MINERALOGICAL, PETROLOGICAL, AND GEOCHEMICAL STUDIES OF DRILL CORES FROM THE MANSON IMPACT STRUCTURE: A PROGRESS REPORT. Christian Koeberl[1,4], Raymond R. Anderson[2], Rudolf H. Boer[3], Joel D. Blum[4], C. Page Chamberlain[4], Alfred Kracher[5], Wolf Uwe Reimold[3], Barbara Träxler[1], and Andreas Vormaier[1]. *[1]Institute of Geochemistry, University of Vienna, Dr.-Karl-Lueger-Ring 1, A-1010 Vienna, Austria (a8631dab@vm.univie.ac.at); [2]Iowa DNR Geological Survey Bureau, Iowa City, IA 52242-1319, USA; [3]Economic Geology Research Unit, Department of Geology, University of the Witwatersrand, Johannesburg 2050, South Africa; [4]Dept. of Earth Sciences, Dartmouth College, Hanover, NH 03855, USA; [5]Dept. Earth Sciences, Iowa State University, Ames, IA 50011, USA.*

INTRODUCTION AND SUMMARY. A core drilling program at the Manson Impact Structure, initiated and supported by the Iowa DNR Geological Survey Bureau and the U.S. Geological Survey, led to the recovery of 12 cores totaling over 1200 m (e.g., [1-3]). All these cores (M1 through M11 and M2A, plus two cores from 1953, 1A and 2A) have been sampled for the present project [4]. Four main impact rock types were encountered and were classified by, e.g., [1-3] according to their main rock components as: (1) Sedimentary Clast Breccia (SCB), (2) Crystalline Clast Breccia with Sandy Matrix (CCB-S) and Melt Rock Matrix (CCB-M), (3) Central Peak Igneous and Metamorphic Rocks (CP), and (4) an overturned flap of Impact Ejecta (IE). The SCB is dominated by clasts of Cretaceous marine shale and mudstone, with subordinate Cretaceous sandstones, Paleozoic carbonates, minor Proterozoic Red Clastics, and rare crystalline rock and impact melt-rock clasts in a medium gray, calcareous, sandy, silty, shale matrix. We have selected 136 samples, representing all major units in all drill cores, for a complete major and trace element study, and a subset of the 136 samples for petrography, microprobe analyses, fluid inclusion study, and $\delta^{18}O$, Rb-Sr, Sm-Nd, and Re-Os isotope analyses. The aim of our studies is a complete characterization of all major target rock, breccia, and impact melt units.

PETROGRAPHY OF M-1 CORE SAMPLES. The M1 core was drilled on the eastern edge of the central uplift to a depth of 214.3 m. It contains abundant impact breccias ([4-6]). Polished thin sections of twenty-eight samples from drillcore M1, covering the interval between 81.8 and 205.2 m (268.5 and 673.2 ft) depth, were studied petrographically. This sample suite consisted of fragmental breccia (to 98.8 m [324.2 ft]), impact melt (103.1 - 147.0 m [338.4-482.2 ft]), fragmental breccia and suevite alternating between 153.2 and 192.3 m (502.7-631 ft), and fragmental breccia till 205.2 m (673.3 ft) depth. Several larger clasts were also sampled. Aspects investigated include nature of breccia matrices, shock effects in clasts, alteration effects, and ore mineral petrography. In every section throughout this drillcore interval at least a few strongly shocked (≥3 sets of PDFs per grain) quartz or feldspar clasts were observed (see also Fig. 1). Microcline frequently shows shock-induced twinning and PDFs, as well as local melting. Plagioclase often displays PDFs oriented either near-perpendicular or parallel to twin lamellae. Partial or complete isotropization of quartz, and to a lesser extent, feldspar was recognized. Isotropization is clearly more important in the impact melt zone than in under- and overlying fragmental and suevitic breccias. In the lower part of the impact melt layer isotropic crystals with melt veinlets were observed, and clast recrystallization and annealing is very prominent. Mafic minerals rarely show shock deformation, besides the ubiquitous kinkbanding of mica. Amphibole is frequently strongly fractured, generally parallel to normal cleavage orientations. Some grains were seen to be locally brecciated, but no characteristic shock metamorphic effects were recorded in this mineral. In the 86.5 m (283.8 ft) specimen some zircon crystals with PDFs parallel to (001) were noticed, and 180.1 m (591.0 ft) contains sphene with PDFs. In agreement with macroscopic observations, we find that the clast population is variable from sample to sample, with regard to proportions of different lithologies (granite, gneiss of granitic to dioritic composition, amphibolite, quartzite, sandstone, shale or mudstone). Sedimentary clasts are important in the population of fragmental breccia from the upper zone, but are very rare and often completely absent in the lower section where crystalline basement-derived material forms the bulk amount of the clast component.

