CHEMISTRY OF THE KARA IMPACT STRUCTURE: CHARACTERISTICS OF IMPACT MELTING AND EXCAVATION. D.D.Badjukov, M.A.Nazarov, and L.D.Barsukova. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow 117975

Introduction. A new geomorphologic analysis [1] of the Kara impact site suggests that the Kara structure is a complex impact crater with a diameter of 120 km that is significantly larger than the original estimates [2, 3]. The suggestion can be examined through geochemical data which should reflect a scale of melting and excavation related to a crater size. In the paper we provide a preliminary reconstruction of an original diameter of the Kara crater and a preimpact target structure based on geochemical and geological data.

Target rocks. The Kara target comprises Paleozoic sediments of from Ordovician to Permian age. The sequence of about 8.5 km thick [4] covers Proterozoic rocks which are very close to the present surface in the central uplift. Before the impact the Paleozoic sequence was overlain by Cretaceous sediments of <0.5 km thick. Permian sandstones and shales constitute an orogenic formation which was formed as a result of uplift and erosion of the Ural. The average composition of the rocks (Table,N1) is unusual [5] and can be modelled by mixing of upper crust (52%) basalt (45%) and ultramafic (3%)components.Other Paleozoic rocks are mainly represented by limestones, shales, and jaspers. Geochemistry of the rocks is poor studied. It can be suggested from lithology, our analyses and published data [6-8] that the formation is generally higher in Ca (limestone), Si/Al (jasper) and K/Na (illite) when compared to Permian rocks. It is also important that the formation includes Mn and Ba ore deposits and diabase dikes [8]. Thus the Kara target contains two layers different in major and trace elements that can be used for reconstruction of a scale of melting and excavation.

Impact melts. It was reported [6] that the Kara impact melts were formed from Permian rocks only. Our analyses of glass fragments from suevites show that the majority of the glasses (Table, N2) are very close in chemistry to Permian sediments. However we identified a group of Ca-rich glasses and a group of silica glasses which are very different in their compositions from Permian rocks. The Ca-rich glasses (Table, N3) are high in Ca,Si,K/Na, and Mn that indicates their origin from Pre-Permian Paleozoic rocks. The Ca-rich glasses are similar in chemistry to blue glasses from Zhamanshin crater [9]. The silica glasses could be formed from Devonian jaspers that is supported by trace element contents. Thus in contrast to [6] we conclude that the melting zone penetrated through Permian sediments. A quota of Pre-Permian melts is ~15 % of total mass of Kara impact melt.

Suevites. It has been shown [2] that suevites of the southern part of the Kara crater are higher in fragments of Pre-Permian rocks than suevites of the northern part of the crater. However clasts of Proterozoic rocks were not identified in the Kara suevites. Our analyses of suevite matrix support the observation. In fact the southern suevites (Table, N4) are higher in Ca, Si, Mn and K/Na relative to the glass-poor upper suevites (Table, N5,) exposed in the northern part of the crater, and to the glass-rich lower suevites (Table, N6), enriched in Permian melts. We estimated that the southern suevites contain only about 46% of the Permian material, whereas the upper suevites and the lower suevites have 67% and 80% of the Permian component respectively. The differences mean that the excavation zone in the southern part penetrated through Permian deposits but did not reach Proterozoic rocks that is consistent with geological data [10]. Therefore the base of the Permian formation before the impact should deep to the north and a pre-impact thickness of the formation should be larger in the northern part of the impact site. Using data on the recent inclination of Permian sediments and the crater bottom we estimated the pre-impact angle of the deep of the Permian formation to be 11°.

Discussion. Thus our geochemical study shows that the Kara impact melt contains about 15% of a Pre-Permian component. Using the value and models of the crater formation [11] we can estimate a depth of melting, and, then, a rim-to-rim crater diameter, if a pre-impact thickness of Permian deposits is known. Geophysical data shows that a recent thickness of the deposits is about 3 km.However Permian deposits were heavily eroded. Because of uplift of the Pai-Khoi mountains the erosion depth is 2 km larger in the southern part of the Kara structure than that in the northern part of the structure [3]. An absolute erosion depth can be estimated suggesting in accordance with geological data that northern suevites of the Kara central depression were not eroded and at present the tops of suevites and Permian deposits are at the same altitude. Under the conditions and using the lunar crater morphometry [11] to calculate an original depth of the Kara crater and its rim height, one can compute the erosion depth in the southern and northern parts of the structure to be 5 and 3 km respectively. Therefore a pre-impact thickness of Permian (and Cretaceous) deposits at the impact center should be about 7 km. It gives the depth of melting of about 10 km, and, then, the Kara rim-to-rim diameter of about 110 km. A reconstruction of the target structure at the impact moment (Fig.) shows that in accordance with geological and geochemical data the southern excavation zone penetrates through the Permian layer but does not

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reach Proterozoic rocks. Thus the consideration supports the results of the geomorphological analysis [1]. The Kara crater original diameter of about 100 km seems resonable.

