THE TUNGUSKA EVENT: MINERALOGICAL AND GEOCHEMICAL DATA. M.A.Nazarov[1], M.I.Korina[1], G.M.Kolesov[1], N.V.Vasil'ev[2], and E.M.Kolesnikov[3]. [1]V.I.Vernadsky Inst. of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow; [2]Commission on meteorites and cosmic dust, Siberia Department of USSR Academy of Sciences, Tomsk; [3]Inst. of Mineral Resourses, Moscow; USSR

Introduction. Cometary event was proposed to explain of Jr enrichment and biotic crisis at the KT boundary[1,2]. However Ir content and composition of mineral component in cometary material are yet unknown. For this reason we studied mineralogy and geochemistry of the Tunguska event in 1908 interpreted as cometary collision[3]. We reported here results of microprobe and INAA study of (1)mineral component separated from three peat layers of various age in 4 cores near to the event epicenter, and (2)black spherules collected from soil[4]in region of its anomaly concentration (80 km to NW from the epicenter). They was presented by 16 large (0.14-0.35mm) spherules selected as probably containing the metal core[5] and bulk sample of small (0.1-0.14mm) spherules. Besides we determined by RNAA Ir content in the bulk epicenter peat and mineral component of the one core.

Results. The peat mineral component is composed of usual sand. Black spherules were identified (but not studied) in the all cores with no concentration in the layer of 1908 age, that does not support data[6]. The all mineral fractions contain also unusual blue glassy agglutinate-like particles (up to 1mm) The 11 such particles were studied in detail. They consist of inhomogeneous glass subdivided according to the composition into low Ti (1), moderate Ti (II) and high Ti (III) types (Table 1). The glasses of the types I and II are enriched in Si,Cr,Fe,Mn,Ca and Co and poorer in P relatively to the type III glass. The latter occurs as porous crust on the types I and II glass particles, sometimes as individual particles. One particle contain high Fe(type IV), but similar to the type I and II glass in other element contents, except Si. In general the all glasses have high Na,K,Co,Mn and Ti, low Ca,Mg and AI and moderate Si concentration with deficiency of sum of analyses in 10-15%, that may be caused by the presence of element lighter Na. INAA data for the particles show the enrichment in Ir,Au,REE,Th and Hf;the type III glass is richer in La than the low Ti glasses(Table 2,Fig.1).Mineralogical study established wustite,faylite and iron metal(Co 9,Ni 3 wt.%) in the Fe-rich particle, and Co-chromite(29%CoO),Co-Cr-magnetite, usual chromite and clastic quartz in the low Ti glasses. The 9 large and 126 small black spherules(Table 3) were subdivided into the following groups: (I)High Ni magnetite plus wustite spherules (all 9 large and only 9 small spherules belong to this group(Fig.2);there is metal core(Ni 82%) in two large spherules(Fig.3a)); (II)Olivine spherules(Fig.3b) with dendritic magnetite(one of them is enriched in Ni); (III)"Impure" magnetite plus hematite spherules(Fig.3c) subdivided further into 6 groups (Table 3); (IV)"Pure" magnetite plus hematite spherules with martite texture(Fig.3d); (V)High Ti spherules; and (VI)Iron metal spherules rimmed by oxides; their metal contains Ni and Co(0.1%) and C(4 spherules).The "impure" and "pure" spherules are the most abundant composing 83% of the all small oxide particles. INAA data for the black spherules(Table 4) are showed on Fig.4. Ir content is 0.035 and 0.054 ppb (±0.008) in the peat layer of 1908 age and above its, respectively, in the event epicenter,and 0.027 in the peat layer of the same age in 80km southward.The peat mineral component have 0.19-0.28 ppb Ir.The Ir increasing in the mineral component of the layer of 1908 age did not detected.

