ORIGIN OF IMPACT MELT BRECCIAS AND SUEVITES IN DRILL CORES FROM THE MANSON IMPACT STRUCTURE DETERMINED FROM MIXING CALCULATIONS.

Christian Koeberl[1], Wolf Uwe Reimold[2], Raymond R. Anderson[3], and Alfred Kracher[4]. [1]*Institute of Geochemistry, University of Vienna, UZA II, A-1090 Vienna, Austria (a8631dab@vm.univie.ac.at);* [2]*Department of Geology, University of the Witwatersrand, Johannesburg 2050, South Africa;* [3]*Iowa DNR Geological Survey Bureau, Iowa City, IA 52242-1319, USA;* [4]*Dept. Earth Sciences, Iowa State University, Ames, IA 50011, USA.*

INTRODUCTION AND SUMMARY. The Manson impact structure in Iowa is a 36-km-diameter well preserved impact crater. During 1991 and 1992, 12 cores were drilled in a joint Iowa Geological Survey Bureau - USGS effort. A variety of impactite lithologies are present, consisting of impact melt rocks, suevites, and several different types of breccia, including an unusual impact melt breccia that has a melt-dominated matrix, as well as some melt clasts. In this contribution, we discuss the bulk composition of three impactites: impact melt breccias from the M1 and the M11 cores, and suevites from the M1 core. We attempted to reproduce the bulk composition of these impactites by mixtures of eight different types of target rocks. The results from harmonic least-squares mixing calculations, using the HMX program, show that the M1 impact melt breccia may have formed from shale, Red Clastics, a mafic component ("amphibolite"), granite, and minor carbonate and biotite granite. The results of the calculations yield about 19% shale, 20% Red Clastics (sandstone, siltstone), 37% amphibolite gneiss, 3% biotite gneiss, and 19% granite for the M1 impact melt breccias. The calculated mixtures for the M1 suevite were not as well constrained as the M1 impact melt breccias, but a reasonably good fit was obtained for about 25% shale, 9% Red Clastics, 43% amphibolite gneiss, 4% biotite gneiss, and 17% granite. The composition of the M11 melt breccias was reproduced by a mixture of about 19% shale, 25% Red Clastics and 48% mafic gneiss components, with 7% contribution from the granitic target rocks.

SAMPLES AND TECHNIQUES. About 140 target rock and impactite samples from 11 of the 12 new (M1 - M11; 1991-92) drill cores, as well as samples from the two 1953 drill cores (1A, 2A) were studied for their mineralogical and petrographical characteristics and major and trace element composition [1-3]. Detailed data on all samples are reported in [3]. From chemical data we identified eight main target rock components. Five of the components are of sedimentary origin: 1. Shale; 2. Sandstone (80-90 wt% SiO_2); 3. Siltstone (all quartz-rich rocks with >90 wt% SiO_2); 4. Red Clastics (i.e., sandstones); and 5. Carbonates (including limestone and dolomite of different age). Three additional components represent the crystalline basement: 6. Amphibole gneiss (<60 wt% SiO_2); 7. Biotite gneiss (60-70 wt% SiO_2), and 8. Granite (>70 wt% SiO_2). The M1 core has been sampled more extensively than the other cores, and also has yielded some of the best impact melt breccia and suevite samples with little compositional variation over the depth in the core [3]. Average compositions were calculated [3] for M1 impact melt breccias and M1 suevites, as well as for impact melt breccias from the M11 core (from the southern flank of the central uplift). There is abundant evidence that the suevites and melt breccias in M1 (and others of similar composition in other cores) result from large scale mixing and, in case of the impact melt breccias, have been subjected to high temperatures.

MIXING CALCULATIONS. We performed a series of mixing calculations to reproduce the observed composition of the impactites (i.e., impact melt rocks and breccias, and suevites) by mixtures of different proportions of target rocks, using the harmonic least-squares (HMX) mixing calculation program [4]. This program allows any number of target rock components and mixture parameters (e.g., elemental abundances) to be employed. In addition, this method has the advantage over other mixing model methods that uncertainties obscuring the parameters of components and/or mixture enter the model computation. Not all chemical data can be used for the mixing calculations (volatile/mobile elements); thus, calculations were performed with major element parameters only, and with major elements in combination with a number of trace elements that appeared to be sufficiently different in abundance from component to component (see Table 1 for details on the computation runs). The calculated mixture compositions are given in Table 1 for various runs (best runs are shown in Fig. 1a-c), together with discrepancy factors that are a calculated measure for the validity of the results: the better and statistically more valid a result, the closer the corresponding discrepancy value approaches 0. For example, the results obtained in Run 1 are not satisfactory, as the Na_2O and K_2O contents in the breccias are probably affected by alteration. Addition of trace element data (Sc, Cr, Co, La, Yb, Hf, Th, and U) to the parameter list did not improve the results, but did not significantly change them either. Deviations of the calculated from the observed values are given in Table 2. The M1 impact melt breccia was formed as a mixture of shale, Red Clastics, a mafic component ("amphibolite") and granite, with minor contributions from carbonate and biotite granite. Results for the M1 suevite were not as tightly constrained as for M1 melt breccia. It appears that the contribution from shale is higher, but that of granite possibly lower. The mixture of M11 melt breccia was nicely reproduced in Runs 2 and 3: these melt breccias were also formed from major shale, Red Clastics and mafic gneiss components, with some contribution from granitic target.

