Advanced Progress of TFEM Method for Hydrocarbon Identification

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ABSTRACT

There is often a high expectation for electromagnetic (EM) method to identify hydrocarbon target, especially in geologically complex areas. To meet such challenges, we have developed the time-frequency EM method. In the paper, a new way of data processing, constrained inversion using logging-seismic model, is developed and discussed, which is used to build the resistivity and polarization models. Some examples are illustrated to present the major functions of TFEM method is directly to detect the hydrocarbon reservoir. The time-frequency EM method (TFEM) that consists of high-powered controlled source (up to 300 kw power and 150A constant transmitting current, high-rate full waveform sampling receivers (130 dB dynamic range and up to 100 times stacking), and advanced data processing to extract both time-domain and frequency-domain responses for high signal-to-noise broadband data. The TFEM method is based on LOTEM (Long Offset Transient Electromagnetic) and CSAMT (Control Source Audio Magnetotelluric) methods. The system uses artificial source, thus there is no static shift, and the vertical resolution is high. Simultaneous observation of electric and magnetic fields can improve the resolution to thin resistive formation. Several parameters, resistivity, vertical conductivity and induced polarizability, can be integrated during the data interpretation stage. In addition, induced polarization (IP) data are also extracted in the time domain. The data are interpreted using joint inversions for electrical conductivity and IP chargeability that incorporate structure information from seismic imaging and well logs and yield quantitative evaluation of potential hydrocarbon reservoir targets for drilling. Results from the applications in several hundreds of exploration examples have shown that TFEM can predict favorable targets and either high-grade or de-risk targets to achieve effective drilling programs. We will then focus on two aspects: one is the method of constrained inversion using logging-seismic model, another is the effectiveness of TFEM in identifying and evaluating hydrocarbon traps. We conclude the presentation by discussing the applicability and limitations of the method. TFEM is an effective approach to identify petroleum targets and reduce exploration risks. The method can serve as a fast and cost-efficient way to predict favorable areas. Judicious and reasoned use of TFEM can lead to significant benefits in the hydrocarbon exploration.