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Purple Springs, Alberta, Canada (10-14W4M): Probable Paleozoic Impact Crater – Part I - Geology

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Summary

The author presents scientific evidence that the complex sub-surface structural feature and associated stratigraphic relationships expressed at Purple Springs, Alberta (10-14W4), is consistent with a terrestrial impact crater.

Introduction

There is a very complex subsurface structural feature roughly 3.4 km in diameter located in the north-west portion of 10-14W4 that has been interpreted to be of impact origin, although other possible origins have been suggested. The impact would have occurred sometime after the deposition of the Mississippian Livingstone formation and prior to deposition of the Jurassic Sawtooth formation, i.e. a roughly 125 million year window. The well 100/04-32-010-14W4M appears to be almost exactly in the center of this feature.

Theory and/or Method

In his University of Calgary Master of Science thesis, Westbroek (1997) examined the Purple Springs subsurface and also a similar feature at White Valley, Sask. He concluded that the Purple Springs feature was likely of impact origin, but with some qualification. Specifically he noted that some characteristics of the Purple Springs feature did not conform to the accepted impact crater model (Melosh, 1989). This Master's thesis accessed and referenced three 2D seismic lines over the Purple Springs feature, however, none of these lines passed over the center of the feature. One significant deficiency with the impact origin theory with respect to the Purple Springs feature is the apparent absence of a central uplift under the center of the feature.

Examples

The Haughton Impact Crater, Devon Island (75 deg. 22' N, 89 degrees 41' W).

The Red Wing Creek Impact Crater, North Dakota (47 degrees 36' N, 103 deg. 33' W)

The Eagle Butte Impact Crater, southeast Alberta.

The James River Structure, northwest Alberta.

The Viewfield Structure, southeast Saskatchewan.

The Hartney Structure, southwest Manitoba.

Geology – See Poster Part I

The feature has undergone significant structural deformation over the period from the time of Sawtooth deposition through to present day, consisting mostly of downward structural movement of the feature, i.e. above the feature the Base of Fish Scales formation is about 25 meters lower than regional, but the Rierdon and Sawtooth formations are about 75 and 125 meters lower than their regional, respectively. There is no surface expression of the feature. The feature contains excellent examples of over thickened beds due to subsidence and of growth faulting. Unfortunately, none of the wells in or immediately around the feature were cored. In the three wells that penetrated the crater floor, there is an anomalous, roughly 5 meter thick, highly radioactive shale that exhibits a reddish/orange color in samples, it looks just like the reddish/orange shale that they use on many park pathways. There appears to be no such shale present in the Paleozoic of southeast Alberta. These shale samples do not respond to a magnet. This shale could be cooked target rock that was blasted straight up out of the crater and thus settle back down into the crater after impact. Thus the origin of this anomalous shale is unknown, but it appears to either be located at the very top of the crater floor or the first sediments deposited on the crater floor. Anomalously thick salt and anhydrate beds in the 4-32 well below the anomalous shale may in fact be rotated blocks of Stettler rock that have flowed from the outer edges of the crater into the center of the crater during crater formation to form the central peak, i.e. they do not appear to be in-situ! There is thick Stettler salt present today in wells within about 20 miles. Thin salt beds above the anomalous shale appear to be in-situ crater lake deposits.

Geophysics – See Poster Part II

This current work had access to and evaluated three 2D seismic lines that pass through or very near the apparent centre of the feature. Line A16312 (Cenovus data) was reprocessed by Divestco, including pre-stack time migration and post stack depth conversion. After flattening the depth seismic section on the top of the Sawtooth event this data show the presence of an obvious basement uplift under the center of the feature. This data also shows that while there is a significant “raised crater rim” at the top of Devonian level, the lack of a significant raised rim on the Mississippian unconformity surface indicates that there has been significant erosion of the surrounding target rock post crater formation. However, exactly how much Mississippian, or even younger, rock that has been removed is unknown. Younger rocks that may have been present at the time of impact, that have since been eroded away in the region, include the Pennsylvanian, Permian and Triassic formations. Perhaps the anomalous reddish/orange shale deposit came from the erosion and re-deposition of the now missing younger rocks that have not been preserved anywhere in southeast Alberta. As of present day there still appears to be a roughly 400 meter diameter up-thrown block of Cambrian/Precambrian rock, with about 50 meters of throw, under the very center of the feature.

Conclusions

By flattening the seismic data on successively older geological formations the author develops a structural picture that is more representative of the time of formation of the feature. This technique demonstrates the presence of an obvious basement uplift under the center of the

feature and this is strong additional evidence to support the interpretation that the Purple Springs feature is indeed of impact origin.

There does appear to be remaining economic potential for Sawtooth oil in and around the crater on the rim, as well as hydrocarbon potential within the lower Devonian and for exotic gases within the Cambrian reservoirs on the up-faulted central uplift below the center of the crater. However, the author would not recommend any additional drilling without having 3D seismic data. Particularly within and below the crater there will be so much off-line energy bouncing around that there will be severe imaging problems with 2D data. Also, because of the velocity anomalies present, conversion to depth is essential.

Suggested additional work: To have a geology student review the drill cuttings from the four wells located within the crater looking for direct evidence of a shock event, i.e. metamorphic mineralization, melt inclusions in the breccia, etc.

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References

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