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REFERENCES: [1] Koeberl, C., Anderson, R.R., Hartung, J.B., and Reimold, W.U. (1993) LPS **XXIV**, 811-812. [2] Koeberl, C., Anderson, R.R., Boer, R.H., Blum, J.D., Chamberlain, C.P., Kracher, A., Reimold, W.U., Träxler, B., and Vormaier, A. (1994) LPS **XXV**, 719-720. [3] Koeberl, C., Reimold, W.U., Kracher, A., Träxler, B., Vormaier, A., and Körner, W. (1995) in Koeberl, C., and Anderson, R.R., eds.: The Manson Impact Structure, Iowa: Anatomy of an Impact Crater, GSA SP, in press. [4] Stöckelmann, D. and Reimold, W.U. (1989) Math. Geol. 21, 853-860.

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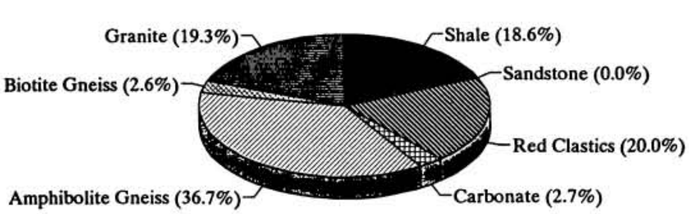
TABLE 1. RESULTS OF HMX-MIXING CALCULATIONS: MANSON IMPACT MELT BRECCIAS AND SUEVITES

Run	Impact Lithology	Source Rock Types								Discrepancy Factor
		Shale	Sandstone	Siltstone	Red Clastics	Carbonate	Amphibolite Gneiss	Biotite Gneiss	Granite	
1	M1 Melt breccia	5.8±1.6	<1	<1	16.5±1.3	1.7±0.5	45±1.2	0.2±1	29.5±1.6	8
1	M1 Suevite	<1.2	<1	<1	<1	<1	67±2	<1	33±3	72
1	M11 Melt breccia	<2	<1	<1	26±1.5	0.6±0.4	42±1.1	<1	7±1.3	8.5
2	M1 Melt breccia	18.6±1.4	<0.6	<0.8	20±0.9	2.7±0.3	36.6±1	2.6±1	19.3±2	1.7
2	M1 Suevite	35±1.6	13.7±1.3	<0.5	3.6±0.9	1.1±0.3	35±1.4	11.3±1.8	<0.6	6.5
2	M11 Melt breccia	16±0.5	<0.7	<0.5	26±0.4	<0.1	42±0.5	10.5±0.4	3.9±0.6	0.04
3	M1 Melt breccia	19.6±1.4	<0.6	<0.7	19.5±0.9	3±0.3	36±1.0	2.2±0.9	19.3±1.6	1.8
3	M1 Suevite	25.3±1.8	0.9±1.6	<1.1	9±0.9	1.2±0.4	43±1.3	3.8±1.5	17±1.6	6.3
3	M11 Melt breccia	18.8±1.5	<0.7	<0.9	25.3±1	0.8±0.25	43±1.2	5.4±1.5	6.9±1.4	1.8
5	M1 Melt breccia	10.9±0.02	0	0	15±0.04	2.9±0.07	39.2±0.06	0	31.2±0.01	11

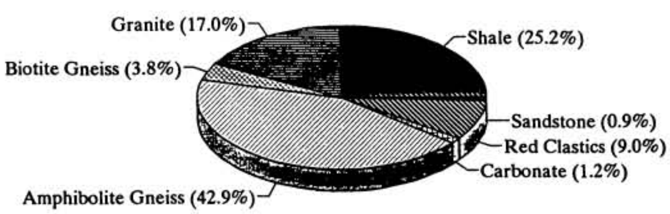
Data in %. All runs were constrained to yield a total of 100 %. Run 1: all major elements except P; run 2: major elements except Na, K, and P; run 3: as run 2, but with granite as pivot (forced) component; run 4: not constrained to 100 % totals - no meaningful results were obtained; run 5: as run 3, but with additional 8 trace elements (Sc, Cr, Co, La, Yb, Hf, Th, U).

Fig. 1a-c: Calculated mixing proportions of Manson target rocks to reproduce the compositions of the M1 impact melt breccia (a), M1 suevite (b), and M11 impact melt breccia (c). The runs with the lowest discrepancy factors are plotted.

M1 Impact Melt Breccia



M1 Suevite



M11 Impact Melt Breccia

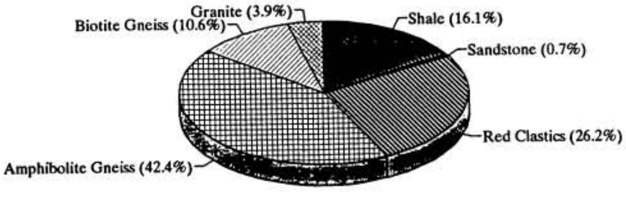


TABLE 2. COMPARISON OF MEASURED IMPACTITE COMPOSITIONS WITH THOSE OBTAINED FROM THE MIXING CALCULATIONS

	M1 Melt Breccia		M1 Suevites		M11 Melt Breccias	
	run 2	$\Delta_{obs-calc}$	run 3	$\Delta_{obs-calc}$	run 2	$\Delta_{obs-calc}$
SiO_2	63.43	-0.05	61.39	<0.01	64.04	-0.45
TiO_2	0.87	0.014	0.84	0	0.991	-0.001
Al_2O_3	13.17	0.08	15.18	0	12.96	-0.08
Fe_2O_3	5.67	-0.20	6.62	<0.01	6.45	-0.03
MnO	0.085	<0.001	0.091	0	0.096	0.003
MgO	3.12	0.08	3.38	0	3.11	-0.02
CaO	3.58	-0.20	4.09	<0.01	2.77	-0.10

All data in wt%. The runs giving the best results (Table 1) were used for this comparison. $\Delta_{obs-calc}$ = observed value (Ref. [3]) minus calculated value. Details see text and [3].