HIGH-RESOLUTION SEISMIC REFLECTION SURVEY AT THE MANSON CRATER, IOWA

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Approximately 17.4 km of high-resolution reflection data were acquired along an east-west radius of the Manson Impact Structure (MIS) to delineate the shallow (upper 300 m) subsurface structural configuration. The geometry of the shallow structure is poorly known due to a 30-90 m thick Pleistocene till cover. The resolution of the new seismic data is roughly 5-10 times that of existing Vibroseis data. Data quality varies rapidly along the line from exceptional to poor, due primarily to velocity variations associated with the geological complexity of the area. Preliminary results indicate subsurface structural blocks previously envisioned to be several hundreds of meters in size are actually an order of magnitude smaller and more complex. A seismogram-by-seismogram analysis is necessary to confidently identify intricate stratigraphic and structural relationships seen on preliminary CDP sections, as numerous faults, diffractions, and complicated reflection patterns create potential pitfalls.

Two existing industry Vibroseis lines ([1], [5]) have been used to help define the deep structure of the MIS. The lines intersect near the central uplift, extend radially to the east and to the south, and indicate the structure is approximately symmetric. Based on the Vibroseis lines, water well cuttings, cores, and geophysical logs, the structure can be broken into three general structural domains ([1], [5]); an outermost, 5 km wide ring fracture zone, a 7 km wide moat, and an apparent central uplift. The seismic signature of the ring fracture zone is characterized by subparallel sets of discontinuous events interpreted to be down-dropped blocks of Paleozoic and Cretaceous strata. A strong reflection event occurs at approximately 2 s (about 4 km depth) and is interpreted to represent the top of the Proterozoic crystalline basement rocks. Numerous normal faults are observed in the upper 500 ms of data within the ring-fracture domain. Within the moat domain the basement reflector shallows rapidly, the Paleozoic strata reflections are absent, and a series of discontinuous, flat-lying events may represent either a melt layer [3] or lake bed deposits [2]. Along the edge of the central uplift, Proterozoic gneissic and granitic basement rocks have been encountered as shallow 30 m below the land surface. The shallow portion of the uplift is not well imaged by the Vibroseis data but the data seem to indicate that the structure is fairly symmetric. Preliminary reprocessing of existing gravity [4] and magnetic data suggest a more complex central uplift. The potential field data indicate the central uplift may be saddle-shaped. Alternatively there may possibly be two distinct uplifts, positioned slightly off the currently believed location [5].

While the Vibroseis data provide critical constraints on the gross structural components, poor near surface (less than 300 m) resolution renders it useless for correlation of well information. For this reason, new high-resolution seismic data was acquired to allow new drilling information to be tied together and correlated with the existing seismic information. In July of 1992, walkaway noise tests were conducted prior to production to determine optimum recording parameters. Parameters varied during the tests included the 50 Caliber rifle, 30.06 rifle (both fired downhole), and the 8- and 12-gauge auger guns [6] as sources, and 0, 50, 100, 140, and 280 Hz low cut filters. The receiver arrays consisted of three 40-Hz geophones equally spaced over approximately 1 m and centered on 2.5 m stations, with source-to-receiver offsets ranging from 2.5 m to 345 m. A 48 channel, 2401-X EG&G seismograph recorded the data in a modified SEG-Y format. Distinct wave types can be identified on the walkaway profiles (Figure 1). After analysis of the walkaway data in the lab, production parameters were chosen: 1) an end-on shooting geometry, 2) the 50 Caliber rifle was (based on relative energy levels and data bandwidth), 3) 50 Hz low-cut filters, 4) 1/2 ms sample interval, and 5) a record length of 750 ms. Over 1,700 shot points of high-resolution shallow reflection seismic data were subsequently acquired along the route of the east-west radial Vibroseis line. A total of 17.4 km of seismic line was acquired with a station spacing of 5 meters and a shot point interval of 10 meters. The data quality of the resulting nominal 12 fold CDP data varies from excellent to poor along the transect.

