A MULTI-ELEMENT STUDY OF ISUA IRON-FORMATION, W-GREENLAND.

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Meta-sediments from Isua, West-Greenland were analyzed by instrumental thermal neutron activation analysis (ITNAA). These sediments are chemical precipitates having some layers of remarkably high Cr content. The latter were compared to Cr-poor layers. It tourned out that the Cr-enriched layers had higher Ir- and Ni-contents than the samples from the Cr-poor layers. Compared to phanerozoic samples the highest Ir-contents are not extraordinarily higher than in a "modern" sediment, and the Cr-poor layers, representing more or less "normal" sedimentation are not significantly higher in Ir than an average phanerozoic shale (s. table).

From the cratering record of the moon we can assume a similar cratering of the Earth at about the time when the Isua rocks were formed. Can such an enourmous flux of extraterrestrial material be detected in those very old Archean rocks? The noble metals, esp. Ir, proof to be sensitive tracers for the detection of an extraterrestrial component in the Earth's crust because of their high depletion in the crust relative to chondritic abundances. Consequently analyzing the noble metal content of sedimentary rocks of archean, proto- and phanerozoic age one should find a certain decrease in noble metal content from the archean to "modern" sediments, representing the decrease of the total amount of the "late accretion" component. When looking at the data (s. table) from the Isua rocks one cannot find that the amount of Ir is considerably higher than in an average phanerozoic sediment taking into account that the Cr-poor layers don't show an Ir enrichment relative to "modern" sediments at all! The question is now are the Isua metasediments still too young to find this higher proportion of a meteoritical component which would mean that the time of the heavy meteorite bombardment ended before the Isua sediments were deposited. Or is there any geochemical or geodynamic process responsible for a redistribution, mixture or dispersion of an extraterrestrial component added to the Earth's crust, thus making its detection difficult or impossible? From the geochemical properties of many noble metals we can assume that they are not very mobile under sedimentary and low grade metamorphic conditions. If a greater proportion of the noble metals in the crust are brought to crust from the space they should be found in a roughly chondritic ratio and be clearly detectable from the highly fractionated indigenous siderophiles (cp. HERTOGEN et al., 1980). Using the Ni/Ir ratio for tracing meteoritic material, we must consider the mobility of Ni in low temperature geological processes, a difficulty which became evident in the discussion of the C/T-boundary noble metal enrichments. As shown by PALME (1982) impact melts of terrestrial meteorite craters contain several noble metals nearly unfractionated relative to chondritic abundances. But not all impact-generated materials have such a quality of preservation as the 290 m.y. old Clearwater impact melt. The "boundary clays" of the C/T-boundary which are thought to contain a certain proportion of meteoritic material are much younger but the original pattern is far less well preserved than the impact melt (PALME, 1982). And all these materials are much younger than archean rocks representing sudden and drastic events while in the archean rock, we are looking for an evidence of a "background" continuous flux. Nevertheless it is clear that late accretional processes have brought a small amount of Ir to the Earth's upper mantle, at a time when this amount of siderophile elements could not be extracted by a metal phase and brought to the core. At this time the mantle should have been roughly chondritic in the noble metals. Partial melting, differentiation and crust formation created rocks which were highly depleted in Ni and Ir bearing phases. Despite the extrusion of considerable quantities of unfractionated mantle material, may be partly after massive break-up of the early crust as a result of several giant meteorite impacts, it is rather likely that the continuous flux of small extraterrestrial objects and dust were the main source of most of the noble metals contained in the archean crust. But a lot of geological processes superimposed a terrestrial signature on the abundance patterns which makes it so difficult to account for the meteoritic component in the old rocks.

The Cr-rich layers of the Isua rocks contain not only a siderophile-enriched component but they are also enriched in Sc, Hf, Ta, and to a much lesser extent in other lithophiles like Th, U and the REE esp. the light REE. The element abundances of these samples are complex and point to different source materials. APPEL (1979) proposed a meteoritic origin of chromite grains found in these layers but the chemistry of the host rock does not show any features compatible with this idea.

