Sector of NAA and Applied Research
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Neutron activation analysis and microscopy of extraterrestrial materials

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Radioanalytical complex REGATA at the reactor IBR-2

ANALYTICAL INVESTIGATIONS AT IBR-2 REACTOR

Instrumental neutron activation analysis INAA	*Epithermal neutron activation analysis ENAA*	*Cyclic neutron activation analysis CNAA*

Life Sciences

- **Biomonitoring** of atmospheric deposition of heavy metals and other elements (Project **REGATA**)
- Control of quality and safety of **foodstuffs**, grown in industrially contaminated areas of RF and South Africa (**grant of SA**)
- Assessment of different ecosystems and their impact on **human health**

Material Science

- **Biotechnologies:** new pharmaceuticals, biosorption and synthesis of nanoparticles
- **NAA for extraterrestrial materials**
- NAA for the technological process of synthesis **of diamonds and NB (boron nitride)**
- Analysis of **archaeological and museum objects** from Russian and other countries
- NAA for **decommissioning of Nuclear Power Plants** and **utilization of industrial wastes**

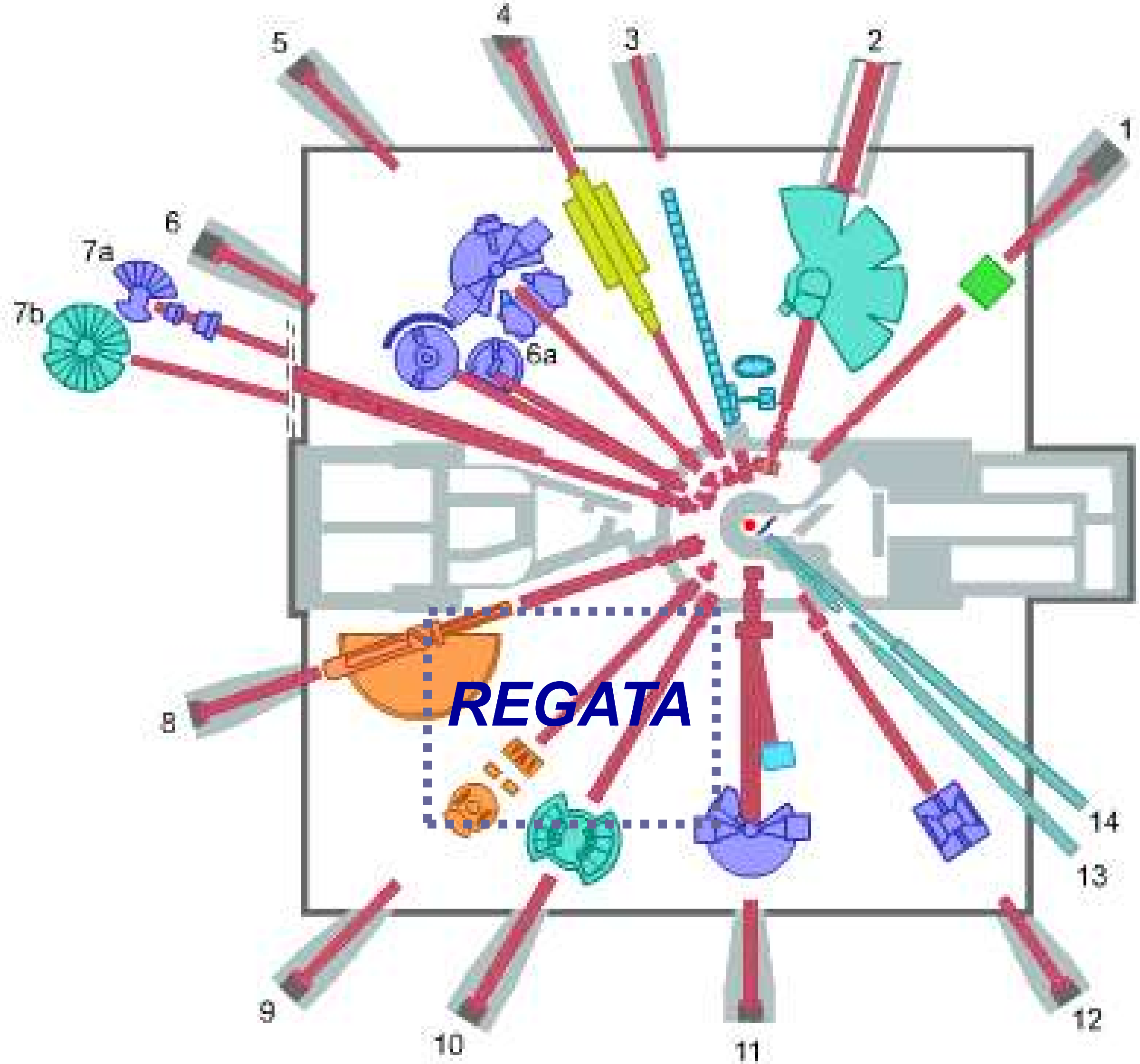
Retro-spective…

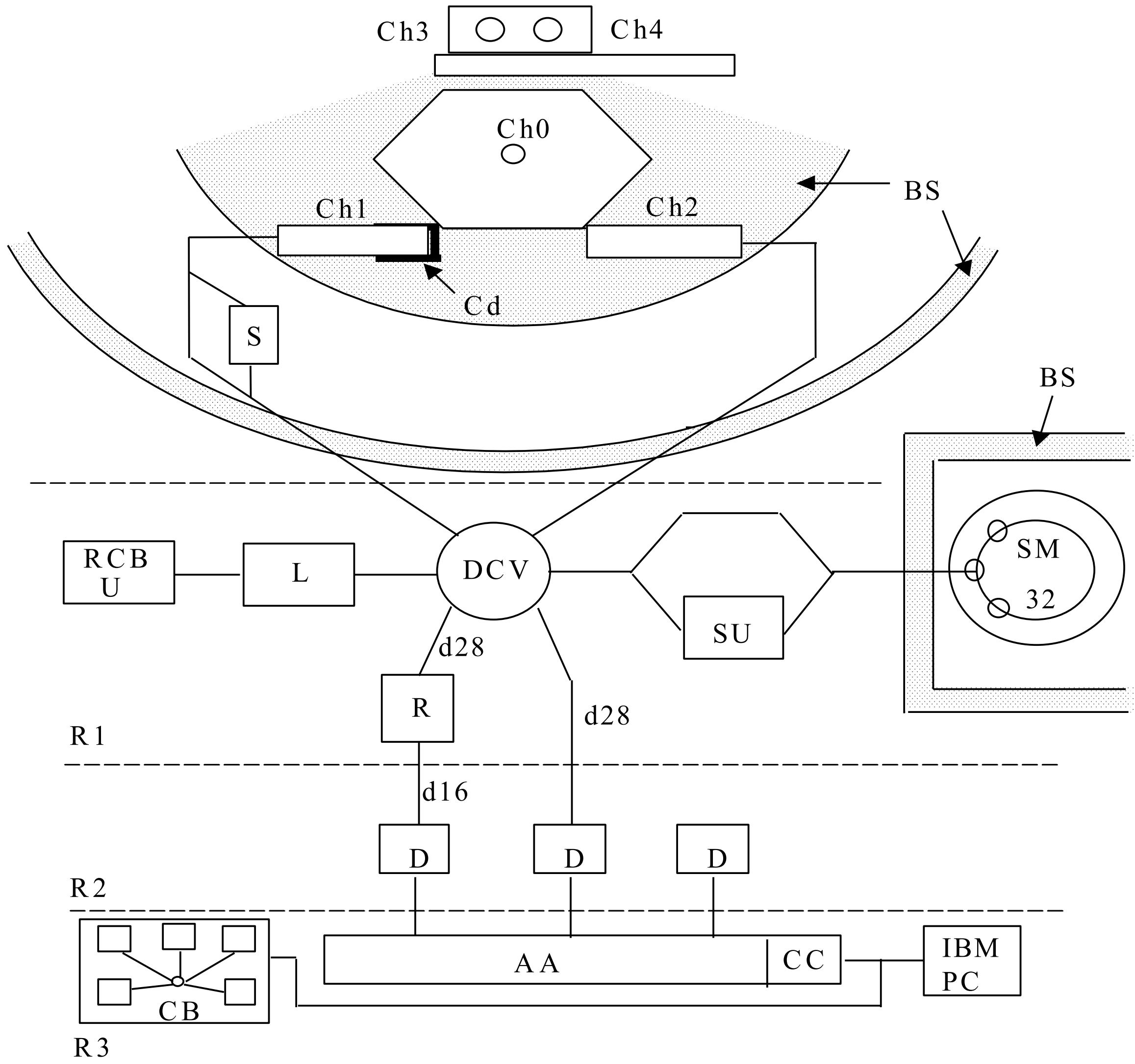
NAA

at IBR-2 reactor

- dinosaurs' eggs from Mongolia – search for iridium (Ir)
- meteorites (GEOCHI RAS, Moscow, Italy)
- nodules from Gulf of Bothnia
  (Faculty of Geography, Moscow State University)
- nodules from North Pacific Ocean
  (Clarion-Clipperton abyssal plane,
  Institute of Marine Geology and Geo-ecology,
