PEERLESS STRUCTURE SOUTHWESTERN DANIELS COUNTY, MONTANA: A PROBABLE MID-ORDOVICIAN IMPACT EVENT. J.M. Comstock[1] and J.R. Morrow[2], [1]University of Northern Colorado, Department of Earth Sciences, Greeley, CO 80639, jocecaje@hotmail.com, [2]University of Northern Colorado, Department of Earth Sciences, Greeley, CO 80639.

Introduction: The Williston Basin of central North America encompasses an area of approximately 320,000 square kilometers located in both the United States and Canada. It is considered to be one of the largest depositional basins on the North American continent and contains rocks of early Paleozoic through Quaternary age that reach a total subsurface thickness of approximately 4800 meters in the central basin area. At least five subsurface circular structures have been found within the basin area (Red Wing Creek, Newporte, Viewfield, Hartney, Eagle Butte and Dumus)[1]. Two of these structures, Red Wing Creek and Newporte, are confirmed impact sites while the others are listed as probable impact sites. Because of its intracratonic location, the Williston Basin has not been significantly affected by major orogenic events and has received considerable geologic study because of its importance to the petroleum industry.

Description of Structure: The Peerless structure is an approximately 6.5 km (4 mile) diameter subsurface anomaly located within southwestern Daniels County, northeastern Montana. The top surface of the anomaly lies at a buried depth of ~ 2470 m (8100 ft) below the ground surface, and disrupted rock units extend to a depth of at least ~ 2896 m (9500 ft). Seismic mapping of the structure shows a typical complex crater, which is composed of a flat topped central uplift of approximately 1.5 km in diameter, an annular ring extending out to approximately 4.5 km and an outer rim approximately 6.5 km in diameter. The Williston Basin units that are affected by the Peerless structure include interbedded sandstone, siltstone, dolostone and limestone of Late Cambrian through Early Silurian. Precambrian metamorphic and igneous rocks, which unconformably underlie Upper Cambrian strata, may have been locally disrupted within the area of the central uplift. The six major formations affected are (in ascending order): Deadwood (Middle-Late Cambrian), Winnipeg (Early-Middle Ordovician), Red River (Middle-Late Ordovician), Stony Mountain (Late Ordovician), Stonewall (Late Ordovician) and Interlake (Late Ordovician-Early Silurian) [2]. The youngest highly disrupted rock unit is the mid-Ordovician Red River Formation, indicating that the impact occurred around 460-480 Ma. However, it should be noted that the irregular upper surface of the structure affected local depositional patterns at least into the Early Silurian. At the time the structure formed, the region was located in a shallow marine setting on the western margin of the Williston Basin.

Preliminary Data: Available proprietary information includes well cuttings, well wireline logs and 2D/3D seismic profiles. 2D and 3D seismic profiles clearly show distortion of the subsurface reflectors and disrupted stratigraphic layers adjoining both sides of the structure. This distortion can be traced down into seismic units that are correlated to the Deadwood Formation, which shows the greatest degree of disruption by the event. Wireline logs from two exploratory wells that penetrated the structure (one in the central uplift and one on the south rim) and several from the surrounding area were correlated to show the structural relief of the crater stratigraphy with respect to surrounding strata. Well and seismic data show a disrupted interval that is at least 200m (700 ft) thick through the central uplift area.

Cuttings from each well were investigated in order to correlate the stratigraphy with wireline log data. The south rim well penetrates an anomalous layer of highly fractured quartz sandstone that would be expected to be part of an ejecta layer, possibly reworked by currents. A majority of the quartz grains present in the central uplift samples show random fractures with approximately 5% showing planar features. The planar features present in the quartz grains have a spacing of 15-25 um (average ~ 20um), and occur along at least 3 preferred orientations. Brecciated quartz sandstone, siltstone and carbonate rock fragments are present throughout the samples observed and apparent concussion fractures, irregular extinction patterns and possible lower birefringence in quartz from the uplift samples argue for high alteration [3].

Well and seismic data from the central uplift region demonstrate the presence of a thin (~ 10 m thick), unusual capping rock unit composed of black, organic-rich siltstone. This layer, which directly overlies disrupted rock of the uplift, has been interpreted as possible fill deposited within a disoxic or anoxic restricted marine embayment made by the uplifted structure rim.

Future Investigations: Additional wireline logs will be correlated in order to prepare isopach maps of the affected stratigraphic layers in the area of the Peerless structure and its adjacent areas. More samples from both the uplift and rim well need to be examined to further identify any possible breccia lenses, ejecta material or tsunami deposits. Also, additional quantitative petrographic analyses of fractured and deformed quartz grains will be conducted to determine crystallographic orientation, dimensions of planar features and the possible existence of planar deformation features. Microprobe analysis of thin sections from cutting chips should be made to test for the presence of any Rare Earth or siderophile elemental enrichment. X-ray diffraction and possible scanning/transmission electron microscope analysis may also be conducted to evaluate the mineral suites present within the cutting samples.

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