



Original research paper

Discovery and geological significance of high quality hydrocarbon source rocks in interglacial of Neoproterozoic in the eastern part of the southern margin of North China

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Abstract

A conglomerate of glacial deposits from Neoproterozoic Sinian is generally developed in the southern margin of the North China Plate. However, whether the hydrocarbon source rock exists in a conglomerate of glacial deposits is still undeterminable as it has not been studied previously. The developmental characteristics of the conglomerate were systematically observed and measured. The conglomerate was subsequently divided into four sets, and the gray-black shale was discovered in between them. The said shale has the thickness of 36 m, 46 m, and 7 m, respectively from top to bottom. The study presents the highly-abundant organic matter in the shale, which belong to the high-quality hydrocarbon source rock. The organic matters are derived from lower organisms. The discovery of thick and high-quality hydrocarbon source rocks in conglomerates opens up new exploration areas for conventional natural gas, as well as provides a powerful basis for shale gas exploration. The dropstones that appeared in hydrocarbon source rocks and conglomerates are cogent evidence of glaciation. The findings provide an important guiding significance for the genesis of the conglomerate.

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Keywords: Southern margin of North China plate; Neoproterozoic; Moraine conglomerate; Hydrocarbon source rocks; Significance

1. Introduction

Due to petroleum exploration in deep zones and age-old formations, there has been increasing interest in Meso-Neoproterozoic hydrocarbon. Sinian gas reservoirs found in the Weiyuan and Anyue gas fields in the Sichuan Basin led to the successful discovery in the Proterozoic Erathem. North China was deposited with a complete package of Meso-Neoproterozoic formations that possesses large thickness. Although there have not been any economic hydrocarbon reservoirs discovered yet, Neoproterozoic oil discoveries in

the early 1980s in Yanshan and Liaoxi in the north [1–3] still indicate the existence of Proterozoic source rocks.

The studies of Meso-Neoproterozoic source rocks in North China began in the 1980s. The paper then mainly focused on the northern part of the North China Craton [4]. Proterozoic source rocks in the southern margin of the North China Craton have seldom been dealt with. The Liulaobei Formation within the Qingbaikouan System is taking shape in a continental shelf environment composed of greyish-green to dark grey mudstone with low TOC content ranging 0.01%–0.5%; the average TOC content is below 0.3% [5,6]. These source rocks were rated to be either of poor quality or as non-source rocks. As a result, there are no promising Proterozoic source rocks discovered yet in the southern margin of North China, where the Neoproterozoic Sinian Fengtai Formation occurs universally. The Fengtai Formation mainly consists of a glacial

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conglomerate known as Fengtai conglomerate. However, there is no certainty whether good source rocks exist in conglomerate strata since source rocks in conglomeratic tillite were not involved in preceding studies.

Fengtai conglomerate, a key bed in the southern margin of the North China Craton, extends westward from Huainan, Fengtai, and Huoqiu in Anhui Province in the east up to Queshan and Linru in He'nan Province, the North Slope of the Qinling Mountains in Shaanxi Province, Ningxia, Qinghai, Gansu, and finally to Xinjiang Province. The span is measured to be 2000 km [7]. As for North China, there may be a correlation between the middle and lower sections of phosphate formations designated by Ye [8]. In the early 21st century, a package of thick Cambrian source rocks was discovered to continuously overlie the Fengtai conglomerate in the southern margin of the North China Craton [9–13]. These source rocks and underlying conglomerate of more than 100 m in thickness sandwiched with shale were jointly entitled the Madian Formation [11]. Nonetheless, no research had been done on source rocks in conglomerate strata. Recent research findings of Proterozoic source rocks and biotypes in the North China Craton were gathered in "The Meso-Neoproterozoic Geology and Oil and Gas Resources in Eastern China" [14], but then this monograph did not cover the existence of source rocks in the Fengtai Formation in the southern margin of the North China Craton.

