A New Thick-Skinned Structure Model for the Kedo Thrust Belt in the West KunLun Mountains, Tarim Basin, Northwestern China*

Jianwei Zhang[1], Guizhong Wang[1], Peiling Ma[1], Bo Xu[1], Xiangzhou Zeng[1], and Xin Luo[1]

Search and Discovery Article #30274 (2013)
Posted June 30, 2013

*Adapted from extended abstract prepared in conjunction with poster presentation at AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013

[1]BGP inc., CNPC, China. (keltb@163.com)

Summary

Kedo thrust belt, located in the transition zone of West Kunlun piedmont tectonic belt in Tarim basin, has long been considered to be a passive-roof duplex belt, similar to the Alberta-style. By using new seismic data acquired by "wide line + big combination", in combination with large amounts of information of three-dimensional non-seismic geophysics, drilling, outcrop, field survey, and digital sand-box simulation results, we propose a new tectonic model. In this model, the Kedo thrust belt is interpreted as thick-skinned structure, and faults are considered as mainly a basement-involved type of anti-listric fault which has a steep dip in the lower portion and gentle dip in the upper portion. The fault displays positive flower structure, is asymmetric, and gradually dies-out in the shallow strata. The main deformational feature of Kedo is a strike-slip thrust structure.

Introduction

The West KunLun Mountains are located in the northern edge of Tibetan Plateau, and the southern edge of Tarim Basin (Figure 1).The uplift of Tibetan Plateau in the Late Cenozoic has been a series of intense movements, which are still active. Under a nearly north-south strongly compressive stress field, Kedo structural belt, with severely deformed formations defining its complex structure, is located in the middle of the West Kunlun Mountains. Conditions for oil and gas geological are relatively good.

Since 1977, Kky oilfield has been found in the forebulge parts . However, during thirty years or more, prospectors drilled in the Kedo periphery but without success. The reasons for failure are given below. Firstly, it is because the surface is huge thick Quaternary, loose loess cover and the underground structure is very complicated, which affected the seismic acquisition, resulting in poor quality of the seismic data. Secondly, petroleum explorationists always use the passive roof duplex structure model to guide the seismic interpretation, but the drilling results are often very different from prospectors' predictions. Perhaps, they have incorrect knowledge of the geological structure.

Surface Geological Outcrop

From the West Kunlun Mountains fold belt to the edge of Tarim Basin (Figure 2), it gradually changes from metamorphic basement to Carboniferous, Permian, Jurassic, Cretaceous, Paleogene, Neogene, and Quaternary strata. Basement metamorphic rocks are distributed extensively from east to west, but the strata change significantly laterally (horizontally) in association with large N-S strike-slip faults .Mesozoic and Cenozoic strata are distributed sporadically, with poor east-west continuity and variable dip, also in association with the N-S strike-slip faults. Large overthrust faults separate basement metamorphic rock from Paleozoic strata, and these faults along the orogenic belt extend in straight pattern. These features illustrate that old strata along high-angle faults are present at the surface without the occurrence of laterally extensive overthrust nappe. Surface characteristics indicate that the Kedo region developed the E-W-trending steeply dipping thrust faults and the N-S-trending strike-slip faults.

Non-seismic Geophysical Profile Characteristics

Some advantages in non-seismic geophysics are: large detection depth, strong penetration ability and Littel surface's effect on acquisition. Non-seismic has a certain guiding value to distribution of faults and strata, which are especially suitable for Kedo area. Correspondingly, we launched a 3D-magnetic-power-integrated exploration. In the north-south non-seismic profile, there is a marked change in impedance between southern old formations and the northern young formation (Figure 3). It reflects that there is high-angle fault contact between the basin and the mountain. We also find that east-west non seismic profile shows an apparent vertical anomaly (Figure 4), which is thought to reflect strike-slip fault zone (Figure 5), which coincides with its outcrop expression.

