Shallow Drilling Hazard Identification Using Multi-Physics Data

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Abstract

Shallow drilling hazard pose a significant challenge for the health and safety of the personnel and for the effective business continuity. Arid regions are particularly prone for dissolution of the formation causing shallow cavities also known as sinkholes. These features can be karstic voids or partially or fully filled with sediments carried by the circulation of water depositing rubbles deriving from the roof collapses of the hosting rock formations. Such structurally weakened features may have stationary stability but can rapidly deteriorate during drilling operations due to extended weight, vibration and more importantly high-pressure circulation drilling fluids. This can produce washouts triggering sudden collapse of the cavity that place rig operations at risk. These types of weakened ground can be identified as they create significant alteration signatures for the elastic, permittivity and electrical resistivity properties as well as measured surface gravity due to reduced rock mass. High-resolution geophysical surveys can map these anomalous zones that could develop into a stability problem for early detection and mitigation of the drilling hazard. We investigated the efficiency of various multi-physics methods in different locations for different geological settings in arid regions where drilling operations encountered stability problems due to shallow cavities. Proprietary seismic data analysis for transmitted pressure (P) waves, multichannel analysis of surface waves (MASW), electric resistivity tomography (ERT), low frequency ground penetrating radar (GPR) and microgravity surveys were applied to evaluate the sensitivity of different geophysical techniques for different shallow drilling hazards. Results were ranked and a set of specifications and guidelines were generated for investigation of the new drilling locations in arid geology. The analysis also addresses the trade off between the depth of investigation, resolution and area of interest for zonation mapping. Among all methods microgravity surveys stand out to be the most effective method to detect weakened zones due to mass deficiency while some empty and filled cavities may have different resistivity and velocity signatures.