AAPG Datapages/Search and Discovery Article #90319 ©2018 GEO 2018 13th Middle East Geosciences Conference and Exhibition, Manama, Bahrain, March 5-8, 2018

Microgravity Investigation for Drilling Hazards in the Eastern Province of Saudi Arabia

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ABSTRACT

The geology of the Eastern Province of Saudi Arabia consists predominantly of carbonate rocks. While the region is currently arid, past rains led to the development of numerous karst structures in carbonate or evaporitic formations in the near-surface, which present a hazard to urban development, drilling, and oil and gas infrastructure. One of the traditional means of mitigating this risk is to drill shallow boreholes to detect the karsts, however this may not provide adequate information to characterize the subsurface. There are a number of geophysical techniques that can be used to characterize the near surface for detecting karst structures including microgravity, shallow resistivity, surface wave analysis and ground penetrating radar. Microgravity is appealing since it directly measures the missing mass associated with karsts, reducing the need for modeling and interpretation. The method has the additional benefit that the depth of investigation and data quality are unaffected by surface conditions which can adversely affect resistivity and ground penetrating radar investigations. High precision microgravity data was acquired using a CG5 gravity meter over the site of a sinkhole in eastern Saudi Arabia that developed during drilling operations. The data covered a 12.5 by 12.5 m grid with a 1 cm tolerance in x, y and z coordinates. The success of these investigations however depends on carefully executing field procedures and on detailed topographic corrections. To overcome these challenges we use a gravity reduction method where the Bouguer and terrain corrections are performed through 3D forward modeling of detailed digital topography derived from Geoeye-1 and vehicle based LiDAR data. The Bouguer density used in the corrections is found through a minimization procedure based on the Nettleton method. The resulting gravity anomaly successfully images a mass deficiency in the vicinity of the sinkhole suggesting the method could be used to mitigate future drilling hazards.