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Research paper

Geochemistry and origin of natural gas in the eastern Junggar Basin, NW China

Ping'an Sun [a, b], Yuce Wang [b], Kun Leng [c], Hui Li [d], Wanyun Ma [c], Jian Cao [b, *]

[a] Key Laboratory of Karst Dynamics, MLR/GZAR, Institute of Karst Geology, CAGS, Guilin, 541004, China
[b] State Key Laboratory for Mineral Deposits Research, Department of Earth Sciences, Nanjing University, Nanjing, 210023, China
[c] Research Institute of Experiment and Testing, PetroChina Xinjiang Oilfield Company, Karamay, 834000, China
[d] Research Institute of Petroleum Exploration and Development, PetroChina Xinjiang Oilfield Company, Karamay, 834000, China

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ABSTRACT

The eastern Junggar Basin in NW China is an important region for natural gas exploration with the giant Kelameili Gas Field having been discovered. However, the origin of gas in the region is unclear, which limits the understanding of gas formation and accumulation, as well as the planning of exploration strategies. Here, we address the origin of gas in this region through a comprehensive investigation of gas geochemistry in the context of geological setting, including gas chemical compositions, carbon isotopes and light hydrocarbons and biomarkers of retrograde condensates. Results show that four main types of natural gases were identified: (1) highly mature to post-mature humic-type gas sourced from Carboniferous rocks with Type III kerogen, (2) mature to highly mature humic-type gas sourced from Permian rocks with Type III kerogen, (3) mature to highly mature sapropelic-type gas sourced from Permian rocks with Type I–II kerogen, and (4) microbial gas sourced from Permian rocks with Type II–III kerogen. These gases vary significantly in geochemistry, and thus can be easily identified. The distribution of the gases follows the "source-controlled" principle in that it is controlled by the distribution and maturity of hydrocarbon source rocks. As such, the gases sourced from the Carboniferous and Permian rocks are the most viable exploration targets, with the areas in and surrounding the hydrocarbon-generation centers being favorable for exploration. These results also provide guidance to natural gas exploration and research in other basins with similar geological settings.

1. Introduction

The eastern Junggar Basin in NW China is an important region for natural gas exploration with the giant Kelameili Gas Field having been discovered in 2005, which contains a proven reserve of hundreds of billions of cubic meters (Fig. 1; Wang, 2005; Da et al., 2010; Kuang et al., 2010). However, the sources and origins of the natural gases in this region are complex, because the region is surrounded by several sags (Fig. 1) and multiple sequences of gas-generating source rocks have been developed (Fig. 2; Dai et al., 2009; He et al., 2010; Xiang et al., 2010; Wang et al., 2011; Yu et al., 2014; Jin et al., 2015; Gao et al., 2016). This limits the understanding of gas formation and accumulation, as well as the planning of exploration strategies. Previous studies have focused on the origin of oils (Da et al., 2010; Yang et al., 2012; Li et al., 2013), while research on gases has been limited to studies of relatively small areas (Li et al., 2010; Zhang et al., 2014). It is proposed that there are several origins of gases in the region, e.g., sources from Carboniferous, Permian and Jurassic rocks (Luo et al., 2005; Li et al., 2009, 2010; Zhang et al., 2014). However, all of these studies were only based on gas compositions and carbon isotopes, meaning that the sources and origins of the gases are still not well constrained without a systematic study.

To improve our understanding of gas sources and origins in this region, we conduct a comprehensive geochemical study of the gases in this study, including gas compositions, carbon isotopes, light hydrocarbons and biomarkers of retrograde condensates. The analytical results, combined with the geological setting of source rock, allow us to assess the sources and origins of the gases. This can expand our understanding of gas genetic

* Corresponding author.
E-mail address: jcao@nju.edu.cn (J. Cao).