  Bucharest University, Romania)
- natural planchettes: moss, peat-bog cores
  (Switzerland, Norway, Western Siberia, Poland)
- meteorites from NASA - Astrobiology

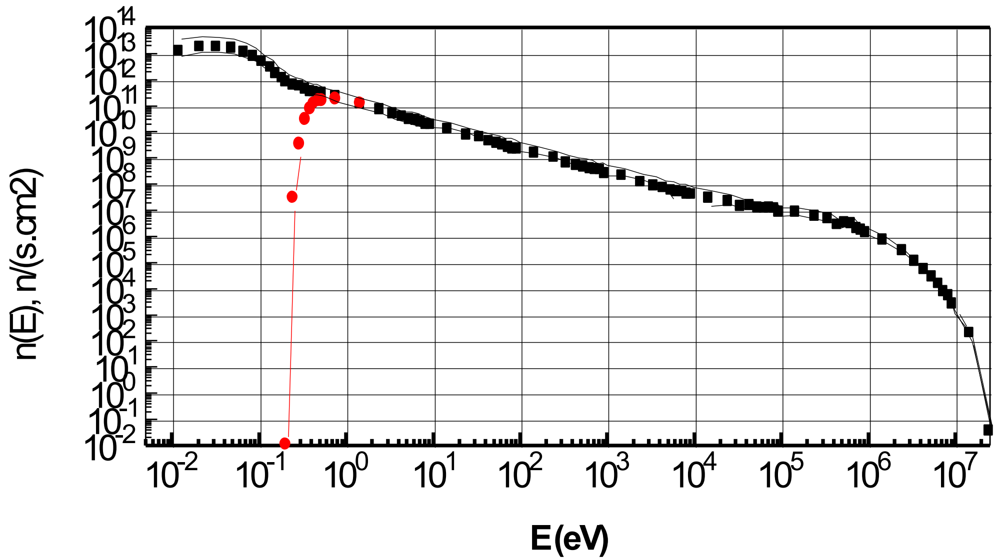
Reactor IBR-2M and Radioanalytical complex REGATA





Ch1-Ch4 –irradiation channels, S- intermediate storage, DCV- directional control valves, L- loading unit, RCB- radiochemical glove-cell, U- unloading unit, SU- separate unit, SM- storage magazine, R- repacking unit, D- Ge(Li) detector, AA- amplitude analyser, CB- control board, CC- CAMAC controller, R1-R3- the rooms where the system is located

Neutron energy spectra and irradiation channels



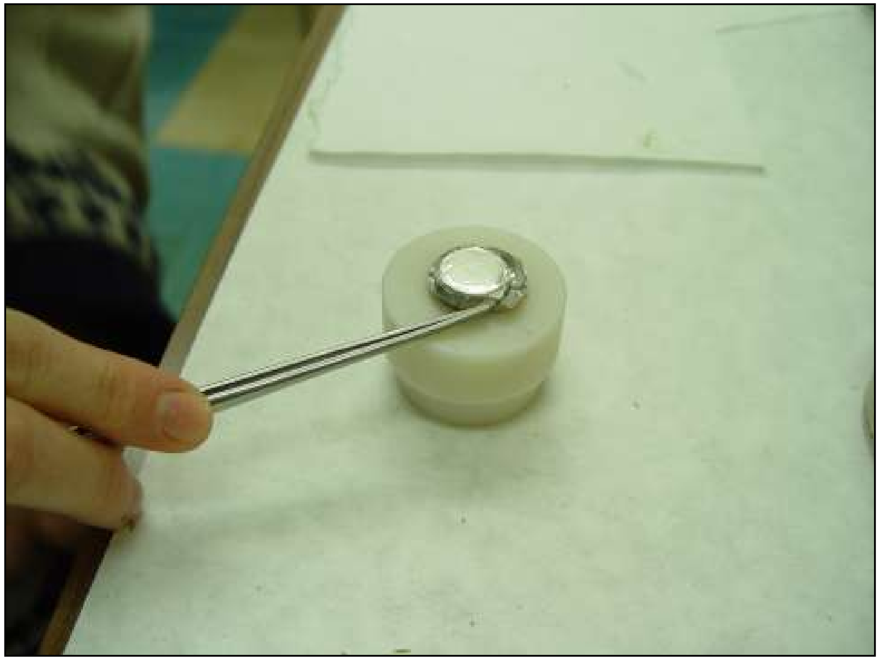
Neutron energy spectra in irradiation channels CH1(■) and CH2 (curve)

