^+ assimilation into organic matter, and nitrogen isotopes are found to provide a record of specific biosignatures and are sensitive to environmental redox changes. Significant difference in nitrogen isotopic compositions has been found to occur between marine and terrestrial organic matter and even in marine OM deposited under different redox conditions.

The potential source rocks for the solid bitumens in the NE Sichuan Basin include Lower Cambrian (ε_{1q}), Lower Silurian (S_{1l}) and Upper Permian Wujiaping or isochronous Longtan Formation (P_{3w}) and Dalong Formation (P_{3d}) black shales and mudstones. The source rocks except Dalong Fm are highly mature to overmature and show similarity in biomarker composition, but significant differences in carbon and sulphur isotopic compositions (Cai et al., 2017). Here we report nitrogen isotopes of these suites of rocks and the solid bitumen with an attempt to correlation between solid bitumen and source rocks using $\delta^{15}N$ values.

Results and discussion

Lower Cambrian black shale deposited under shallow water platform in the Shatan section shows kerogen $\delta^{15}N$ values from -2.4 to -0.6‰ (n=20; Fig. 3C). The values are slightly lighter than those from Lower Silurian from Shuanhe and Huayinshan sections with the values from -2.0 to +1.3‰ (n=17). The Upper Permian Wujiaping or isochronous Longtan Fm in the Guanzi outcrop section and Well 10-VI in Huayinshan have mudstone kerogen $\delta^{15}N$ values from 1.2 to 4.0‰ (n=9), coal in Changjiangou outcrop section of 9.6 and 11.7‰ and a shale sample in well Heba1 of -1.7‰. The uppermost Permian Dalong Fm or isochronous Changxin Fm -0.5 to 2.7‰ (n=17). It can be seen that kerogen $\delta^{15}N$ values show positive shift from the Lower Cambrian, Lower Silurian to the Upper Permian Longtan Fm and then negative shift towards the Dalong Fm. This trend is consistent with variation in atmospheric oxygen content with increase from early Cambrian towards late Permian and then dramatic drop during the latest Permian and Permian and Triassic transition when biota extinction occurred.

The four suites of source rocks can be distinguished using $\delta^{13}C$ - $\delta^{15}N$ relationship (Fig. 1A). The Lower Cambrian source rocks have lightest $\delta^{13}C$ and $\delta^{15}N$ values, followed by the Lower Silurian. The Longtan Fm (P_{3w}) has the heaviest values. The Dalong Fm has $\delta^{13}C$ values between the lower Silurian and the Longtan Fm but shows variable $\delta^{15}N$ values. Different kerogen $\delta^{15}N$ to distinguish source rocks from different age. The four suites of source rocks show overlap of $\delta^{34}S$ values when the range of all the data is considered (Fig. 1B). If the average or medium value of the data is considered, the Lower Cambrian is heaviest, followed by the Lower Silurian and the Upper Permian is the lightest.

Interestingly, eastern and western solid bitumen samples from Upper Permian and Lower Triassic show significant difference in $\delta^{15}N$ value with significant heavier values in the eastern gasfields (Fig.1C). The data are consistent with our previous finding that aryl isoprenoids were

detected only in the west, indicating that at least part, if not all, of the western solid bitumens were derived from organic matter deposited under euxinic environment, likely from the Upper Permian Dalong Fm or Lower Silurian. In contrast, eastern solid bitumens may have derived from the Upper Permian Longtan Fm as suggested by other kinds of data (Cai et al., 2017 and references therein).

