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Application of CSAMT to oil shale exploration in Tongchuan area of Ordos basin, China

Chunguan Zhang

School of Earth Sciences and Engineering, Xi'an Shiyou University; Department of Geological Sciences, University of Saskatchewan; chunguan.zhang@usask.ca

Bingqiang Yuan

School of Earth Sciences and Engineering, Xi'an Shiyou University; yuanbingqiang@sohu.com

Yuhong Li

Xi'an Center of Geological Survey, China Geological Survey; 929726833@qq.com

Summary

In order to investigate the distribution rules of oil shale in Tongchuan area of Ordos basin, four CSAMT (Controlled Source Audio-frequency Magnetotelluric) profiles were completed in the early 2011. Two-dimensional apparent resistivity profiles were derived by terrain correction, regularization filtering method, and high-pass filtering of the anomalies in the apparent resistivity. In this paper, we combine the existing geological and geophysical data with the inverted features of the unfiltered and high-pass filtered apparent-resistivity anomalies. We also examine the relationships between the high-pass filtered apparent-resistivity anomalies and the distribution of oil shales in three available drillings, and discuss the distribution of prospective areas for oil shale in the study area. The results show that there is a close relationship between the oil-shale distribution and a belt of high magnitudes of the high-pass filtered anomalies of the apparent resistivity. Two prospective areas with different depths for oil shales are identified within the study area.

Introduction

Oil shale represents a dense organic-rich sedimentary rock with kerogen ash content of 33%, which is a form of an unconventional oil and gas reservoir (Li et al., 2012; Wang et al., 2016). Through processing similar to that for natural light petroleum (hydrocracking, extraction, and refining) getting gasoline, kerosene, diesel, paraffin and other chemical products are obtained from oil shale (Wang et al., 2014). Tongchuan area in southern Ordos basin is one of the regions that have the most abundant oil shale resources in China (Li et al., 2016; Wang et al., 2016). In this area, the Triassic Yangchang formation is considered as the greatest potential layer for oil shale exploration (Bai et al., 2010; Li et al., 2016; Sun et al., 2011; 2015; Wang et al., 2016).

Geological Setting

The Ordos basin is a polycyclic petroliferous sedimentary basin formed from a cratonic platform in the western Chinese Mainland and has stable subsidence and obvious migration and twisting of sags (Yang and Pei, 1996; Yang et al., 2005). The study area is located in the northern part of the Weibei uplift in the Ordos basin. The Weibei uplift is connected with the North Shaanxi slope in the north, is adjacent to the Jinxi flexural fold belt in the east, and borders the western margin of therust structural belt in the west (Fig. 1). The Mesozoic and Paleozoic formations in the study area are extremely gentle monoclines (Yuan et al., 2016). Apart from a few regions, the dip is generally less than 1° to the west and there are no large-stress structures or faults (Zeng and Li, 2009).

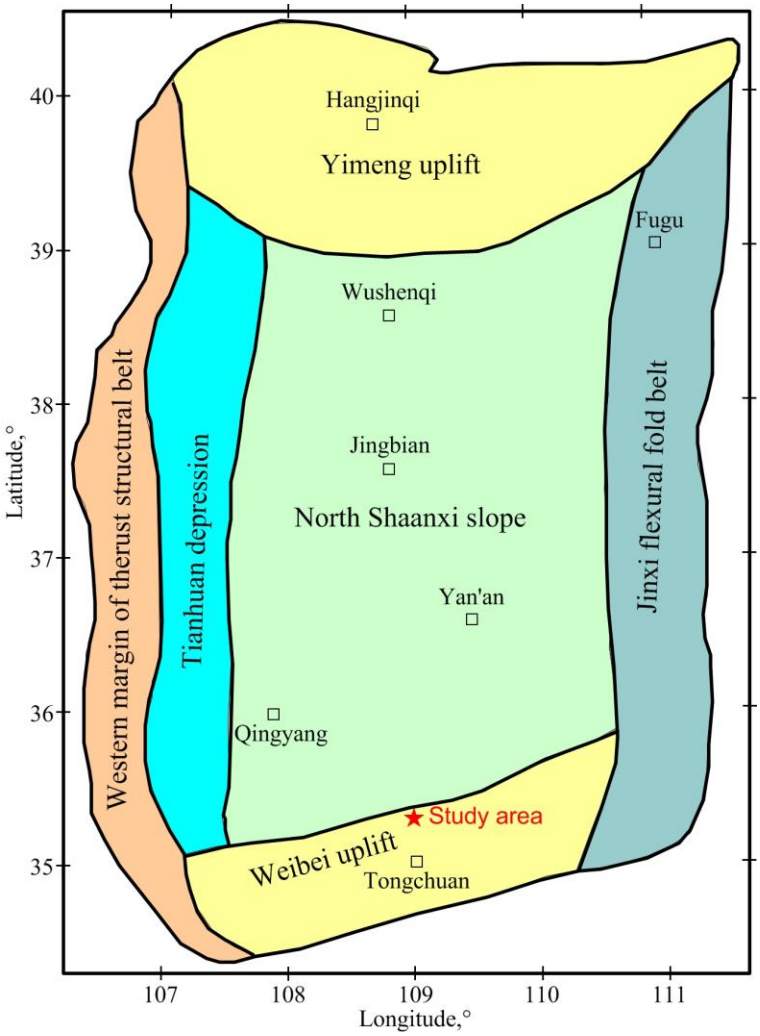

Fig. 1 Tectonic sketch of Ordos basin and location of study area (red star).

Data and Processing Techniques

The four CSAMT profiles of this study were collected by Xi'an Center of Geological Survey, China Geological Survey from April, 2011 to June, 2011 in Tongchuan area of Ordos basin. In order to analysis the relationship between the apparent resistivity anomalies and the oil shale distribution, the authors also collected three drillings.