Comprehensive Interpretation of Seismic and Non-seismic Data

During the past decades, many scholars have considered the Kedo thrust belt to be a passive-roof duplex, similar to the Alberta-style (the thin-skinned triangle model). This model is widely and successfully used in the gas and oil exploration of Kuqa depression, northern Tarim Basin. However, our study shows that the Kedo thrust belt is quite different from the Alberta Style: (1) the deep strata experienced several deformational stages; thus, the strata were strongly faulted and fractured; (2) the anhydrite beds in the middle of the stratal sequence is only 0-100 meters thick, and its plasticity is poor; (3) the younger strata, restricted in distribution, contain faults; (4) outcrops are randomly distributed. In addition, the thin-skinned triangle model is not consistent with drilling, outcrop, new seismic, and other data; therefore, the thin-skinned triangle model should not be applied in Kedo thrust belt.

By using the seismic data acquired by wideline and large array after 2007, in combination with large amounts of information from drilling, outcrop, field survey, digital-sand-box simulation, three-dimensional modeling, and digital outcrop technique, we propose a new tectonic model. As shown in Figure 6, in this model, the Kedo thrust belt is interpreted as thick-skinned structure, and faults are considered as mainly basement-involved type of anti-listric fault, which has a steep dip in lower part and gentle dip in upper part. The fault displays positive flower structure, is asymmetric, and gradually dies-out in the shallow strata. The major differences between the viewpoints of this study and other interpretations include: (1) the fault is interpreted to have affected the basal Cenozoic strata and cuts the shallow formations, rather than serving as a passive roof detachment fault paralleling the shallow strata; (2) steep-dip, rather than gentle-dip, faults might have occurred in the deeply buried strata. Strike-slip faults perpendicular to the structural trend are well developed. The Kedo thrust belt is divided into several secondary tectonic belts from east to west by strike-slip faults. Based on the new structural model, Kedo #1 condensate gas reservoir was discovered in 2010.

Conclusion

- The Kedo thrust belt is basement-involved thick-skinned structure, not similar to Alberta-style model (the thin-skinned triangle model).
- The main deformational feature of Kedo is a strike-slip thrust structure. It combines the structural styles of both foreland compression and a lateral displacement parallel to strike of fault.

