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Restudy of acid-extractable hydrocarbon data from surface geochemical survey in the Yimeng Uplift of the Ordos Basin, China: Improvement of geochemical prospecting for hydrocarbons

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Abstract

Two geochemical surveys were conducted in 1992 and 2000 respectively in the Yimeng Uplift of the Ordos Basin, China. The earlier survey grid had 1×5 km spacing and the later survey grid had 0.5×0.5 km spacing. The acid-extractable hydrocarbons of both surveys show similar geochemical trends. However, the anomalies obtained with traditional statistical methods do not correlate with existing oil/gas fields. This study reveals two problems in the data and their processing. The first one is interference caused by the variation of soil composition. We applied a wavelet-analysis-based method to eliminate this interference in the data of the later survey. The second is that micro-seepage anomalies did not identify existing oil/gas fields and seepage anomalies related with faults had not been previously recognized. We modified the logic multiplication cluster analysis and applied a multi-fractal model and a back propagation artificial neural network to recognize these two types of anomalies that cannot be recognized with typical statistics in the study area. The recognized seepage anomalies display a string-bead-shaped pattern and some are distributed along a large fault in this area. The fault is the main pathway for hydrocarbon migration. The micro-seepage anomalies are ring-shaped and are mostly distributed close to the fault. They coincide with oil/gas field and structure traps. Therefore, reprocessing of existing geochemical data using these new methods can greatly improve their usefulness in hydrocarbon exploration.

Keywords: Hydrocarbons; Geochemical exploration; Interference; Anomalies; Data processing

1. Introduction

The analytical method for acid-extractable hydrocarbons occluded in soils was developed in 1930s (Horvitz, 1939, 1972, 1985). Since then, this method has become common in surface geochemical exploration and plenty of data derived from it have accumulated throughout the world. However, it commonly suffers from the interference caused by variation of soil composition (Horvitz, 1985; Ruan and Cheng, 1991; Abrams, 2005). Because of this, some geochemical signatures are not considered to be distinguishable from background sediment signals with current methods used by industry (Abrams, 2005). This could be one of the many reasons why geochemical hydrocarbon exploration still remains an unconventional approach in the petroleum industry, although geochemical hydrocarbon exploration was systematically studied back in 1929 (Davidson, 1994; Saunders et al., 1999). To improve the application of these data to hydrocarbon prospecting, we have studied the data-processing methods since 1990s, which include interference elimination and anomaly recognition. Although the methods for anomaly recognition were developed on the basis of typical statistics (Zhang, 1993; Zhang and Liao, 1998), they sometimes cannot be used because the data do not meet the prerequisite of typical statistics (normal distributions of

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multi-population) or cannot be separated into background and anomalies by probability graph. This paper presents a case study in the Yimeng Uplift of the Ordos Basin in central China, which involves undefinable anomalies because the anomalies cannot be properly recognized with traditional statistic methods. To solve this problem, we applied a wavelet-analysis-based method (Zhang et al., 2003) for interference elimination, employed the multi-fractal model (Cheng et al., 1994; Cheng, 1999) for univariate recognition, improved logic multiplication cluster anlysis and utilized back propagation artificial neural network (Zhang and Bai, 2002) for multi-variate anomaly recognition in this paper, and achieved a better result than previous studies. This paper illustrates that the integrated application of these new methods can greatly improve the predictive capability of the existing data.

2. Background and previous work

The Ordos Basin is situated in central China, limited by latitudes 34:00°N–40:35°N and by longitudes 106:50°E to 111:10°E, with an area of 250,000 km^2 (Fu et al., 2001). It is divided into six structural units: Yimeng uplift, Weibei uplift, Western edge thrusting belt, Jinxi flexural fold belt, Tianhuan depression and Shanbei slope. Three giant gas fields, Jingbian in Ordovician carbonates, Yulin and Suligemiao in Lower Permian clastics, have been found on the Shanbei slope. The study area is located in the Yimeng Uplift and lies north of the Yulin Gas Field (Fig. 1).