Discussion. The studied glass particles are enriched in Ir, but they are similar to some types of structural glass[7]in alkalies and "color" element(Co,Cr,Mn) contents that supposes their industrial origin.High Ir content may be explained by Co presence inasmuch as these elements associate in Cu,Niore mines.The other glass particles analysed early from the Tunguska event region are probably industrial also. In fact, glass spherules described by[4,5,8,9] in their high Ca content and low Na/K ratio are near to blast-furnace slags[10].Three spherules collected from the peat layer of 1908 age[11] are identical in composition to container industrial glass[7]. However according to INAA data[12]the bulk samples of the same spherules have perhaps tektite-like composition that demands additional study of such particles. Now only olivine spherules reported here are certainly extraterrestrial as analogous to stony spheres of the deep-sea sediments[13,14].The black spherules of group 1 appear the strong resemblance with iron cosmic spheres[13,15-17]and are obviously extraterrestrial also.Such spherules have been already described in the Tunguska event region[4,5]. In contrast the high Ti and metal spherules are clearly volcanic and industrial, respectively.The cosmic origin of the "pure" and "impure" spherules are doubtful.The first is similar to industrial spherules of New York City area[18].The second, especially enriched in Mn, may be metallurgical products.In support of the fear the siderophile pattern of the large spherules is almost chondritic,while the one of bulk sample of the small spherules are fractionated showing industrial signs (high Re,Mn and As).From Ir content the bulk small spherule sample should contain 15% of the group I spherules, that is compatible with mineralogical data.It suggests very little content of cosmic material in the Tunguska event region.Low Ir content in the bulk peat samples confirms this conclusion. Higher Ir content in the peat mineral component is anomalous,but it corresponds to $1\cdot10^{-14}g/cm^2\ 10^2y$, that is 100 times lower than the value calculated from usual influx of cosmic dust[19].Thus our data conflict with[4,6] who suggested extraterrestrial anomalies in the Tunguska event region from spherule distribution. It means that either the anomalies was formed by selective concentration of terrestrial dust or the Tunguska bolid contained or produced the dust in its co.position yet unknown in space but similar to the some industrial materials.On the other hand, our data assume that either the Tunguska bolid did not contain chondritic or iron component at all, or this component was presented only by very fine dust that had large time of residence in atmosphere and was not deposited in the event region. If the Tunguska bolid indeed contained ~20% of dust[20], then Ir content in the body may be estimated as 100 ppb as maximum using Cl dust composition. Hence, Ir content in the Tunguska bolid material can be from 0 to 100 ppb. Within this uncertainty Tunguska-like cometxry event could cause both low Ir PT and high Ir KT biotic crisises.

Table 1. Tunguska glass composition (microprobe data, wt%)

	I		II		III		IV	
	x	s	x	s	x	s	x	s
SiO_2	52.62	5.37	53.69	2.91	45.24	2.18	37.25	4.47
TiO_2	.31	.34	2.78	1.34	13.08	3.05	1.14	.50
Al_2O_3	6.96	1.34	8.64	1.05	8.07	1.25	6.67	.55
Cr_2O_3	.24	.77	.12	.09	.01	-	.17	.20
FeO	1.51	2.00	.51	.20	.16	.10	26.85	4.80
MnO	1.13	1.23	1.23	.23	.12	.19	.87	.30
MgO	.54	.39	1.03	.27	1.28	.44	.84	.11
CaO	4.74	1.92	3.29	.67	.78	.56	3.21	.30
Na_2O	12.56	1.64	15.54	1.12	12.59	1.78	11.80	1.28
K_2O	2.08	.51	1.64	.16	2.48	.41	1.18	.37
NiO	.31	.21	.09	-	.02	-	.11	.06
CoO	.89	.88	1.61	.30	.21	.35	.93	.93
P_2O_5	.31	.65	.16	.15	2.01	.90	.21	.03
SO_3	.10	.16	.15	.14	.04	-	.14	.16
Sum	84.30		90.48		86.09		91.37	
N	15		15		22		5	

Total iron expressed as FeO. x - average; s - standard deviation; N - number of analyses.

Table 2. Trace element contents of Tunguska glasses. (INAA data. Units ppm, except Ir and Au, ppb.)

	Cr	Sc	Co	Ga	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Hf	Th	Au	Ir
1	1100	5.1	8600	-	54	15	12.5	5.3	2.5	1.5	4.6	.70	5.6	22.5	880	22
2	140	4.9	1300	202	9.6	23	23	7.8	2.8	1.9	4.1	1.0	3.8	11.0	220	51

1 - type I or II glass; 2 - type III glass (see text and table 1).

