

The First Application of TFEM Method in Gas Production Monitoring

Wang Zhigang¹, Liu Xuejun¹, Zhang Lin¹, and Tang Biyan¹

¹BGP, CNPC, Zhuozhou, Heibei, China.

ABSTRACT

Enhancing oil recovery and reducing cost become more and more important for oil companies, especially under the current low oil price circumstances. Core testing results show that electrical resistivity changes significantly as oil-gas-water saturations change, which makes electromagnetic techniques promising for reservoir monitoring. Time frequency electromagnetic (TFEM) method is a patented technology of BGP which has already been used in oil and gas appraisal. This paper elaborates a pilot project of using TFEM to monitor gas production in one of the oil fields in west China. Three TFEM lines have been deployed. Each line goes right through 2 production wells and one source covers all of these 3 lines. The first measurement acquired nearly perfect data, the SN ratios of electrical data are greater than 5000 while the magnetic data are greater than 87. We then use these data to conduct both free and constrained inversions to obtain the resistivity profile of the reservoir. The free inversion result shows a low resistivity anomaly around the water gas contact, but its depth is smaller than the known reservoir. To improve the accuracy of the depth inversion, we conduct model constrained inversion. The initial model is based on seismic and logging data. For the formations above the reservoir, the thickness and initial resistivity are defined by seismic and logging data respectively. For the formations inside and below the reservoir, the thickness and initial resistivity are not given in the initial model. The inversion result also shows that there is a low resistivity anomaly presents below the reservoir where the wells already producing water. According to the result, we can roughly determine the vertical distribution of water and gas, however, the accuracy can't meet the requirements for gas production. To further improve the inversion accuracy, whenever there is a TFEM line goes through a production well, we use the well resistivity logging data as constraints. We call it "well constrained inversion". The results which show further vertical accuracy improvement can be used to identify the distribution of water and gas by resistivity variation. The first data acquisition has already completed, and the second one is planned to do in 2018. By calculating the difference between the two measurements, information about water gas contact uplift and the distribution of water and gas can be obtained.