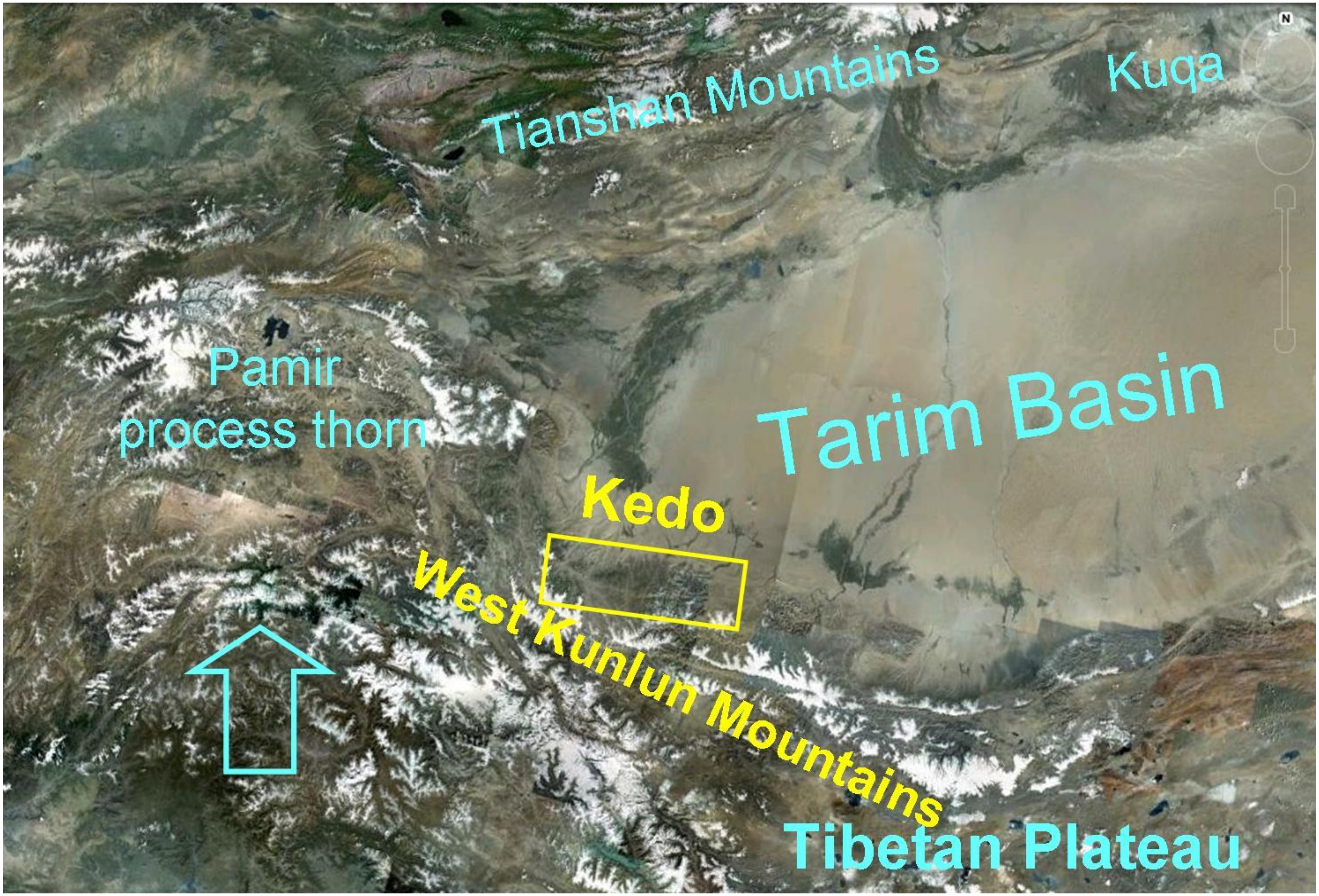

Figure 1. Location map of Kedo thrust belt.