Table 3. Black spherule compositions. (Microprobe data. Wt.%)

	I				II	III											IV	V
						a		b	c		d		e		f			
	x	s	x*	s		x	s	x	x	s	x	s	x	s	x	s	x	
SiO_2	.20	.33	0	0	38.71	.14	.16	1.78	1.03	.56	4.96	.54	.08	-	.32	.07	.09	0
TiO_2	.05	-	.05	-	0	.03	-	.03	.05	-	.07	-	.05	-	.05	-	.04	40.86
Al_2O_3	.28	.27	0	0	1.40	.22	.28	.39	.36	.24	1.17	.23	.10	.18	.93	.24	.05	.08
Cr_2O_3	.28	.56	.23	.14	.13	.03	-	0	.02	-	.02	-	.01	-	0	0	.03	0
FeO	86.7	6.74	95.1	1.51	24.6	80.7	7.57	78.7	88.6	2.41	83.4	1.17	87.5	4.47	86.0	2.41	90.8	55.13
MnO	.03	-	.01	-	.16	1.11	.39	2.21	.08	-	.16	.04	.34	.07	.10	.07	.04	.76
MgO	.08	-	0	0	32.75	2.51	2.27	6.93	.10	.12	.34	.07	1.30	.68	.26	.09	.06	1.18
CaO	.14	.18	0	0	.46	3.39	3.02	.49	.12	.18	.56	.25	3.17	3.29	0	0	.02	0
NiO	4.88	3.69	2.63	1.07	2.21	.06	-	.02	.04	-	0	0	.03	-	0	0	.05	0
CoO	.41	.25	.45	.13	.01	.04	-	.06	.04	-	.03	-	.04	-	.02	-	.06	0
Sum	93.0		98.47		100.4	88.13		90.6	90.4		90.7		92.6		87.7		91.2	98.0
N	9		9		3**	10		2	17		6		5		3		61	6**

Total iron expressed as FeO. * - large spherules; ** - represented compositions; x - average; s - standard deviation; N - number of spherules.

Table 4. Element contents of Tunguska black spherules. (INAA data. Units ppm, except Ni and Co, wt.%)

	Ni	Co	Re	Ir	W	Au	Ga	Ge	Mn	Sc	As	Lu
1	9.6	.39	.3	5.5	.6	.74	<1	32	107	-	.8	.05
2	.3	.046	.7	.82	.26	.47	<1	30	450	<4.9	7.5	120

1 - large spherules; 2 - small spherules.

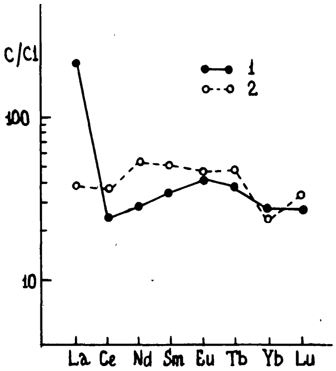


Fig.1.Cl-normalized REE patterns of low Ti (1) and high Ti (2) glasses.

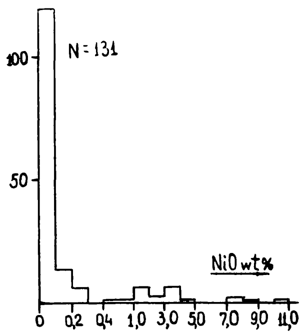


Fig.2. Ni contents in black spherules.

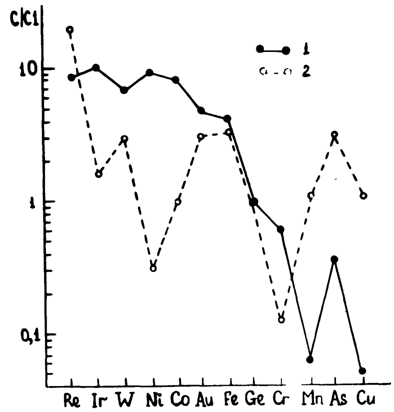
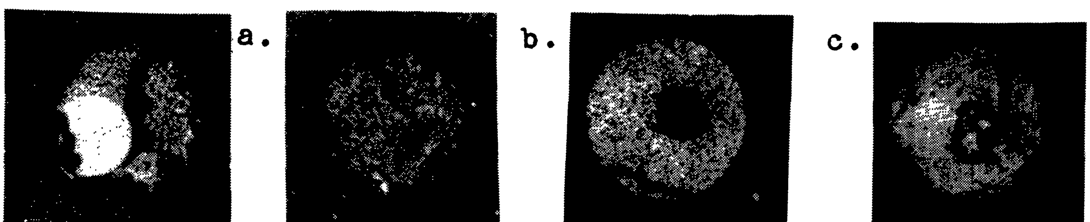


Fig.4. Cl-normalized element patterns of large (1) and small black spherules.

Fig.3



a. b. c. d.

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