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Petroleum system assessment of conventional-unconventional oil in the Jimusar sag, Junggar basin, Northwest China

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ABSTRACT

In recent years, petroleum assessment incorporates the petroleum system concept method instead of the play concept method to estimate petroleum resources, because conventional-unconventional petroleum resources are more reliably estimated by the genetic similarities of petroleum fluids in the petroleum system. Conventional-unconventional oil resources co-exist in the Lucaogou-Permian petroleum system in the Jimusar sag of the Junggar basin, Northwest China. The mean in-place resources (IPR) of tight oil of the Lucaogou Formation (LF) were estimated at 2.0 billion tons by an integration method in the Jimusar sag. Based on the assessment of the technically recoverable coefficient by drill productivity, it is estimated that the mean technically recoverable resources (TTR) of tight oil are about 0.11 billion tons. The mean IPR and TTR of conventional oil of the Wutonggou Formation (WF) were evaluated at 0.36 billion tons and 0.06 billion tons by analogy methods, respectively. The ratio of mean IPR of unconventional oil to conventional oil in the Jimusar is about 5:1, but the ratio of mean TTR is only about 2:1. In addition, tight oil development is higher cost than conventional oil so far. Therefore, the development of tight oil in the Jimusar sag should be a careful consideration. Anyway, the integrated resource assessment of unconventional and conventional oil in the Jimusar sag could provide as a classic example for other lacustrine petroleum systems.

1. Introduction

In recent years, U.S. Geological Survey (USGS) petroleum assessments have incorporated the total petroleum system concept method instead of the play concept method to estimate petroleum resources (Magoon and Schmoker, 2000; Pollastro, 2007; Pollastro et al., 2013). Because particular emphasis is placed on the genetic similarities of petroleum fluids within a total petroleum system (Klett and Charpentier, 2003), the resource assessment values obtained by the USGS have become more reliable and can be are used by other agencies, such as the National Petroleum Council (NPC) and U.S. Energy Information Administration (EIA), as their base resource estimates. For purposes of assessment, oil and gas resources are commonly classified as conventional accumulations or continuous accumulations by USGS (Schmoker, 2002; Klett and Schmoker, 2002; Pollastro, 2007). Although continuous accumulations are defined by a set of geologic characteristics rather than specifically as unconventional accumulations (Schmoker, 2005), the term "unconventional" is now commonly applied (Olea et al., 2010; Cheng et al., 2013; Zou et al., 2012). Unconventional accumulations in tight reservoirs typically extend over large areas that are not influenced significantly by the water column (Schmoker, 2002; Pollastro, 2007); in contrast, conventional accumulations are hosted in a single structural or stratigraphic trap (Zou et al., 2013). Unconventional hydrocarbon resources (UHR) often have more potential than conventional hydrocarbon resources (CHR) (Gray, 1977; Masters, 1979). Based on the resource triangle concept (Gray, 1977; Masters, 1979), Cheng et al. (2013) estimated that the ratio of the total unconventional gas resources to total conventional gas resources in North America is approximately 4 to 1. Similarly, Zou et al. (2012) considered that the ratio of the total UHR to the total CHR in China is also about 4 to 1. However, these studies are only statistical analyses. Therefore, a case study of a given petroleum system assessment including UHR and CHR would be significant for understanding the ratio of UHR to CHR.

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Jimusar sag is located in the southeast of the Junggar Basin (Yang et al., 2004), north-western China (Fig. 1A). Previous studies showed that conventional oil (structural-lithologic accumulation) in the Jimusar sag is from the Late Permian Wutonggou formation (WF) and oil in-place potential to be added to reserves was up to 100 million tons (Wang, 2011, 2013). In 2012, a high yield commercial oil flow was obtained through reservoir volume fracturing in the first horizontal well (Well Ji 172_H) of the Middle Permian Lucaogou Formation (LF) in the Jimusar sag (Zhao and Du, 2012), resulting in a significant breakthrough for tight oil exploration in the basin, and commercial oil flows have been obtained from multiple wells during exploration in recent years (Kuang et al., 2012, 2013). Although the LF in the Jimusar sag is a set of high quality source rocks, the upper and lower tight reservoir sections (or upper and lower sweet spots) are developed as tight oil reservoirs (Zhao and Du, 2012; Kuang et al., 2013). Tight oil as unconventional oil is the realistic resource for recent exploration in Xinjiang Oilfield Company PetroChina (Zhao and Du, 2012; Kuang et al., 2013). Therefore, more and more evidences supported that the hydrocarbon source rocks of LF, tight oil reservoirs of LF and structural-lithologic reservoirs of WF formed an conventional-unconventional petroleum system (the Lucaogou-Permian petro-