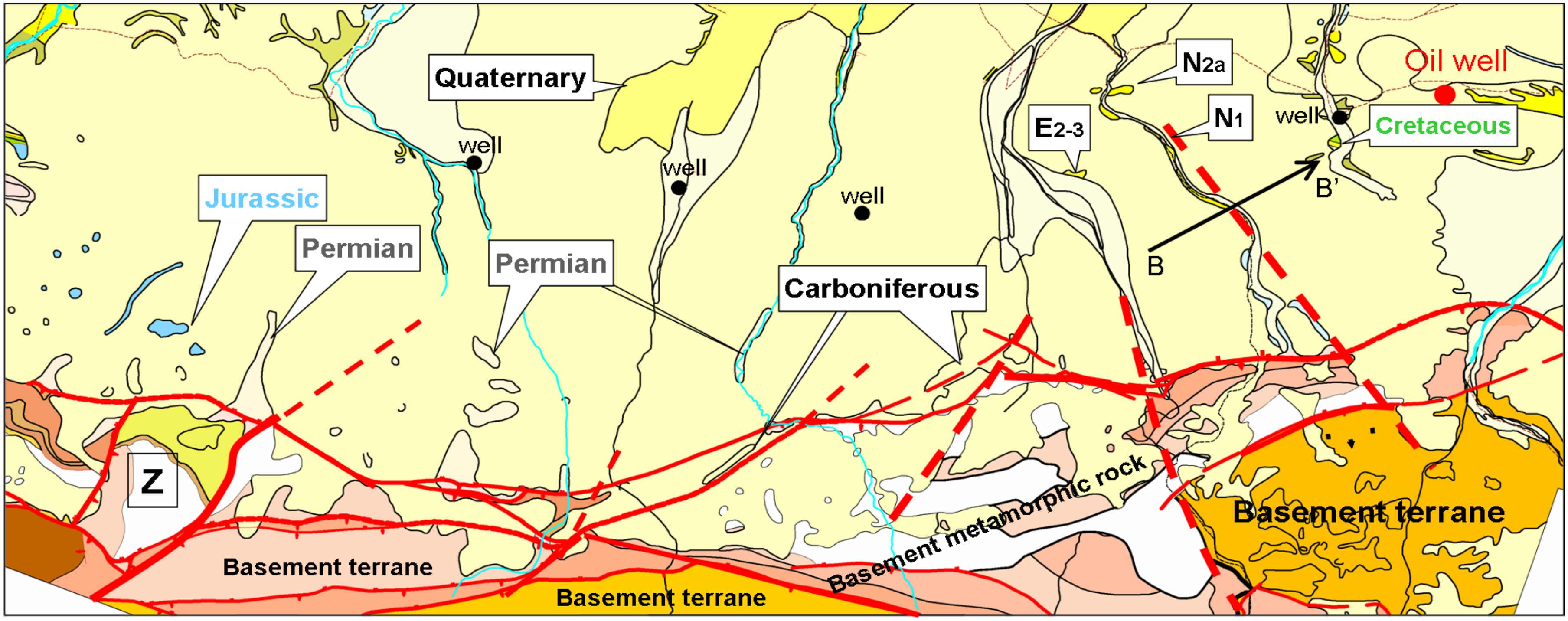

Figure 2. Generalized geologic map of Kedo area.

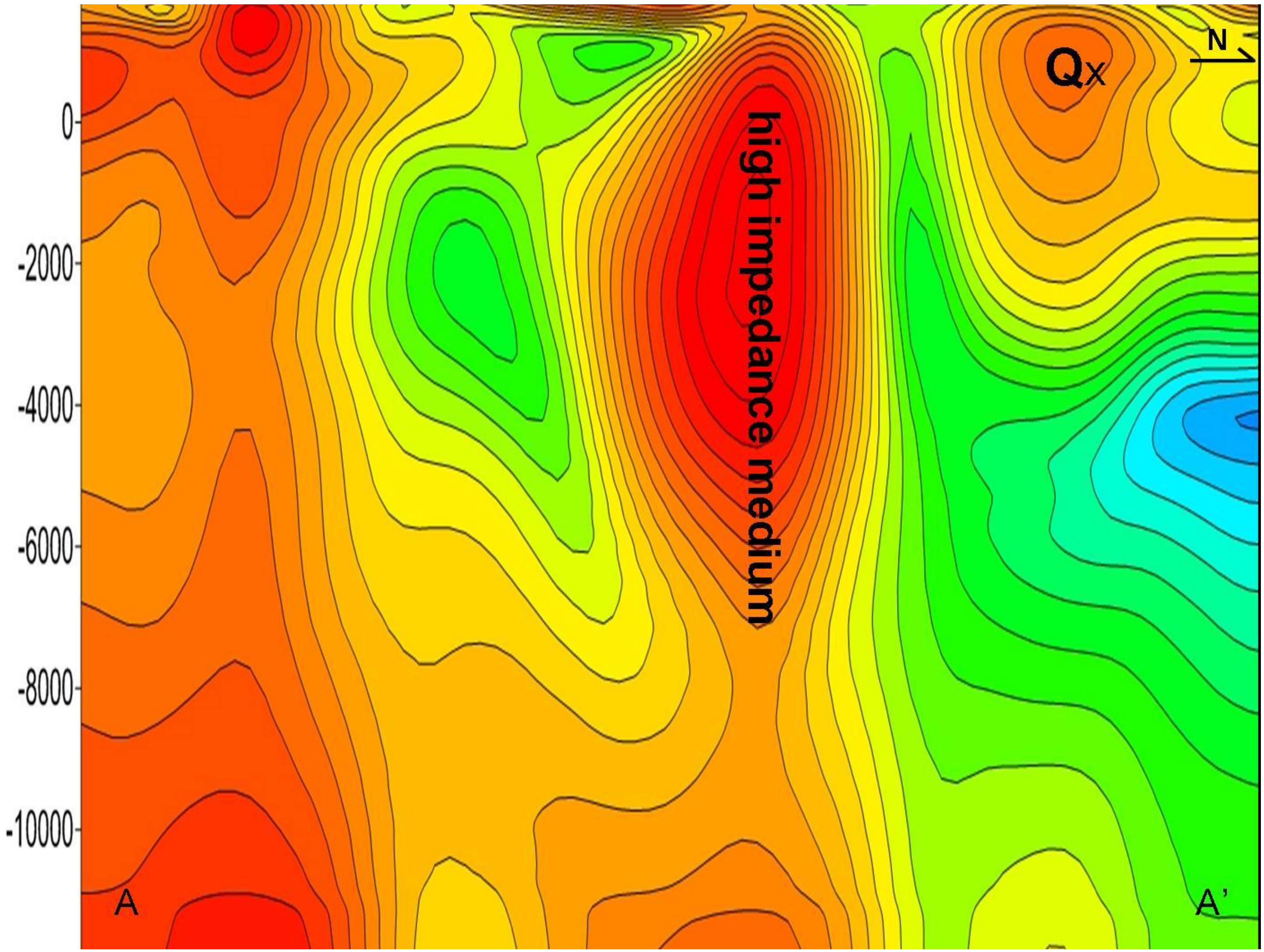

Figure 3. N-S 3D non-seismic (magnetic anomaly) profile.

