THE PERMIAN - TRIASSIC BOUNDARY EVENT: GEOCHEMICAL INVESTIGATION OF THE TRANSCAUCASIA SECTION.

A.S.Alekseev[1], L.D.Barsukova[2], G.M.Kolesov[2], M.A.Nazarov[2] and A.G.Grigoryan[3] [1]Geological Faculty,Moscow State University,Moscow; [2]V.I.Vernadsky Inst. of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow; [3]Inst.of Geological Sciences, Armenia Academy of Sciences, Yerevan, USSR.

Introduction. The biotic ctisis at the end of Cretaceous was interpreted as result of asteroid or cometary event,because of Ir enrichment of the KT boundary sediments [e.g.1]. It suggests that other great faunal changes in the Earth history could be caused by the similar extraterrestrial events. The strongest extinction took place at the end of Permian. It had disappeared about 96% of species [2] and up to 52% of families [3] of marine organisms. However Ir anomaly was not detected at the Permian-Triassic (PT) boundary in China [4]. In this work we studied the extraterrestrial version of the PT event as the view from Ir and other elements stratigraphy of Sovetashen PT section in South Armenia [5].

Sampling. According to our data the upper part of Paratirolites Beds in the Sovetashen section (Fig.1) is composed of the grey limestone (bed 1) and the nodular, irregularly clayish, red limestone (bed 2).The latter is conformably overlained by the thin layer (20 cm thick) of red marl (bed 3). This marl is characterized by the presence of rhombohedral calcite crystals (probably chemical precipitate) and by the surprizing constancy of granulometric composition of clastic material represented by clayish fraction only. The upper unit of the marl (3B) is more calcareous with signs of silicification and contains small limestone pebbles. Above it is a stromatolitic limestone (bed 4) followed by thin-bedded limestones with Claraia and ammonites (bed 5). Usually the PT boundary is placed at the base of Otoceras Zone [6].This level matches to bottom of the bed 3 from our conodont study. Sampled localities are showed on Fig.1; the boundary material was sampled continually by 1-3 cm thick specimens.Ir was determined by RNAA with 30% accuracy. Other element contents were measured by XRF method.

Results. Ir content in Sovetashen section (Fig.1,Table) ranges from 0.003 to 0.04 ppb and is not anomalous relatively to terrestrial Ir background [7]. There is not any correlation of Ir with other elements. When calculated to insoluble residue Ir content is certainly highest at the top of the each stratigraphical unit that may be controlled by the rate of sedimentation. From this point of view the lowest rate of deposition took place at the end of Permian. Other element contents are typical for sedimentary rocks. There are strong positive correlations among Fe, Ti, K, Mg,V, Zr and P with insoluble residue, while Sr distinctly follows Ca content. Ba concentration is nearly constant in the most part of the section, but it suddenly decreases at the very base of Triassic by a factor of 4. In general, distribution of elements except Mn, Ba and Ir, in the PT boundary deposit may be easy represented by mixing of carbonate and clayish (illite) components fixed in composition, although some contribution of silica into 3B unit is necessary also.

Discussion. We conclude from the model mixing calculation that the chemical composition of the clayish material did not change essentially and its source was the same during the PT boundary sedimentation. Therefore the negative Ba anomaly indicates the change of sedimentary environment preventing of Ba precipitation, but not input of special low Ba clayish component. The poorness in fauna and the presence of chemically deposited calcite at the PT boundary demands that the environment change was resulted from decreasing of bioproduction. It is compatible with the reduction of Ba conteht, because Ba geochemistry is strongly controlled by organic matter [8]. However the Ba crisis could be also caused by decreasing of salinity of sea water. Experiments [9] show that decreasing of salinity up to 5‰ prevents $BaCO_3$ deposition, and if Mg/Ca ratio in sea water is <1, it can leads to precipitation of rhombohedral calcite like to observed in the PT sediments. Thus the sharp faunal change at the PT Sovetashen section is marked by crisis of bioproduction to be perhaps accompanied by decreasing of salinity. This crisis was the most abrupt and heavy at the very base of Triassic being expressed in layer of 5 cm thickness (Ba anomaly) that assumes catastrophe nature of PT biotic event. Now geographic scale of the crisis is not clear because of the very poor geochemical knowledge of PT sections. However salinity crisis was argued in Abadeh section [6] from Li and B distribution and was postulated for the whole Otoceras Zone from fauna study [10]. Besides the usual presence of clayish bed at the PT boundary in the all complete sequences [5,6,11,12] as well as at KT boundary [13] suggests that the PT event could be produced by same reason.

The absence of Ir anomaly at the PT boundary in Armenia and China would not invalidate extraterrestrial cause for this event.In fact,if the content of projectile in sediment is 1% as minimum diluted by ejecta and sedimentary material, and the projectile Ir content was <10 ppb then the sediment would have contained < 0.1 ppb Ir that cannot be considered as anomalous. Hence only impact of projectile with Ir content >10 ppb could be determined in sediments.The such projectile would have been >4 km in diameter with provided that the projectile material was spread equally in 2 cm thick sedimentary layer on the whole Earth surface and the projectile density was $<3\ g/cm^3$.However the real fixation of cosmic Ir in sediments is strongly connected with environment of deposition [14].For example we determined only 0.4 ppb Ir in the Kølby Gaard KT section (our unpublished data) in contrast to 58 ppb Ir in Stevns Klint clay [14]. Thus,dilution of projectile by sedimentary material may be higher then it was postulated above, and more

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rich in Ir impact could be not recognized in sediments. Nevertheless the collision of projectile with < 10 ppb Ir and any mass would not be identified certainly. It suggests that the PT event could be resulted from collision of achondrite asteroid or cometary event, if the cometary body contained < 2% component C1 but not from high Ir impact. Cometary impact have been already supposed for PT event [4] and can be possible indeed because cometary material is probably poor in Ir [15]. Moreover cometary impact, when compared with achondrite one, has some advantage as more frequent in time. If the PT projectile impacted polar region it would generated wide spreading of polar water decreased in salinity at least in Early Triassic [16] that would killed of stenohaline organisms and could be responsible for both biotic and salinity crises assumed at the PT boundary. However there is not clear evidence from the Ir and other element geochemistry that PT event was indeed caused by impact. Consequently, the other early proposed reasons for PT extinction can not be excluded also including the model of gradually (non-catastrophic) decreasing of salinity of sea basins at the end of Permian [17].