Because there is a close relationship between the 2-D apparent-resistivity anomalies and the terrain, we first calculated the values of the terrain effect and then produced the final apparent-resistivity anomalies. In this paper, the regularizated filtering technique was used to extract the high-spatial frequency anomaly of the apparent resistivity. By processing the results obtained by repeated analyses using varying filter windows, the filter window with a geometric scale of 400 meter was chosen as the best and used in subsequent interpretation.

Features of the Apparent-Resistivity Anomalies and their Geological Significance

The cross-sections of the high-pass filtered anomalies of the apparent resistivity show that the apparent-resistivity anomalies are characterized by pronounced subhorizontal belting (Fig. 2). The high-pass filtered

anomalies in Lines 1, 2 and 4 show a good lateral continuity, whereas the lateral continuity within Line 3 is poorer than in the other lines.

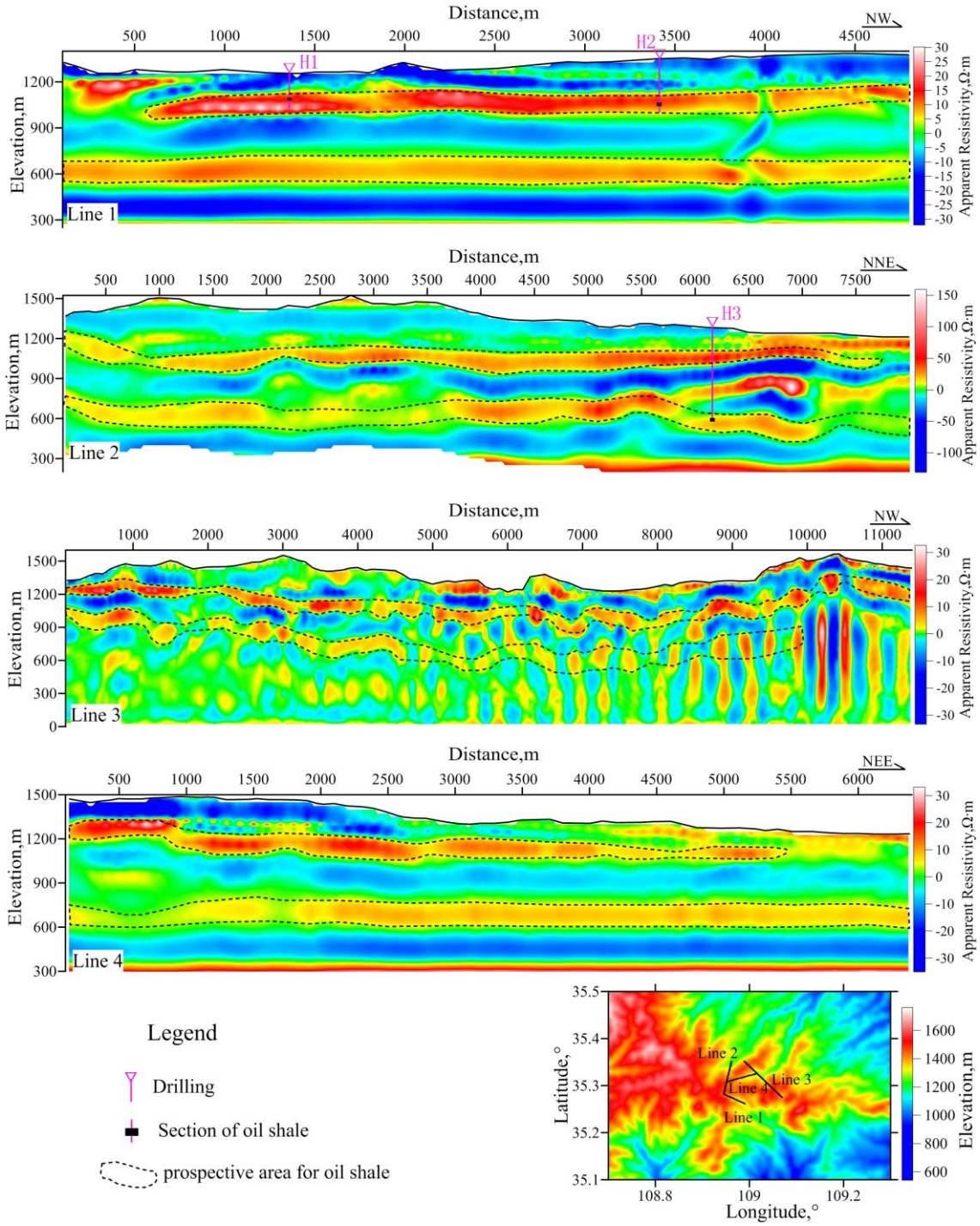

Fig. 2 High-pass filtered anomallies within the four apparent resistivity profiles of CSAMT for 2-D inversion. A filter with 400-meter geometric scale was selected.

The profiles of Lines 1 and 2 show that the locations of oil shales in the available three drillings correspond to the high values of the high-pass filtered anomalies (Fig. 2). Based on this relationship between the presence of oil shale and the high-amplitude belts of the high-pass filtered anomalies of the

apparent resistivity, two prospective areas with different depth for oil shales were predicted in these four profiles (dotted contours in Fig. 2).

Conclusions

(1) There is a close relationship between the oil shale distribution and the high-amplitude belt-like features in the high-pass filtered anomalies of the apparent CSAMT resistivity. The sections of oil shale of these three drillings correspond to high value of the high-pass filter anomalies.

(2) Based on the above observation, two prospective areas with different depth for oil shales are identified in the study area.

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