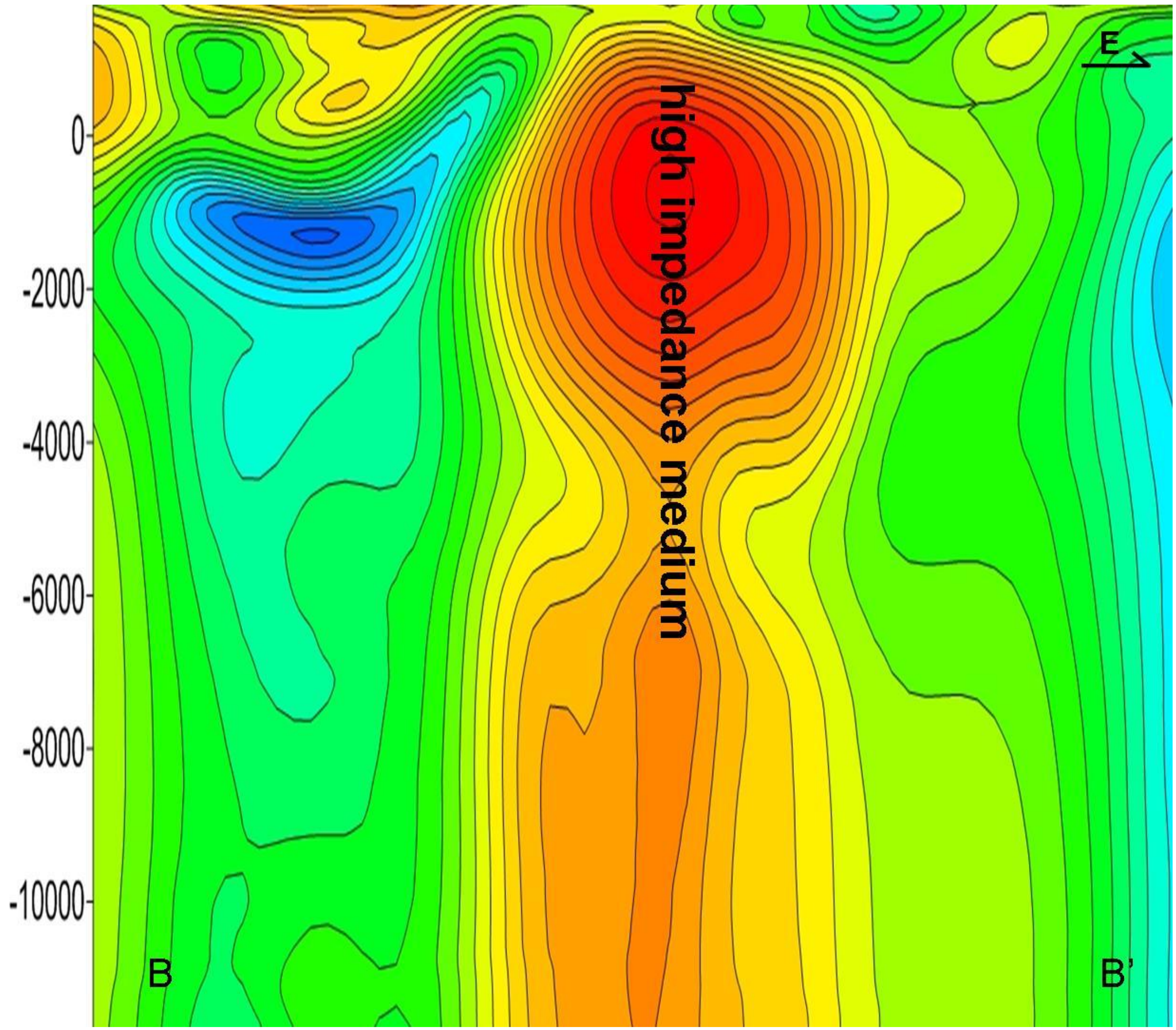

Figure 4. E-W 3D non-seismic (magnetic anomaly) profile.