Our study of the Fengtai Formation, which outcrops in the Meishan section in the east of the southern margin of the North China Craton, was made through field observation and geochemical analysis. There were three packages of high-grade source rocks identified in the conglomerate strata, wherein two of which have large thickness. This discovery demonstrated the existence of high-graded Meso-Neoproterozoic source rocks in the southern margin of North China. The implication of the aforementioned is that it is plausible to find conventional gas and shale gas in new prospects. Mass drop pebbles were also found in the conglomerate and on source bed surfaces and served to be evident proof of the glacial origin of conglomerate; an issue that is currently in a controversy.

2. Samples and methodology

2.1. Samples

All the samples were acquired from the Meishan section in the east of the southern margin of the North China Craton. Unweathered samples were mostly extracted from the middle and upper thick source rocks in a newly operated quarry. The analogues obtained from the bottom of the section have been intensely weathered. Thus, they are purple in color for no rock materials have been mined for the time being.

2.2. Methodology

Geochemical analyses of source rocks were made by the Central Laboratory of Geological Sciences, RIPED, PetroChina. In accordance with the industry standard SY/T5238-

2008, organic carbon and T_{\max} were measured using carbon-sulfur analyzer and PyroLogger, respectively. The kerogen carbon isotopic composition was tested using Flash2000 and Delta Advantage. As for Biotype identification, it was performed by Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences. Mineral substances were first eliminated from the rock samples. Subsequently, the residual organic matter was used for microscopic identification.

3. Discovery of high-graded source rocks in the Fengtai conglomerate within the Meishan section

The Meishan section lies in the east of the southern margin of the North China Craton and the north side of the Dabie orogenic belt. The section is in Sishilichangshan region at the junction of Huoqiu County, Anhui Province, and Gushi County, He'nan Province, which is also the binding site of the North China Plate in a collision with the Yangtze Plate (Fig. 1). Thick conglomeratic tillite pervasively occurring under the Cambrian System was designated as the Fengtai Formation or Fengtai conglomerate [15]. This formation in Sishilichangshan is composed of greyish-black to greyish-purple conglomerate of medium to large thickness intercalated with thin greyish-purple marl and limy and argillaceous dolomite. Grey, greyish-purple, brown-yellow, and yellow-green shale occurs at the top and bottom of the formation. It is also worth noting that the thickness exceeds 150 m [15]. The Fengtai Formation had been taken as a region-wide key bed for an extended period of time, which may mainly be composed of conglomerate and not contain source rocks.

The mine was exploited in the last few years; thus, there is more about the Fengtai Formation to understand through the study of unweathered outcrops. We classified four packages of conglomerate in the region of interest, between which, three packages of source rocks were identified. Each package of conglomerate and source rocks was further divided into several layers (Fig. 2). Phosphate concretions are common in source rocks (Fig. 3) and mostly occur in layers 0–1, 11, and 14. The

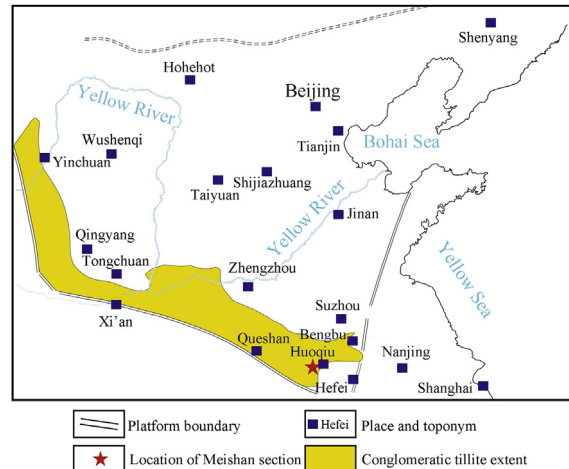


Fig. 1. Location of Meishan profile at the southern margin of the North China (the distribution range of glacial conglomerate according to Ye [8], 1983).

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