GEOCHEMICAL STUDIES. 136 samples from all 12 new and the two 1953 drill cores were prepared for complete major (XRF) and trace (INAA, XRF, AAS, DCP) element analyses. We have completed the major element analyses, and most of the trace element analyses. A subset of these samples (incorporating most compact rocks, but not shales) was selected for petrographic, mineralogical, and electron microprobe studies. We have been trying to locate pristine impact glass, which is extremely rare but was found in a sample from the M7 core. However, most glass is devitrified (Fig. 2). Quartz samples of clearly post-impact origin were selected for fluid inclusion studies (classical, and mass spectrometrical), attempting to determine the composition of a possible post-impact (impact-induced) hydrothermal fluid. These studies are in progress. Table 1 gives an example of major element data from suevitic and fragmental breccia samples from the 192.3 to 214.1 m depth interval of the M1 core. For three of the samples in Table 1, plus a clast sample, Fig. 3 shows the rare earth element (REE) patterns. The Rb-Sr, Sm-Nd, and oxygen isotopic compositions of a variety of samples have been measured, adding to earlier data [7,8].

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Fig. 1: Multiple sets of PDFs in quartz from breccia (2A core, depth 109.8 m); crossed nicols, image width: 1.1 mm. **Fig. 2:** Spherulitic devitrification of completely melted, originally probably granodioritic clast in impact melt rock (M7 core, 65.6 m depth); crossed nicols, image width: 1.75 mm.

Table 1: Major element composition (XRF) of 2 suevitic breccias (Suev), one fragmental breccia (FrBre), and matrix from a fragmental breccia, all from M1 core; sample numbers are depths in feet. Data in wt%.

	630.9 Suev	631.0 Suev	647.0 FrBre	702.5B Matr
SiO_2	59.41	60.00	60.69	59.42
TiO_2	0.93	0.90	0.85	0.89
Al_2O_3	15.62	15.32	14.67	15.01
Fe_2O_3	7.04	7.18	6.90	6.53
MnO	0.113	0.113	0.127	0.089
MgO	3.80	3.92	4.70	3.49
CaO	5.36	5.33	4.56	5.48
K_2O	4.51	4.85	4.43	5.41
Na_2O	1.94	2.06	1.80	2.26
P_2O_5	0.211	0.189	0.219	0.214
L.O.I.	0.83	0.80	1.42	1.47
Total	99.77	100.65	100.36	100.26

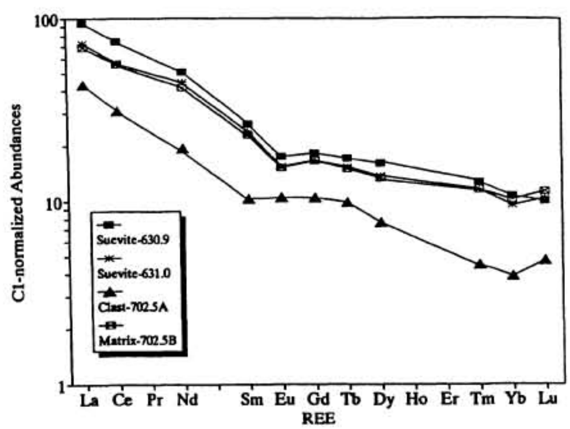

Fig. 3: C1-normalized REE abundance patterns in two suevitic breccias (Table 1), and of a large pegmatite-granite clast and matrix (Table 1) of a fragmental breccia, from M1 (sample numbers are depth in feet).