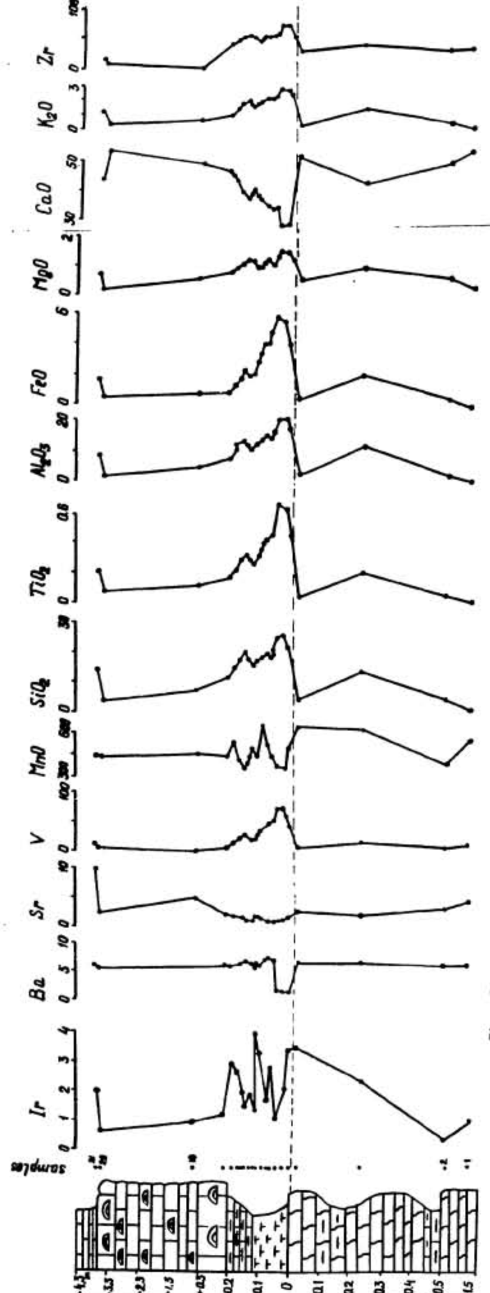

Fig. Distribution of elements at Sovetashen PT boundary. Units wt.%, except Ba and Sr, 10^{-2} wt.% and MnO, Zr, and V, ppm, and Ir, 10^{-7} wt.%. Total iron expressed as FeO.

Table

Element contents in Sovetashen PT boundary samples.

Dist. from bound. (cm)	Sample No	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	K_2O	P_2O_5	L.i.w.	Total	Sr	Zr	V	Ba	Ir
-130	1	1.46	.03	.70	-	.30	.055	.37	53.66	.21	.054	41.64	98.48	431	35	-	559	.008
-60	2	5.18	.07	1.83	-	.75	.041	.63	49.65	.57	.084	40.06	98.86	324	34	-	568	.004
-4-0	4	4.24	.06	1.51	-	.53	.065	.56	51.62	.43	.038	40.93	99.98	294	30	9	606	.035
0-2	5	21.39	.46	8.77	.001	4.05	.050	1.20	34.99	2.29	.080	29.79	103.07	179	64	42	135	.034
2-4	6	25.73	.63	10.71	.003	5.69	.036	1.50	28.74	2.73	.091	26.30	102.16	121	74	74	153	.021
4-6	7	24.91	.66	10.59	.002	5.80	.037	1.47	28.24	2.71	.081	26.10	100.60	121	74	73	154	.010
6-8	8	20.79	.46	8.11	.-	4.64	.045	1.28	35.02	2.20	.079	29,58	102.20	110	59	53	689	.028
8-9	9	18.61	.44	7.09	-	4.23	.052	1.06	33.95	2.10	.064	30.31	97.91	131	58	49	698	.016
10-11	11	18.10	.37	6.65	-	3.43	.044	1.10	37.12	1.93	.068	31.86	101.33	152	54	34	605	.039
13-14	14	17.51	.29	5.92	-	2.05	.039	1.17	38.93	1.61	.064	33.06	100,64	140	51	23	615	.014
16-18	16	17.46	.29	6.05	-	1.76	.041	1.04	39.17	1.67	.067	32.94	100.49	163	53	21	610	.027
18-20	17	15.49	.22	5.19	-	1.40	.054	.91	43.11	1.41	.062	34.99	102.84	192	47	11	581	.029
20-22	18	11.26	.17	3.58	-	.88	.045	.72	46.30	.95	.073	37.36	101.34	231	40	9	583	.012
360	20	3.19	.06	.89	-	.45	.044	.22	54.01	.29	.028	41.51	100.85	203	-	8	559	.006
380	21	13.47	.19	3.93	-	1.51	.043	.66	44.20	1.06	.049	36.05	101.18	995	10	10	590	.020

Units wt.%, except Sr, Zr, V, and Ba, ppm, and Ir, ppb. Total iron expressed as FeO.

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