A Geomodel for Subsurface Karst

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Project Objectives

- To develop a geomodel of karst occurrence calibrated from a doline analysis from the Nullarbor Plain, Australia.
- To populate the geomodel with additional examples of karstified areas, both modern and subsurface, i.e. Spain and Yucatan.
- To apply the geomodel to a subsurface example using extracted seismic attributes such as faults, fractures, and seismically-resolvable dolines.

Project Rationale

Accurate maps of the subsurface distribution of karst are important for mitigating geohazards and understanding reservoir connectivity. Often obscured in seismic data, karst cannot always be mapped directly (Grasmueck et al., 2013) and it is here that geostatistical models can be used to simulate its likely distribution, including the size, shape, orientation, and clustering of dolines. Machine-learning algorithms that utilize spatial data for predictive purposes are common in ecological modeling (Schratz et al., 2018). By using a database populated with doline morphometric parameters, these modeling methods will apply to geologic modeling of lateral karst occurrence. This was the motivation for a study in the Nullarbor Plain of Australia, which has provided a rich database of doline morphometric characteristics and their tectonic controls across a wide area (2,500 sq. km) with a broad diversity in the motif of surficial karst.

Approach

Depressions were automatically extracted and manually mapped from digital terrain models (DTMs) for a total 2,500 sq. km area of the Nullarbor Plain. These dolines were quantified based on morphometric and spatial attributes. Tectonic and geomorphologic controls were then mapped from DTMs and Total Magnetic Intensity data. The relationship between these controls and the subsequent dolines was quantified.

Following the protocols of Zhu et al. (2016) and Schratz et al. (2018), doline parameters of the Nullarbor act as predictive variables for spatial distribution of karst in the subsurface. Furthermore, the key to developing such

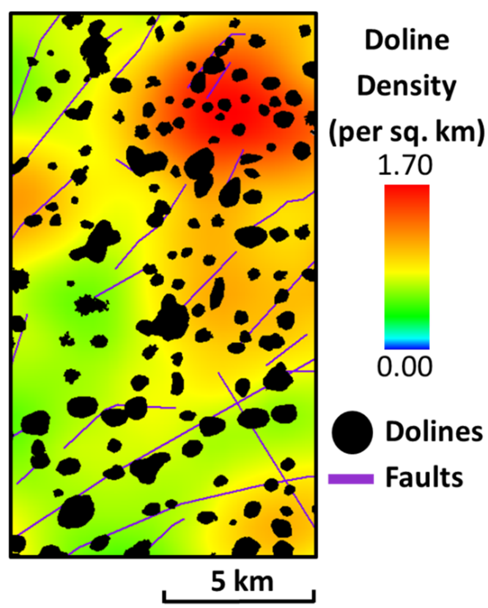

Figure 1: An example of a heat map within the Nullarbor Plain depicts density of dolines per sq. km. Areas with small dolines are more intensely karstified than areas with large dolines.

models is the analysis of a broad portfolio of analogs which can be mapped to provide the spatial statistics necessary to populate a geo-model. Surficial karst mapping will expand beyond Australia to encompass additional surficial and subsurface karst landscapes, such as Spain and the Yucatan. With these data, a geomodel will be developed to back-solve the distribution of karst in areas which cannot be readily remotely sensed, including the subsurface. Parameters that are known to exert control on karst distribution, such as faults and fractures (Guidry et al., 2007), and a partial understanding of the existing karst system, such as the presence of isolated large dolines (Harris et al., 2018) will be extracted from seismic data to guide the probability of doline encounter.

SIGNIFICANCE

Parameters that are known to exert control on karst distribution such as faults and fractures and existing large dolines are routinely extracted from seismic data (Russel-Houston and Gray, 2014). By applying a karst-occurrence geomodel, the occurrence of smaller dolines that are more frequent, but often fall below seismic resolution, can be predicted. This strategy will aid in the avoidance of geohazards as well as providing an enhanced understanding of the heterogeneity of subsurface reservoirs.

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