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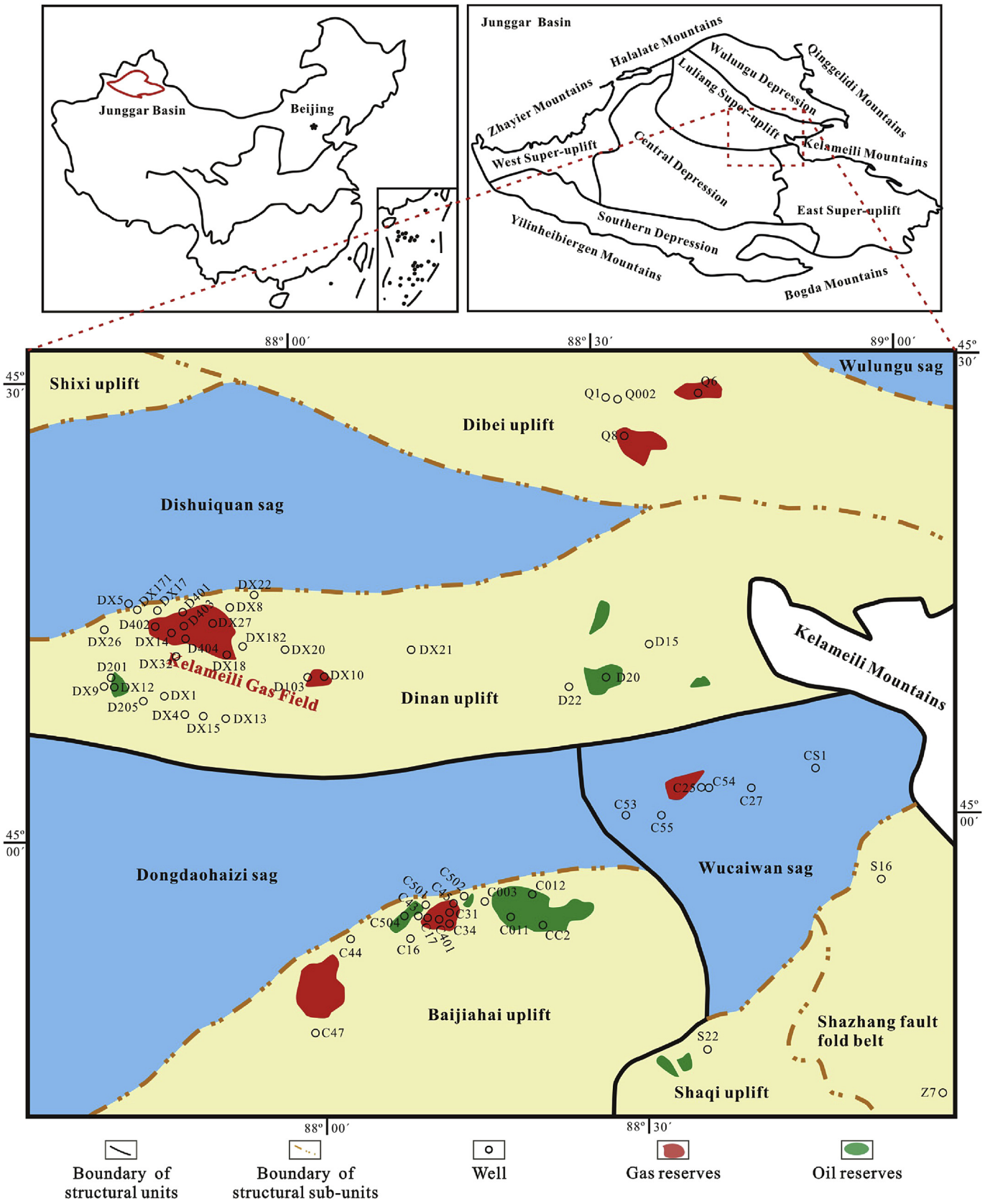

Fig. 1. Sketch map showing structural units and gas distribution in the eastern Junggar Basin.

types in the basin and assist in guiding regional gas exploration. In addition, results and understanding can also be referred in other basins with similar geological settings. Thus the study here can have both regional and general implications.