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The geophysical characteristics of impact craters and implications for hydrocarbon reservoirs

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Summary

Meteorite impacts have been a primary force in sculpting Earth's surface. Fortunately, most of this artistry occurred in the distant past and is now only represented by rare blemishes and deeper anomalies. However, because of the explosive nature of a bolide (asteroid or comet) impact, the resultant brecciation and excavation, with follow-on erosion and deposition, reservoir environments can be created. There are a number of well-known buried impact craters that host hydrocarbon resources (e.g., Ames, Steen, Red Wing) or are associated with them (e.g., Chicxulub). These craters are typically characterized by central uplifts, faulted rims plus gravity, magnetic, and seismic anomalies. Knowing how to recognize these craters as well as develop them can make identifiable and economic reservoirs. In addition, there are likely many more undiscovered craters that could be prospective for hydrocarbon development or sequestration and storage.

Impact cratering

Solar System vagabonds (asteroids or comets) have periodically collided with Earth causing minor (Meteor Crater in Fig. 1) to catastrophic excavations (Cantarell deposits from the Chicxulub event in Fig. 2). According to the Earth Impact Database hosted at the University of New Brunswick, there are some 190 confirmed impact structures on Earth. Given erosion, tectonics, and volcanism that seems reasonable. However, as most craters have been found in Europe and North America and with known cratering rates, it is likely that many more (perhaps over 300 on the surface) remain, especially in less explored areas (Hergarten and Kenkmann, 2015).

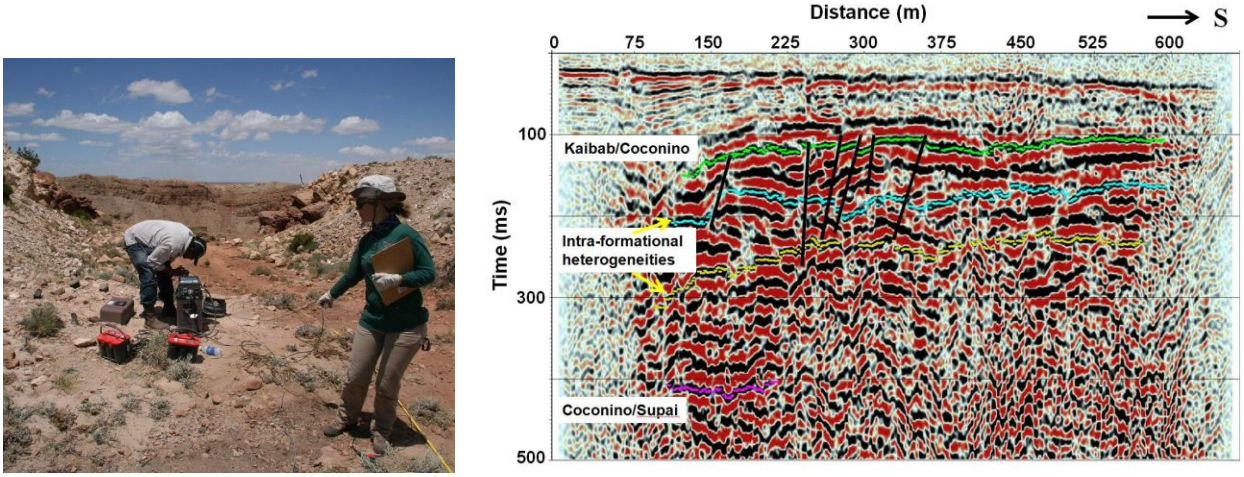

Figure 1. Photo of seismograph deployment at Meteor (Barringer) Crater, Arizona and resultant radial seismic section from the southern rim (after Roy and Stewart, 2012; Turolski, 2013).

The resultant craters can have concentrated minerals or eventually become hydrocarbon reservoirs (Donofrio, 1981; Grieve and Masaitis, 1994). Impact craters are generally circular

features (or with tectonic history perhaps more ellipsoidal) with a bowl or sombrero topology. There are numerous other geologic processes, including volcanism, karsting, and diapirism that can produce circular anomalies. However, distinct morphologic structures (uplifts, moats, radial and circumferential faulting, anomaly ratios, relatively shallow disturbances relative to the diameter, gravity and magnetic signatures) assist in high-grading possible impact craters. However, mineralogic definition will be required to prove the impact origin of the structure. If a crater is in a petroliferous region where hydrocarbons could be generated or migrate and be trapped, then the potential for a reservoir exists. Developing the reservoir using possible fault geometries and porosity and permeability pathways may enhance productivity. Meteorite impacts craters provide interesting opportunities for resource development on account of their size, porosity and permeabilities, and trapping potential.

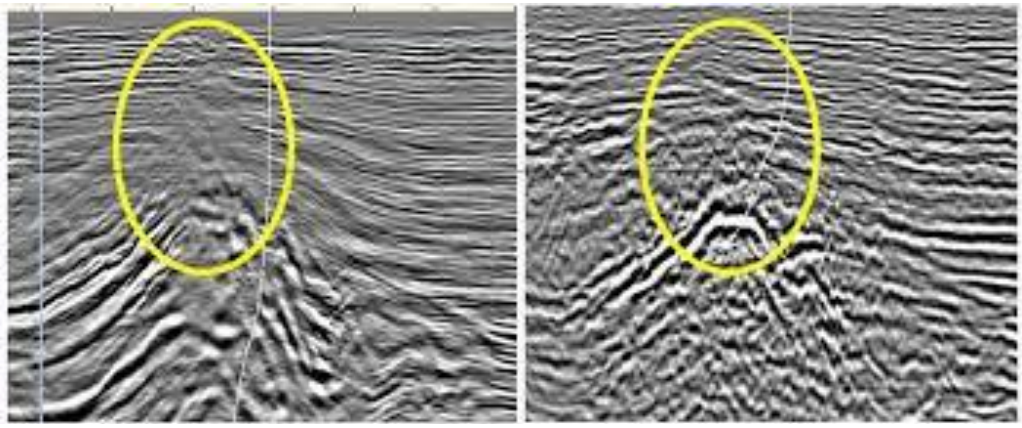

Figure 2. PP and PS sections from the supergiant Cantarell oilfield, offshore Mexico. The reservoir interval is interpreted to be partially formed by breccia from the Chicxulub impact (Chernikoff et al., 2007).

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