References:

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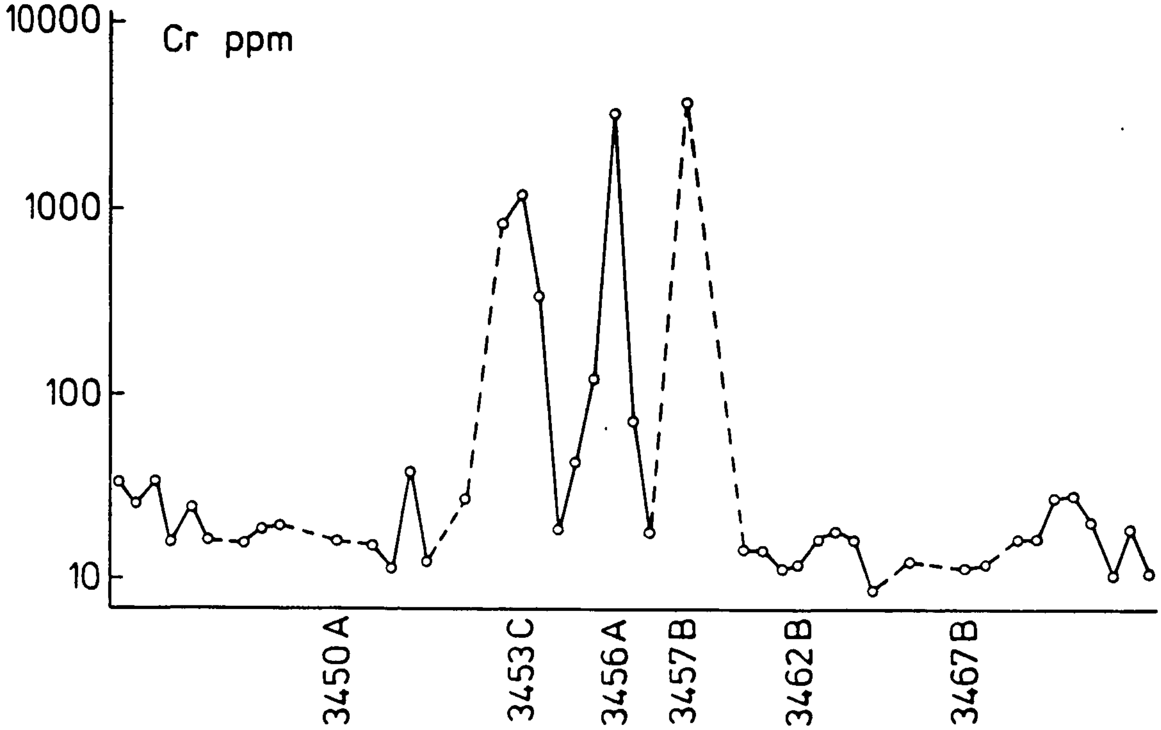

Fig. 1: Chromium-content of a section in the Isua iron-formation. Unpublished data obtained by atomic absorption spectroscopy, kindly permitted for use by P. APPEL, Geological Institute, University of Copenhagen. Samples analyzed by ITNAA are marked by sample number.

