RESEARCH PROGRAM ON THE MANSON IMPACT STRUCTURE, IOWA: E.M. Shoemaker and D.J. Roddy, U.S. Geological Survey, Flagstaff, AZ 86001 and R.R. Anderson, Iowa DNR Geological Survey Bureau, Iowa City, IA 52242-1319.

At or near the end of the Cretaceous, at least two large impact events occurred in the western hemisphere [1,2,3]. One impact formed the 180-km diameter Chicxulub crater on the northern tip of the Yucatan peninsula. Another formed the 35-km diameter Manson structure in western Iowa. Several lines of evidence, including the chemical and isotopic composition of glass found in the K/T boundary layer at sites in the Gulf of Mexico and Caribbean region [4,5,6], the regional variation in thickness and the size of spherules in the K/T boundary layer [7,8,9], and indications at and near the boundary of disturbance and deposition of beds by giant waves in the Gulf of Mexico [10,11], point to Chicxulub as a major source of K/T boundary material, including a lower layer of clay at K/T boundary sites in western North America. The size, abundance, and mineral and lithic composition of shocked grains from an upper K/T boundary layer found at western North American sites, on the other hand, point to Manson as a possible source crater [7]. More than one impact seems to be indicated by the K/T boundary stratigraphy in western North America [12], and present constraints on the age of the Manson structure suggest that it, as well as Chicxulub, may be a K/T boundary crater [1].

Multiple craters produced over a relatively short interval of time are much more likely to have been formed by impact of comets rather than by impact of asteroids. Among likely mechanisms that could have produced multiple craters at or near the time of the K/T boundary are 1) splitting of a comet shortly before impact with Earth (impacts may have been spaced over about an hour), 2) fragmentation of a very large, Sun-grazing, periodic comet to form a compact stream of comets that intercepted the Earth's orbit (impacts may have been spread over about a century), and 3) perturbation of the Oort comet cloud by a passing massive object to form a comet shower in the inner solar system (impacts may have been spread over about a million years). Only in the first two cases are the impacts likely to have been close enough in time to contribute to the observed K/T boundary layers. All mechanisms could have produced many more than two craters. In the first case, the craters would be confined largely to one hemisphere of the Earth, whereas in the second and third cases, the craters could be very broadly distributed over the Earth.

Research programs were initiated in the U.S. Geological Survey and the Iowa Department of Natural Resources, Geological Survey Bureau (IDNR-GSB) to elucidate the relationship of the Manson impact event to the K/T boundary. Primary goals were to determine the size, structure, and precise age of the Manson crater and to determine whether Manson ejecta are represented among the shocked mineral and lithic grains in the upper K/T boundary layer in western North America. In 1991, the USGS and IDNR-GSB joined in a cooperative project to drill the Manson structure. Drilling is required to investigate the geology of the structure, because it is concealed beneath Pleistocene glacial drift. Priority targets for the drill were the impact melt sheet and a possible post-crater lake-bed sequence that was thought to occupy part of the crater floor. Precise isotopic ages and possible traces of the impactor were sought from the melt sheet; it was hoped that study of the postulated post-crater lake-bed sequence might yield a tightly constrained biostratigraphic and magnetostratigraphic age of the crater. Additional objectives of the drilling were to obtain a broad picture of the structure of the crater, and to investigate the pre-crater Cretaceous stratigraphy and the shock and post-shock processes that have affected the crater.

The Manson project was expanded in 1992 into a multidisciplinary research effort funded by the USGS, IDNR-GSB, the National Science Foundation, the Department of Energy, and the National Aeronautics and Space Administration. This effort is a component of the interagency Continental Scientific Drilling Program. The current investigator team includes:

R.R. Anderson, IDNR-GSB (crater structure and Cretaceous stratigraphy)
R.A. Black, Univ. Kansas (high-resolution seismic profiles)
L.J. Crossey, Univ. New Mexico, (post-impact hydrothermal alteration)
C.T. Foster, Univ. Iowa (petrology)
B.M. French, NASA (shock metamorphism)
W.D. Gosnold, Univ. N. Dakota (heat flow)
J.B. Hartung, IDNR-GSB (crater structure and petrology)
G.A. Izett, USGS (petrology of melt sheet and shock metamorphism)

M.J. Kunk, USGS (isotopic age determination and ejecta characteristics)
J.M. Mikesell, USGS (in-hole geophysical logging)
D.J. Nichols, USGS (palynology)
J.B. Plescia, JPL (gravity survey)
H.N. Pollack, Univ. Michigan (heat flow)
M.K. Reagan, Univ. Iowa (petrology)
R.L. Reynolds, USGS (magnetic properties of core)
D.J. Roddy, USGS (cratering processes, shock metamorphism, and petrology)
J.G. Rosenbaum, USGS (magnetic properties of core)
E.M. Shoemaker, USGS (crater structure and paleomagnetism)
N.M. Short (shock metamorphism)
M.B. Steiner, Univ. Wyoming (paleomagnetism)
B.J. Witzke, IDNR-GSB (crater structure and stratigraphy of target rocks)
P.K. Zeitler, LeHigh Univ. (isotopic age determination)

Drilling was completed in December 1992 and returned about 1200 m of NX core from twelve holes with about 95% core recovery. Many of the drill sites are close to a seismic reflection line that extends eastward from the center of the crater to the rim. The seismic reflection profile, provided by Amoco, served to guide siting of holes planned for exploration of different structural terranes in the crater. A brief overview of the rocks cored and the broad structure of the crater is given in the accompanying abstract by Anderson et al. [13]. Initial reports by many of the other investigators will also be presented at the conference.

A complex impact melt sheet was encountered on the flank and possibly in the center of the central uplift. An intensive search using several holes failed to discover any early post-crater lake beds; the evidence now available from drilling suggests that the Manson structure has been too deeply eroded for early post-crater sediments to have been preserved. A distinctive and somewhat unanticipated feature of the Manson structure is the presence of debris flows and landslide blocks, composed chiefly of Upper Cretaceous shales, that mantle most the interior of the crater, including parts of the central peak. The mechanisms of emplacement of the landslide debris remain to be determined. Landsliding appears to have been due to prompt collapse of the crater rim. Both ejecta and a substantial part of the bedrock Cretaceous section of the rim probably were sources of the slide materials.

The drill core is being split. Half will be archived at the USGS Core Research Center, Denver, Colorado, and will be available for continued research. The other half will be archived at the IDNR-GSB core facility, Iowa City, Iowa. Qualified investigators who are interested in working on the core should contact one of the authors.

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