Seismic Detection Of Subsurface Karst-Like Structures

10.5339/qfarc.2014.EEPP0551

Roland Gritto, Ph.d.; Valeri Korneev; Elnaiem Elobaid; Fathelrahman Mohamed; Fadhil Sadooni

Corresponding author :
roland.gritto@arrayinfotech.com
Array Information Technology, Berkeley, United States

Abstract

Karst is ubiquitous on the peninsula of Qatar, including depressions, sinkholes, and caves. Aerial reconnaissance indicates that the widespread depressions, sinkholes, and caves reveal NE-SW and NW-SE orientations, similar to the joint and fracture systems. Faulting and fractures play a major role in the development of karst, where fluids find pathways through limestone and dissolve the host rock. The resulting fissures may grow larger as more surface water is funneled through to form cavities or karst. Sinkholes may also form, when cavern roofs collapse, and it is this last characteristic that is of concern to rapidly growing metropolitan areas, that expand in heretofore unexplored regions. Qatar has seen a recent boom in construction, including the planning and development of complete new sub-sections of metropolitan areas. Before planning and construction can commence, the development areas need to be investigated to determine their suitability for the planned project. Of particular concern to construction projects are ubiquitous karst features that are prone to collapse, particularly when surface loading is increased due to construction. In this study, we present a spectral-based analysis to seismically detect the presence of karst-like subsurface void in Doha, Qatar.

Seismic waves are well suited for karst detection and characterization. Voids represent high-contrast seismic objects that exhibit strong responses due to incident seismic waves. However, the complex geometry of karst, including shape and size, makes their imaging nontrivial. While karst detection can be reduced to the simple problem of detecting an anomaly, karst characterization can be complicated by the 3D nature of the problem of unknown scale, where irregular surfaces can generate diffracted waves of different kind. In our current project we use an innovative approach to detect and characterize subsurface voids by spectral seismic analysis. We devised an iterative approach to progress from symmetrically shaped subsurface voids with known geometry to more complex geometries and finally to realistic karst features. In the current paper, we present results from a seismic imaging experiment of a vertical water-collection shaft located on the campus of Qatar University. The experiment consisted of four seismic lines, including two geophone and two source lines, oriented in a rectangular geometry surrounding the water-collection shat. The seismic source was a 10 kg sledge hammer, while the geophones consisted of three-component 10 Hz sensors. Seismic source and geophone spacing was 0.5 m, while each line was 15.5 long. The water collection shaft had a diameter of 2.7 m and an approximate depth of 4 m. Seismic waves scattering off the shaft were visible in ambient noise records and in unprocessed data generated by the seismic source. We will present the results of our novel approach using spectral analysis of scattered seismic wave to determine the location and to estimate the volume and dimensions of the water-collection shaft.