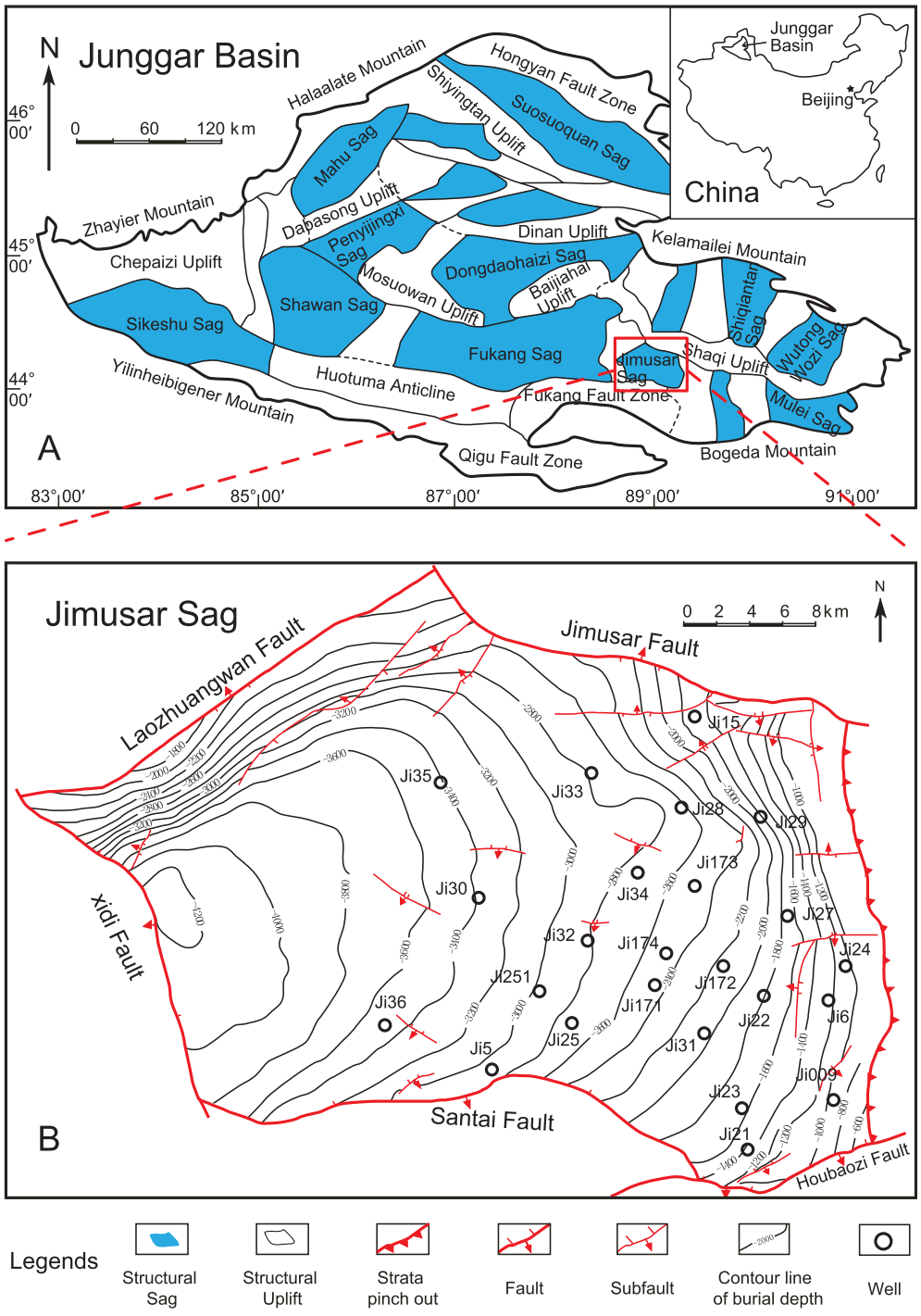

Fig. 1. Location and sketch geological map of the Junggar basin and Jimusar Sag. A: the primary uplifts and sags of the Junggar basin (modified from Yang et al., 2004); B: the structural map of the top of the Middle Permian Lucaogou Formation of the Jimusar Sag (modified from Zhao and Du, 2012).