Seismic Characterization of Collapse Dolines in the Grosmont Formation, Alberta Canada

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Upper Devonian Grosmont Formation carbonate reservoirs in north-central Alberta contain over 400 billion barrels of bitumen. Thermal pilots in the Grosmont that were operated in the 1970's and 1980's produced significant bitumen, but further development was deferred due to low oil prices, a lack of infrastructure, and a requirement for more advanced technologies, including 3D seismic.

The Grosmont was deposited in a shallow marine carbonate platform. Subsequently these rocks were dolomitized, buried to a depth of about one kilometer, and then exhumed at the surface no later than the Early Cretaceous. Meteoric water influx caused selective dissolution and leaching, and resulted in the development of paleokarst features, such as collapse dolines and caverns. When encountered in wells, collapse dolines are identified in logs and cores, in part by lack of correlation to the otherwise laterally extensive carbonate units of the Grosmont platform. Collapse dolines were recognized in the early pilots' single well penetrations, as 2D seismic data of the period enabled only limited resolution of their geometry.

In the winter of 2009-2010, Osum Oil Sands Corp. acquired a high resolution 3D seismic volume over nine sections in Township 85, Range 18W4M, southeast of the early pilots and along the subcrop trend of the Grosmont 'D' interval. Evaluation of seismic character enabled the interpretation of the presence of collapse dolines within the Grosmont Formation. Collapse dolines were identified by examining an amplitude extraction of the seismic volume along the Grosmont 'D' unconformity surface. On this surface, dolines are represented by significant amplitude dimming, roughly circular in shape, with an average diameter of 70 m (range of 30-150 m). The dolines' internal structure is poorly imaged with a seismic character that is chaotic in contrast to the parallel reflections of regional Grosmont stratigraphy. The collapse dolines appear to be either singular or clustered, with larger dolines often irregular in shape and likely the result of coalesced smaller features. Doline clusters trend northwest to southeast and are likely influenced by both the orientation of maximum stress and variations in carbonate lithology and mineralogy within a stratal package with a southwesterly dip. Clusters of dolines are associated with combinations of paleo-highs, faulting, or downlap of the overlying Wabiskaw. These observations and interpretations imply multiple geological processes of porosity modification and structural collapse.

We speculate that imaging the internal structure of dolines would require considerably more seismic imaging effort; however, being able to identify doline locations will assist with future well planning and project development.