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	1			2			3			4			5			6		
	x	Sx	N	x	Sx	N	x	Sx	N	x	Sx	N	x	Sx	N	x	Sx	N
SiO2	62.31	1.23	12	61.77	.20	144	69.28	1.06	18	65.84	1.52	11	63.93	.42	16	61.96	.45	14
TiO2	.95	.03	12	.88	.01	144	.60	.03	18	.70	.03	11	.84	.01	16	.97	.01	14
Al2O3	15.79	.42	12	15.97	.17	144	9.97	.45	18	12.29	.69	11	14.37	.19	16	16.06	.26	14
FeO	7.19	.41	12	6.49	.09	144	4.01	.17	18	5.16	.22	11	6.24	.12	16	6.93	.24	14
MnO	.11	.02	12	.08	.01	144	.29	.05	18	.22	.04	11	.15	.01	16	.10	.01	14
MgO	4.57	.26	12	5.00	.08	144	2.53	.17	18	4.22	.36	11	4.18	.12	16	5.81	.27	14
CaO	3.86	1.07	12	4.22	.17	144	10.01	.55	18	7.68	.72	11	6.28	.36	16	3.22	.15	14
Na2O	3.02	.23	12	3.37	.08	144	.73	.13	18	1.53	.24	11	1.70	.18	16	2.40	.22	14
K2O	2.00	.20	12	2.07	.02	144	2.34	.11	18	2.16	.10	11	2.09	.08	16	2.33	.10	14
P2O5	.20	.01	12	.15	.01	80	.24	.04	5	.20	.00	11	.22	.01	16	.22	.01	14
Sc	19.6	1.3	9	21.5	1.1	16	12.7	1.9	4	14.6	1.2	5	17.7	1.1	9	20.9	1.4	8
V	172	12	11	178	12	5				158	3	9	166	4	15	169	3	13
Cr	265	25	12	239	16	19	59	4	4	157	20	10	212	6	15	277	7	13
Co	26.0	4.4	9	24.2	1.3	16	15.5	.9	4	16.1	1.3	5	19.6	1.2	8	21.2	1.8	8
Ni	151	13	12	125	8	12	70		1	105	8	10	122	4	16	140	5	13
Cu	91	11	11	108	12	5				104	4	9	108	6	15	110	5	13
Zn	126	4	11	131	4	5				152	6	9	143	3	15	130	2	13
As	8.4	1.8	7	11.3	1.2	8	3.8		1	5.9	1.3	5	9.1	2.1	5	12.3	1.8	3
Rb	58	4	12	65	3	12	82	5	4	72	4	9	61	3	15	48	5	13
Sr	182	40	12	312	30	12	208	12	3	358	37	9	300	22	15	329	72	13
Zr	159	8	12	168	11	12	140	50	2	149	9	9	154	5	15	160	7	13
Sb	.5	.1	6	.9	.16	8	2.0	.6	3	2.3	.8	3	2.5	.5	6	.78	.1	3
Ba	278	30	12	527	61	12	555	9	3	783	83	9	490	30	15	562	149	13
La	16.7	1.4	9	21.2	.7	16	22.5	.9	4	21.5	2.6	5	20.8	1.1	9	18.2	1.1	8
Ce	36.4	2.5	9	43.6	1.2	16	41.8	3.8	3	44.9	4.2	5	40.5	2.5	8	37.8	2.3	8
Nd	17.0	1.0	9	20.1	.7	16	22.3	1.9	4	20.2	1.7	5	18.6	1.0	8	19.1	1.4	8
Sm	4.2	.2	9	4.8	.1	16	4.3	.2	4	4.4	.3	5	4.2	.2	9	4.3	.3	8
Eu	1.06	.04	9	1.13	.04	16	.90	.06	4	1.07	.13	5	1.12	.05	9	1.00	.12	8
Tb	.63	.04	9	.79	.03	16	.61	.03	4	.76	.06	5	.71	.03	9	.72	.02	8
Yb	2.3	.14	9	2.7	.1	16	2.0	.1	4	1.97	.1	5	2.1	.1	9	1.97	.14	8
Lu	.35	.02	9	.42	.02	16	.30	.01	4	.32	.02	5	.34	.01	9	.31	.02	8
Hf	4.2	.1	9	4.5	.3	10	2.9	.1	3	3.9	.6	5	4.2	.4	7	4.2	.4	8
Ir,ppt	376	125	9	314	57	6				130	24	4	346	30	6	292	38	5
Au,ppb	.68	.15	3	1.4	.7	3				1.3	.4	3	1.3	.3	5	1.1	.14	4
Th	5.4	.6	9	6.8	.7	16	5.0	.1	3	5.9	.2	5	5.9	.4	9	6.2	.7	8
U	2.0	.1	9	2.8	.2	14	3.2	.1	4	3.3	.7	5	3.2	.4	9	2.7	.3	8

x - mean value; Sx - standard error of the mean; N - number of analyses. All Fe as FeO.