Preliminary interpretations of the seismic data suggest that the structural blocks originally assumed to be hundreds of meters in size are actually on the order of tens of meters in size. Many of the shot records have multiple faults, and/or diffractions interpretable on the field files (Figure 2). Because of the geologically complex structures and lateral as well as vertical velocity variations the subtle stratigraphic and structural details present require essentially a seismogram-by-seismogram analysis for interpretation.

References
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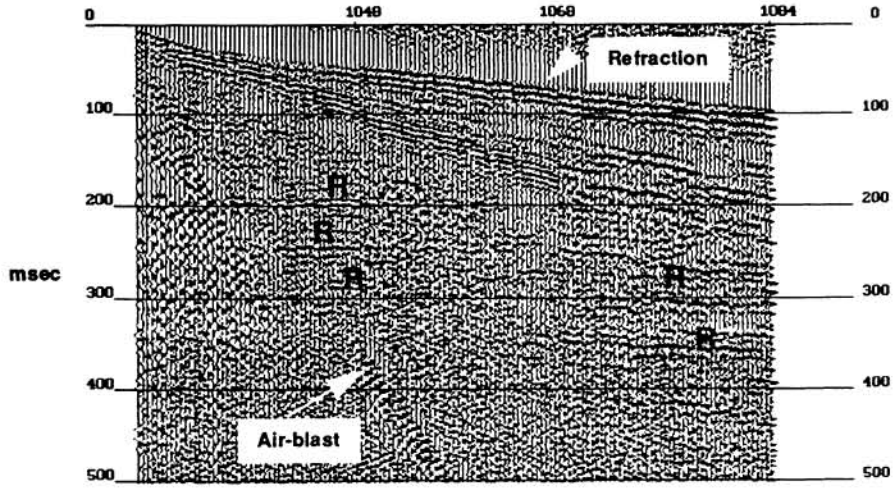

Figure 1. Walkaway noise test, AGC scale and digitally filtered, acquired with the 50 Cal. rifle. Reflections can be interpreted from 30 ms to 500 ms in these data (marked by an R).

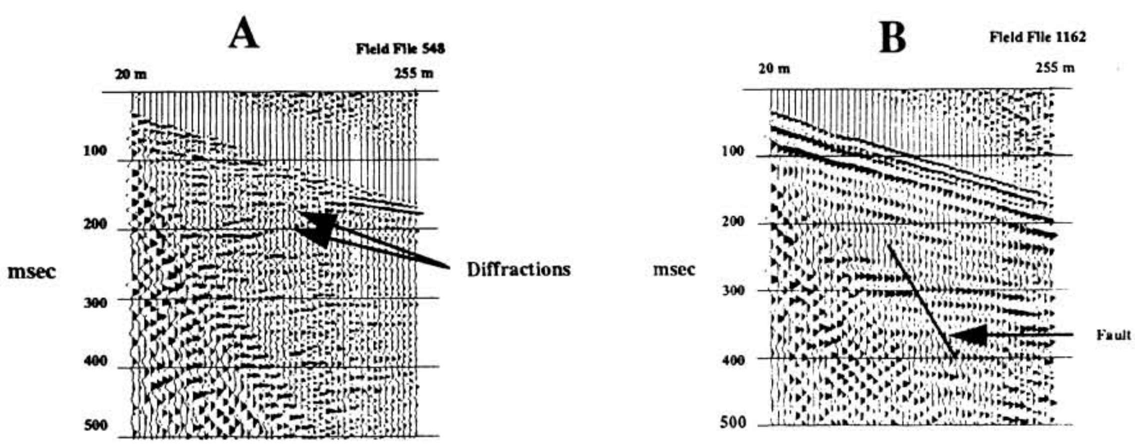

Figure 2. Field files, AGC scaled and digitally filtered, showing easily identifiable diffractions (A) and a fault (B).