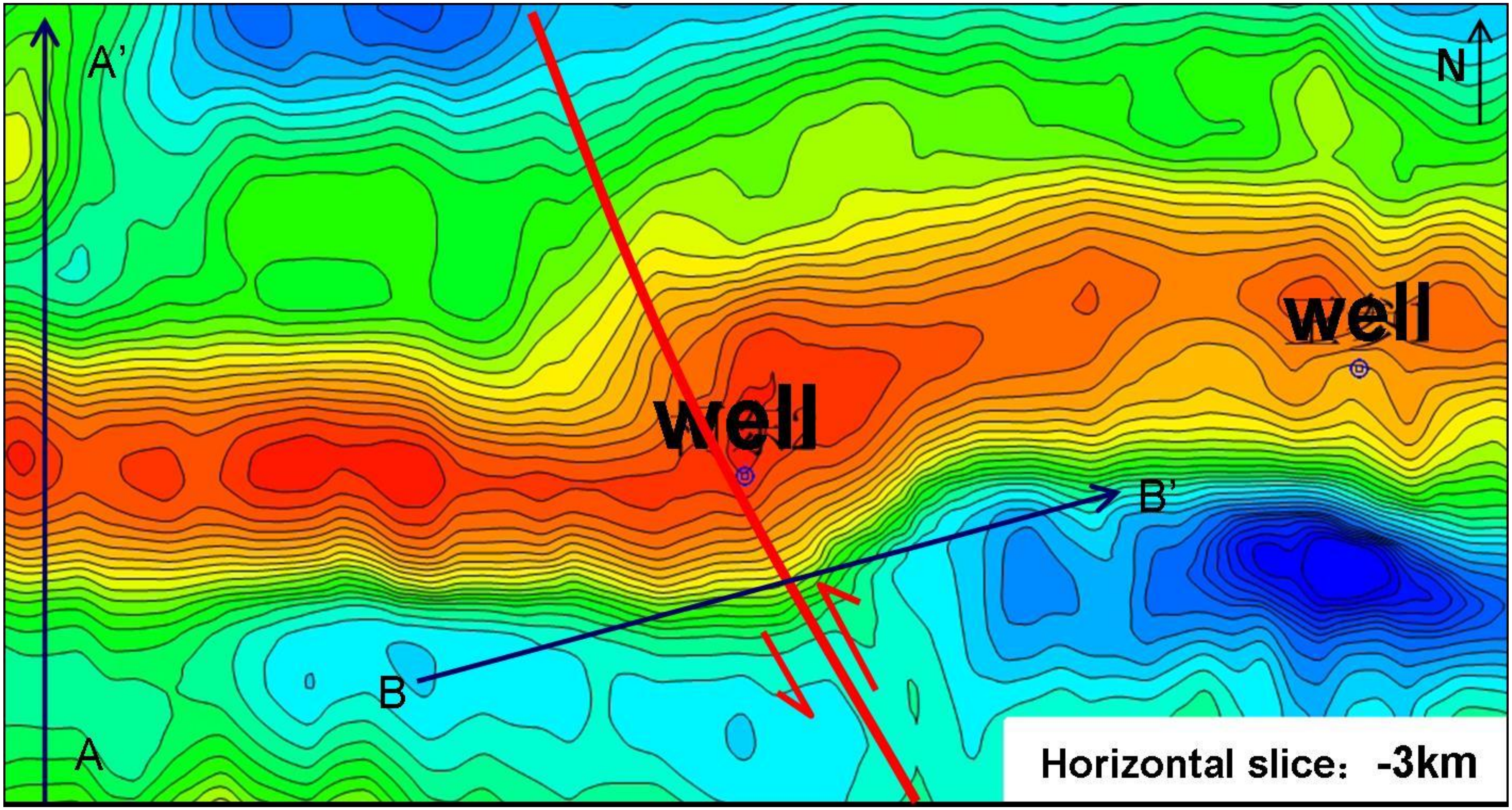

Figure 5. Horizontal slice map of 3D non-seismic (magnetic anomaly) data, reflecting the location of strike-slip fault. Location of profiles are shown.