The basement of the Ordos Basin consists of Archean and Proterozoic metamorphics and the sedimentary cover is composed of Paleozoic to Cenozoic sequences (Yang et al., 1992; Ritts et al., 2004; Fig. 2). Beneath the Ordovician weathered crust are cryptite, algae-bearing dolomite, pelitic limestone and shale, which have a thickness of 50–500 m. The Ordovician rocks are widespread across the basin (Fu et al., 2001).

Due to depositional hiatus and erosion, the Upper Ordovician to the Lower Carboniferous sequences is not preserved in the basin (Fig. 2). The Carboniferous contains marine and non-marine clastic rocks and carbonates, and the Permian is dominated by non-marine clastics. The

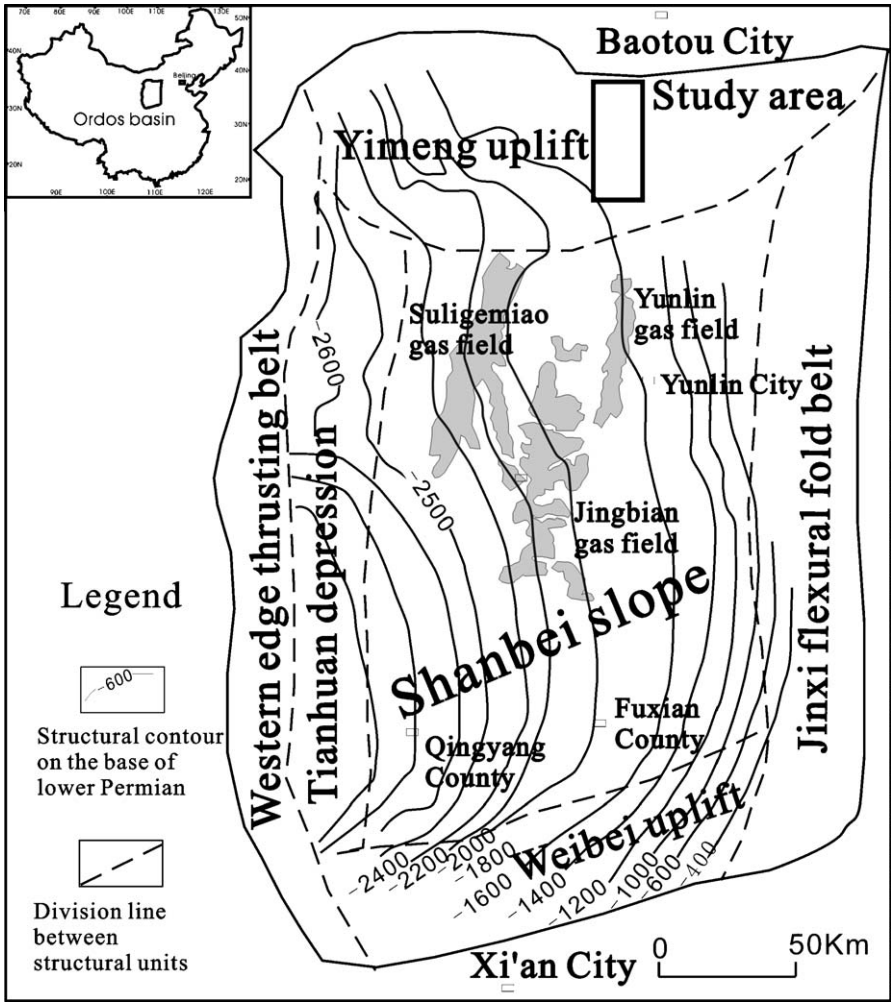

Fig. 1. Structural contour to the base of Lower Permian (in meters below sea level) of the Ordos Basin as well as the location of the study area (after Zhang and Chang (2002)).