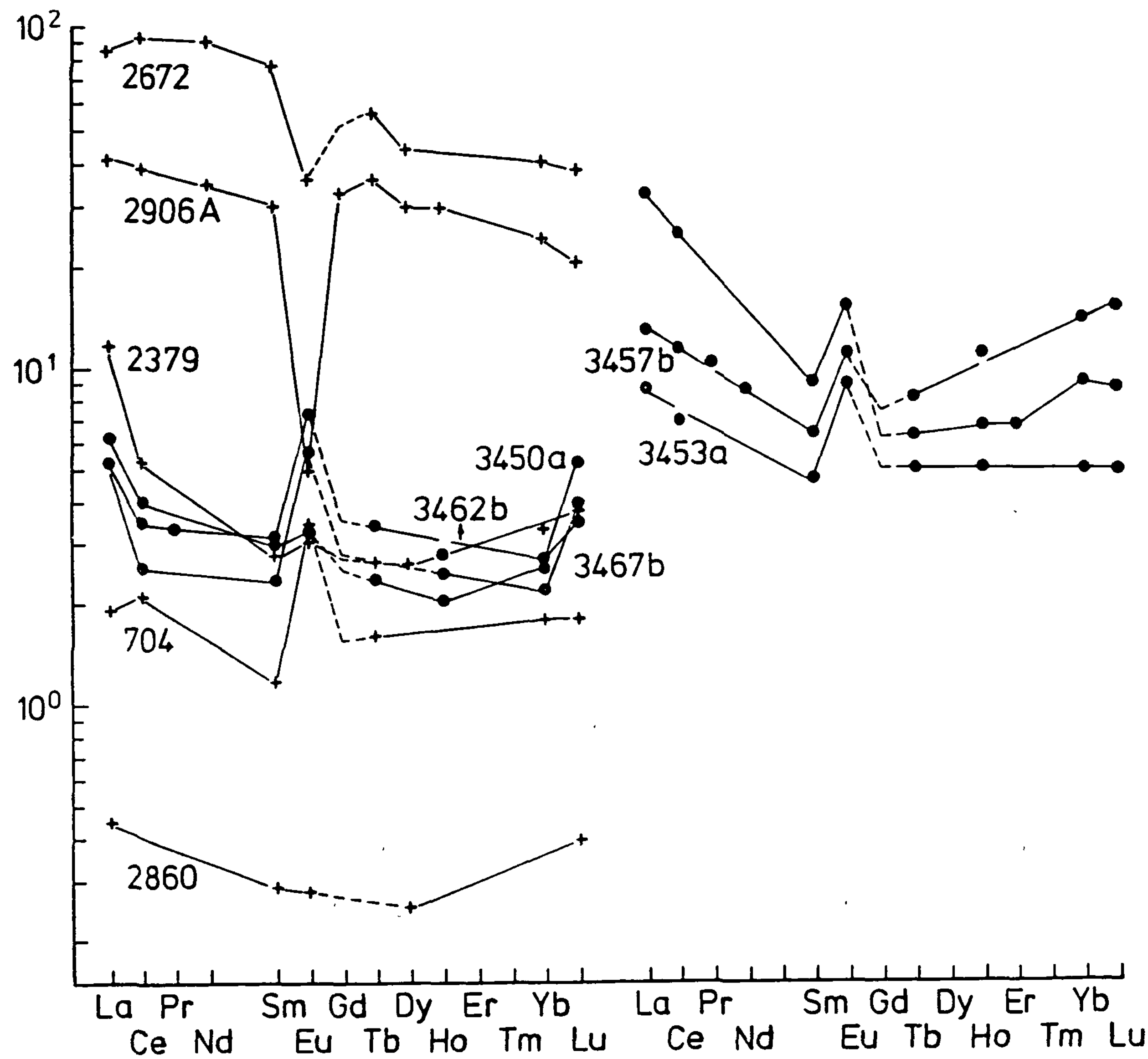

Fig 2: REE-pattern of Isua-rocks normalized to C1-type carbonaceous chondrite REE contents. Data from samples 2860, 704, 2379, 2906A, 2672 unpublished results from B. SPETTEL, Max-Planck-Institut f. Chemie, Mainz, kindly permitted for use. The REE values of C1-type carbonaceous chondrite were taken from PALME et al. (1981).

Sample	Na	K	Rb	Cs	Sc	Cr	Mn	Fe[%]	Co	Ni	Cu	Zn	Ga	As	Br	Sb
3450a	16.8	6	36	<0.05	2.68	4.91*	31400	46.4	17.7	72*	44.5	63.3	3*	0.09	0.3	0.03
3453c	27.4	17		<0.1	24.8	1410	22800	36.8	34.5	400	38	230	14.6	0.345	0.2	0.14
3456a	29.2	12			24.2	3590	18900	42.3	27.3	735		153	15.5	0.345	0.2	0.13
3457b	28.0	10	26	<0.14	24.8	3940	9840	42.5	29.2	850		210	14.0	0.25	0.2	0.06
3462b	13.2	3	25	<0.24	2.55	8.24*	28200	48.2	20.4	77*	37.4	65.5	1*	0.048	0.2	0.06
3467b	15.8	5	50	0.2	2.68	9.59*	32100	44.5	16.2	70*	19.2	64.8	3.5*	0.165	0.2	0.04
Error [%]	3	30	30	50	2	2 *7	2	2	2	2 *15	15	10	5 *15	25	25	30

Sample	La	Ce	Pr	Nd	Sm	Eu	Tb	Ho	Tm	Yb	Lu	Hf	Ta	Ir	Au	Th	U
3450a	1.53	2.58			0.46	0.19	0.087	0.116	0.14	0.42	0.13		0.01*	0.001	0.001	0.18*	0.14*
3453c	2.13	4.41			0.713	0.514	0.183	0.282	0.151	0.81	0.121	0.502	0.102	0.004		0.28	0.21
3456a	7.82	15.7		4.7	1.38	0.877	0.228	0.38		1.46	0.214	3.63	0.363	0.005	0.003	1.57	0.756
3457b	3.13	7.2		3.6	0.971	0.632	0.3	0.62	0.46	2.24	0.371	4.03	0.458	0.0033	0.004	1.89	1.09
3462b	1.28	2.25	0.32		0.485	0.433	0.127	0.16		0.45	0.088	0.03	0.18*	<0.001	0.002	0.065*	0.098*
3467b	1.30	1.65			0.361	0.308	0.23	0.14		0.36	0.098	<0.06		<0.001	0.0017	0.05*	0.15*
Error [%]	3	20	25	25	5	5	15	20	25	15	15	5	10 *25	25	25	10 *25	10 *25

Tab. 1: Analytical results of several samples from the Isua iron-formation (cp. Fig. 1) obtained by ITNAA. The analytical precision is given in %. All values in ppm, except Fe [%].