

## Impact Craters in Seismic Data: Ongoing Study of Astroblemes and Their Importance to the Oil & Gas Industry

Amanda K. Obodovsky

Divestco

### Summary

Since the acquisition of seismic data in the 1960's, impact structures have been seen in seismic data. These are structures that were created earlier in the Earth's history from a meteorite impact and have since been buried underground. While many of these unique structures are known to be located in the Western Canadian Sedimentary Basin, we also find these buried impact craters around the world with many well-known astroblemes located in the US. Some of these structures occur in areas with oil and/or gas concentrations and are of interest to the industry for economic reasons, while others exist in zones without any hydrocarbons and are of scientific interest in gaining a better understanding of these structures and events. As an astrobleme hunter and seismic processor the goal of this presentation is to seek out these buried impact structures and study them using the seismic data processing methods.

### Theory

To begin, let us start with definitions:

Astrobleme: (from Greek astron, blema, "star wound"), remains of an ancient meteorite-impact structure on the Earth's surface, generally in the form of a circular scar of crushed and deformed bedrock.

Impact Crater: a depression that results from the impact of a natural object from interplanetary space with Earth or with other comparatively large solid bodies such as the Moon, other planets and their satellites, or larger asteroids and comets.

For this presentation the terms 'astrobleme' and 'impact crater' can be used interchangeably.

Before we can interpret seismic data for astroblemes, first we need a basic understanding of what the structure of an impact crater looks like. The following image shows both a simple and complex crater in profile view. A few features to note are: the overall bowl shape of the structure, the raised rim, and the vertical faults radiating outwards from the impact often causing blocks to slump downwards towards the center. All three of these features can be seen in seismic data when looking at impact events and are clues to determining if a structure is indeed an astrobleme.

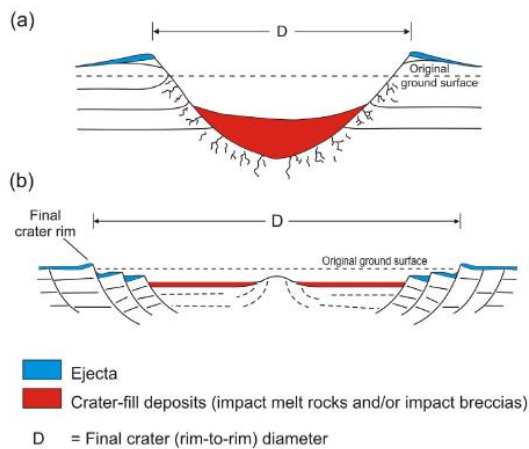


Figure 1. General structure of an impact event. The top image shows a simple crater, while the bottom image shows a complex crater.

## Results & Conclusions

This presentation is divided into three main parts: Past Discoveries, New Techniques, and New Discoveries.

**PAST DISCOVERIES:** There have been many astroblemes discovered using seismic data in the Western Canadian Sedimentary Basin and around the world. Viewfield and Steen River are two well-known examples from the WCSB and many in the industry have worked with these astroblemes in the past.

**Viewfield:** Discovered in 1969 and located in southeastern Saskatchewan, the Viewfield Structure was among the earliest impact structures discovered in seismic data. While being an interesting find, this crater gained notice because of the large hydrocarbon accumulation associated with it, predominantly along the rim on the structure. Over the years there have been over 50 active wells in the rim structure of this astrobleme with a reserve of 27 million barrels. (Sawatzky, H. B., 1972)

**Steen River:** Located in northern Alberta, the 25km diameter Steen River structure is the largest known impact crater in the Western Canadian Sedimentary Basin. The oil, and subsequently the impact structure, was discovered in 1963, but the area remained dormant for many years due to the remote location and lack of pipeline infrastructure. When the assets were bought in the mid 1990's exploration and drilling in this region resumed (Robertson, G. A., 1997). Since then, more than 130 seismic lines have been obtained across this feature, including several 3D seismic data projects, and over 40 wells have been drilled around the rim. (Mazur, M.J., et. al, 2000) This impact crater also has striking magnetic field anomalies around the central peak and concentric gravity anomalies that correlate to both the magnetic anomalies and the crater structure itself. (Hildebrand, A. R., et. al, 1997)

**NEW TECHNIQUES:** By using new techniques on older seismic data we are able to greatly improve the quality of the image of astroblemes. In particular, Divestco's SPRINT 6D and Diffraction Imaging are useful for interpolating data and better imaging the complex details of the impact structures. This is especially true for sparse datasets as can be seen in an example from the central Alberta foothills.

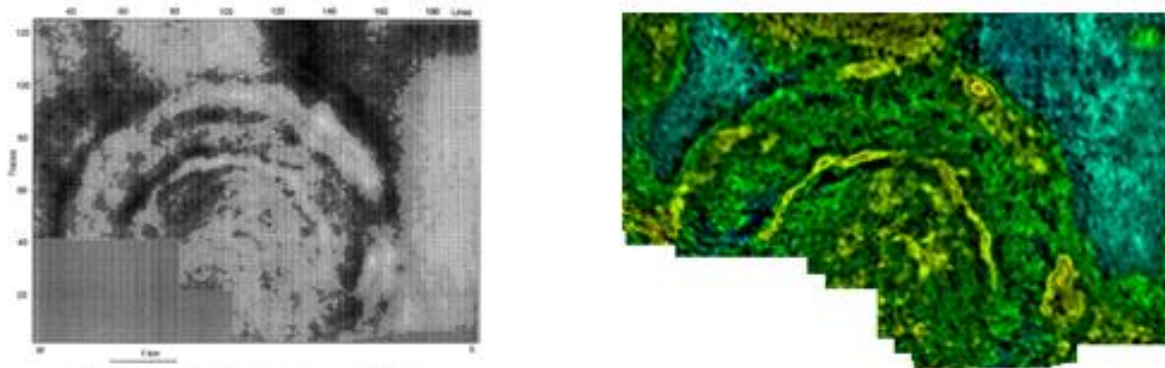


FIG. 1. Seismical data slice at 2100 ms showing the concentric plan of the hole.

Figure 2. A comparison of an astrobleme found in the central Alberta foothills. The left is from the 1993 paper by Isaac & Stewart: 3-D Seismic Expression of a Cryptoexplosion Structure. The right is using Divestco's processing techniques to improve the quality of the image.

**NEW DISCOVERIES:** Hidden away in existing seismic data are many astroblemes that remain undocumented. Those who have worked with the data are aware of their existence, but due to various reasons, there are no publications detailing these structures. The final part of this project seeks to process and analyze astroblemes like these so that a size and age for these impacts can be established and added to databases of known impact structures.

### **Novel/Additive Information**

Impact craters are an important part of the Earth's history and by uniting astrophysical knowledge with geophysical processing and interpretation we can gain a better understanding of these structures. This will add value for both the oil and gas industry that seeks to extract hydrocarbons from around these structures and the scientific community that seeks to better understand and catalogue these impact events.

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