

## Geochemical characteristics and correlation of oil-source in Minfeng area for Dongying depression, Bohai Bay Basin, Eastern China

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The Minfeng area is located in the northeast of Dongying Depression. The characteristics of the gas chromatography of saturated hydrocarbons and the steroid terpane biomarkers show that there are three sets of source rocks with obvious differences including the upper part of the fourth member of the Shahejie Formation (simplified as Es4s), the middle part of the third member of the Shahejie Formation (simplified as Es3z), and the lower part of the third member of the Shahejie Formation (simplified as Es3x). There are four types of oil.

Further studies focus on oil-source correlation. Based on the techniques of fingerprint identification, scatter diagram analysis and mathematical statistics, the results indicate that oils in reservoirs of the second member of the Shahejie Formation (simplified as Es2) (from 7 to 10 sand units) of Yong3 fault-block, Es2 (No.4 sand unit) of Yong51 fault-block and Yanjia area came from Es4s source rock. Oils in reservoirs of Minfeng sag came from Es3z and Es3x source rocks. Oils in reservoirs of Es2 (No.3 and No.5 sand units) of Yong3 fault-block, Yong66 fault-block, Yong12 fault-block, Yong51 fault-block are mixed by oils coming from Es4s and Es3x. Oils in reservoirs of Es2 (No.3 and No.5 sand units) of Yong2 fault-block, Yong63 fault-block came from Es3z source rock.

It is possible to infer that oils from Es4s source rock, which were mainly along the favorable sandbodies and unconformity, migrated laterally from sag to Yanjia area and eventually filled in the sandy conglomerate bodies of Es3 and Es4 because of lack of oil-source faults. Oils are diverse types because of many oil-source faults in Yong Anzhen area. It implies that traps in Yonganzhen area formed in the same period according to the distribution of the types of oils on the plane. Early generated oil accumulated in the reservoir which was near to the source rocks. With the further burial depth of the source rocks, overlying source rocks gradually entered the hydrocarbon generation period, the oil began to accumulate in traps which were further distance from the source rocks.

## Direct atmospheric O<sub>3</sub> and O<sub>2</sub> signatures from the deep past and their first-order pattern

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The isotope compositions of atmospheric O<sub>3</sub> and O<sub>2</sub>, two of the most important molecules in the atmosphere, offer us windows to the deep history and evolution of the Earth. Sulfate is an oxyanion capable of recording direct O<sub>3</sub> and/or O<sub>2</sub> signatures from the distant past. Recently, an improved understanding of the triple oxygen isotope systematics of various sulfur oxidation processes has demonstrated that secondary atmospheric sulfate bears O<sub>3</sub> signature ( $\Delta^{17}\text{O}$  positive), while sulfate of oxidative weathering origin bears O<sub>2</sub> signature ( $\Delta^{17}\text{O}$  negative). The ultimate source of the <sup>17</sup>O anomalies in O<sub>3</sub> and O<sub>2</sub> is the Chapman reaction in the stratosphere, which via stratosphere-troposphere exchange links the concentrations and triple oxygen isotope compositions of atmospheric O<sub>2</sub>, CO<sub>2</sub>, and O<sub>3</sub> to the rates of bioproductivity, weathering, and organic burial on the Earth surface.

Despite many unfilled gaps in its record, I propose here that, from existing data, a first-order temporal pattern for sulfate  $\Delta^{17}\text{O}$  for the last 3.5 billion years has emerged. There are three outstanding features. (1) The Marinoan O-17 Depletion (MOSD) event at 635 Ma is a clear anomaly in which the  $\Delta^{17}\text{O}$  of sulfate reached as negative as  $-1.64\text{‰}$ . The most viable explanation for this event is a post-glacial, ultra-high pCO<sub>2</sub> world, which is consistent with the "snowball" Earth hypothesis. Data for other alleged "snowball" Earth periods are lacking at this time, and other secondary "depletion" events are predicted. (2) The Archean sulfate has an average  $\Delta^{17}\text{O}$  value of  $-0.05 \pm 0.05\text{‰}$ , while the post-Archean sulfate has an average  $\Delta^{17}\text{O}$  at  $-0.12 \pm 0.05\text{‰}$  (MOSD data excluded), a pattern that is consistent with the lack of O<sub>3</sub> shield, i.e. the absence of Chapman reaction, in the Archean. However, the role of thermal alteration has yet to be examined. (3) The oldest sulfate with distinct positive  $\Delta^{17}\text{O}$  values has been traced back to the Eocene (~35 Ma). However, if O<sub>3</sub> became essential in atmospheric oxidation of SO<sub>2</sub> as soon as the <sup>33</sup>S anomaly ceased to exist in rock records,  $\Delta^{17}\text{O}$ -positive sulfate should have been produced since the Early Proterozoic Era. Bear in mind that any geological record is the net result of production and destruction. By understanding the geologic context of sulfate records, and by exploring diverse and continental deposits in particular, we shall piece together a first-order, direct geological record of atmospheric O<sub>2</sub>, O<sub>3</sub>, and CO<sub>2</sub> for the last 3.8 billion years.