Effects of the Airwave in Marine CSEM for Various Source Receiver Orientations

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Abstract—

Introduction: In Controlled Source Electromagnetics (CSEM) in a marine environment, one is interested to detect resistors, e.g., hydrocarbon reservoirs, in the subsurface. However, the recorded signal is strongly affected by the energy which is refracted at the water air interface and travels through the air. In processing one wants to eliminate this airwave from the data. Different approaches, including modeling and adjacent subtraction [3], wavefield decomposition [1] or interferometry [6], exist. Another option is to use a setup of vertical sources and receivers. In this situation, the airwave is completely absent. CSEM with vertical sources and receivers is provided by the Norwegian company Petromarker [2]. Due to currents, sea bed topography and other effects, it is quite difficult to manage a perfect vertical orientation of sources and receivers. The effects of imperfect verticality are investigated in this research.

Method: 2.5D Electromagnetic fields in a halfspace of water below a halfspace of air are modeled analytically in the Laplace-space domain for all nine source receiver pairs [4]. Adjacent the data is transformed to time domain using the Gaver-Stehfest algorithm [5]. The source, which is located in the water, is a point source in space and time. The nine datasets (three source orientations times three receiver orientations) are geometrically combined at one time step to form a field created by specific, independent orientations of source and receivers.

Results: The airwave alters the data only if both, source and receivers, are tilted in either inline and/or crossline direction. A tilt in the source, but complete verticality of the receivers, does not produce any effects of the airwave or vice versa. Consequently if one of the two, either source or receivers, can be kept in almost perfect verticality, a tilt in the other one can be accepted, because the effects of the airwave are still minimal. Tilts in crossline direction seem to be more severe than in inline direction.

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