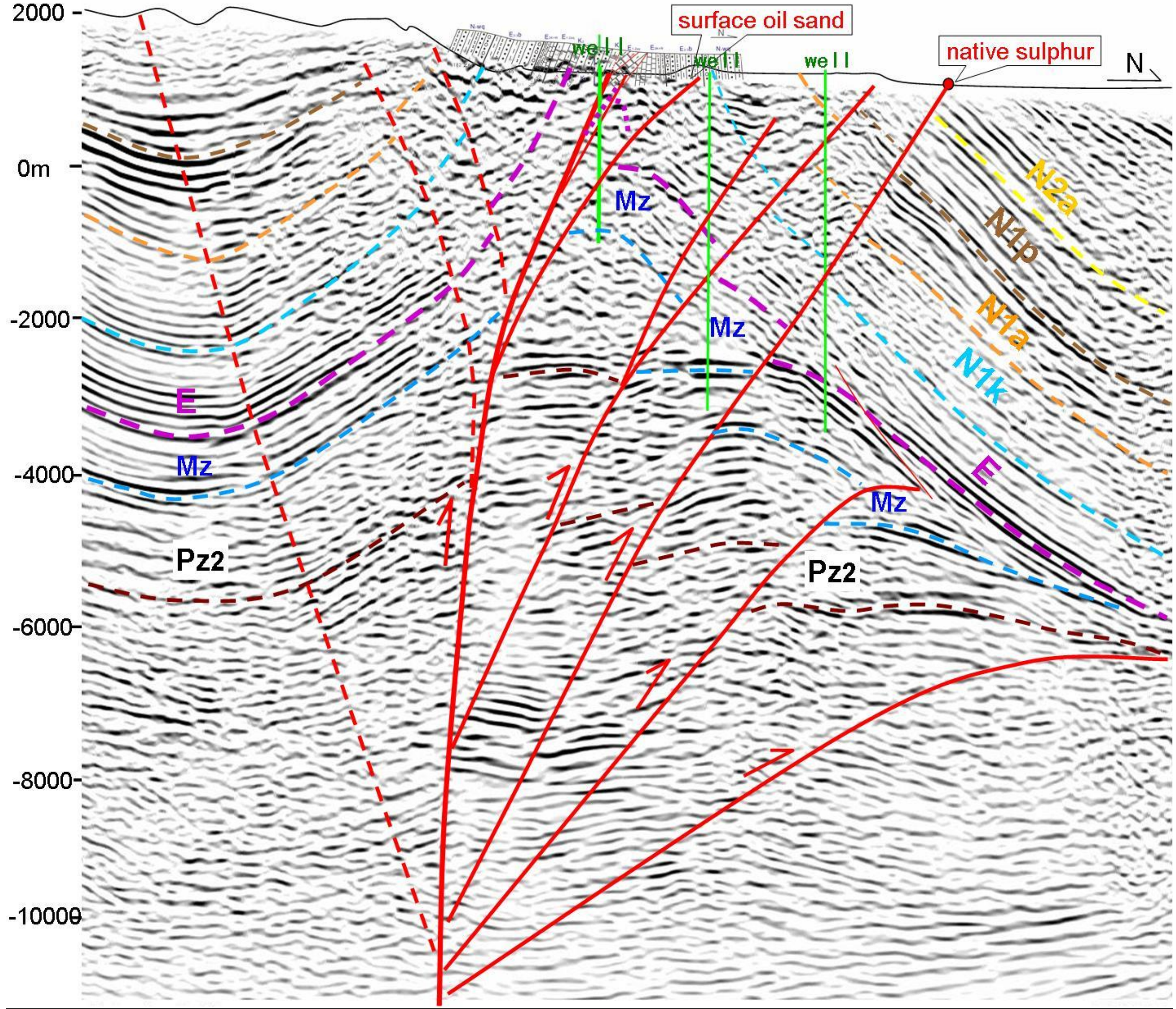

Figure 6. Typical N-S seismic profile from 3-D survey, with interpretation from integration of various data types.