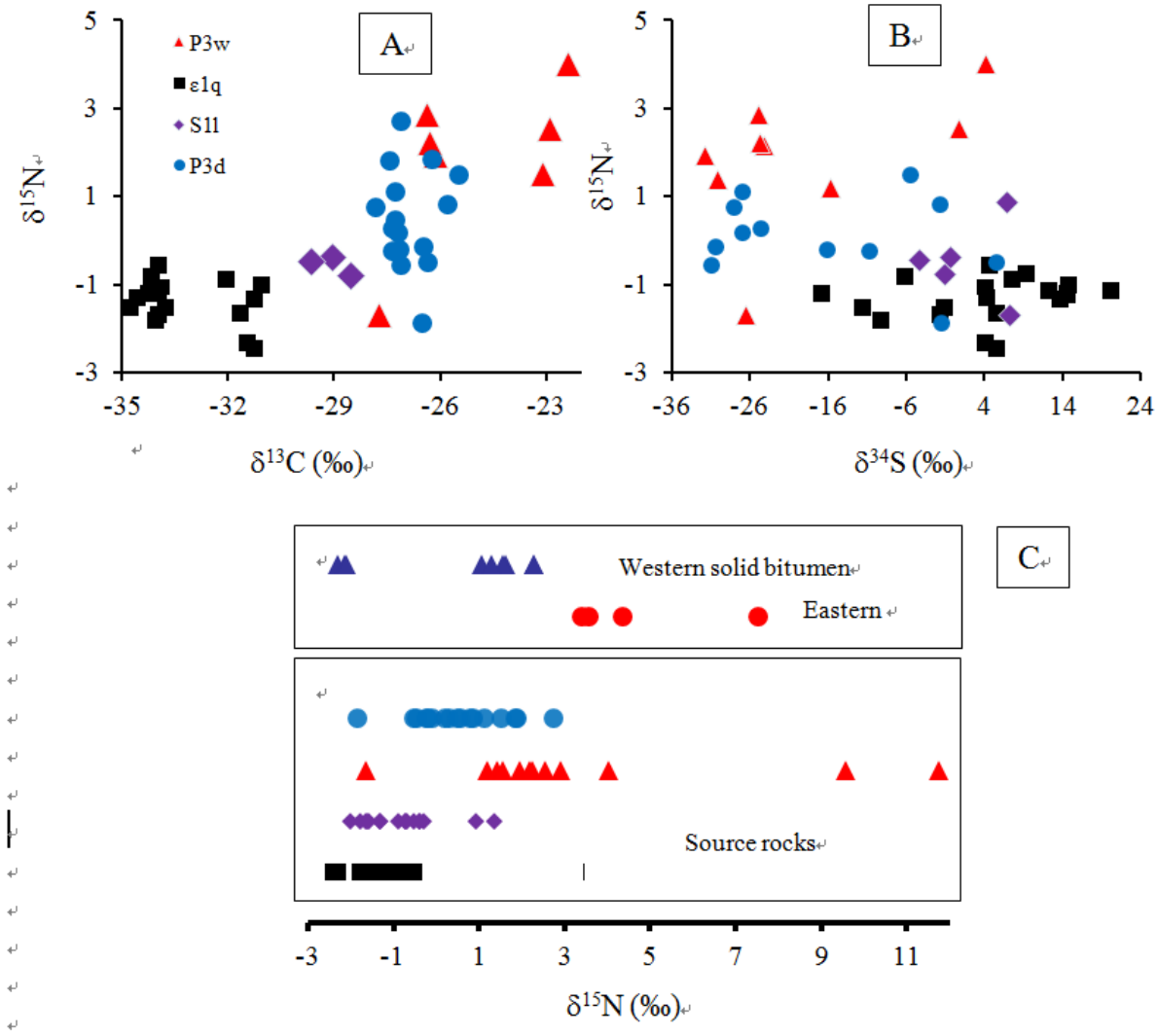

Figure 1 *Relationships of kerogen $\delta^{13}C$ values to $\delta^{15}N$ (A) and $\delta^{34}S$ (B), and comparison of solid bitumens in the western and eastern gasfields and source rocks of different strata.*

Conclusions

Kerogen $\delta^{15}N$ values from the four suites of potential source rocks in the northern Sichuan basin show significant differences and can be used to reflect deposition environment, and to correlate with the P_3d-T_1f solid bitumen in the area. The $\delta^{15}N$ values show significant differences between eastern and western solid bitumens, supporting that they were derived from different source rock as previously proposed by us in the 2011 AAPG Herdberg meeting.

References

Cai,C.F., Xiang, L., Yuan, Y.Y., Xu, C.L., He, W.X., Tang, Y.J., Borjigen, T., 2017. Sulfur and carbon isotopic compositions of the Permian to Triassic TSR and non-TSR altered solid bitumen and its parent source rock in NE Sichuan Basin. Organic Geochemistry (in press).