The main characteristics of the irradiation channels at 1.5 MW

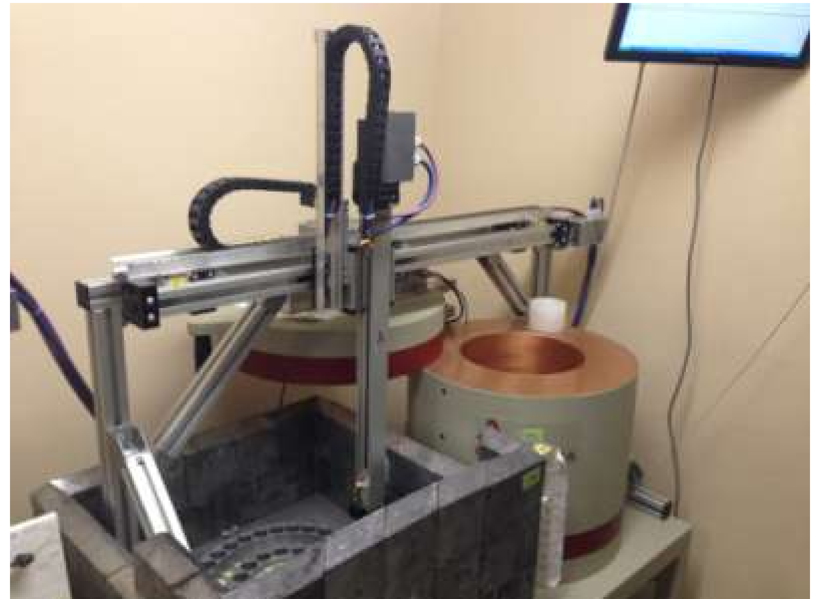
Irradiation site	Neutron flux density (n/cm^2 s) 10^{12}			T °C	Channel diam., mm	Channel length, mm
	Thermal	Resonance	Fast			
Ch1	Cd-coated	3.31	4.32	70	28	260
Ch2	1.23	2.96	4.1	60	28	260
Ch3	Gd-coated	7.5	7.7	30-40	30	400
Ch4	4.2	7.6	7.7	30-40	30	400

Chemical laboratory of Dept. NAA & Applied Research

and some equipment for sample preparation




1.
2.
3.



Three sample changers were installed

Each sample changer consists of:

- two axes liner movement device M202A (DriveSet, Germany);
- rotating disk with 40 cells for samples (JINR);
- three axes Xemo Motion controller with software and cables (Systec GmbH, Germany)

World experience of applying NAA, ENAA, and RNAA to extraterrestrial materials (the lunar rocks and fines)

Lunar samples

Apollo 11 (1969) carried the first geologic samples from the Moon back to Earth.

In all, astronauts collected 22 kilograms of material, including 50 rocks, samples of the fine-grained lunar "soil," and two core tubes that included material from up to 13 centimeters below the Moon's surface

Six missions with astonauts

Apollo 11, 1969, **N. Armstrong, B. Aldrin,** M. Collins

Apollo 12, 1969, **Ch. Conrad, A. Bean,** R.F. Gordon

Apollo 14, 1971, **A.Shepard, E. Mitchell,** S. Roosa

Apollo 15, 1971, **D. Scott, J. Irwin,** A. Worden

Apollo 16, 1972, **J. Young, Ch. Duke,** Th. Mattingly

Apollo 17, 1972, **E. Cernan, H. Schmitt**, R. Evans

Apollo 13 did not land due to a mechanical problem that nearly killed the crew. The 3rd man listed in each mission did not walk on the Moon, but instead stayed in orbit around the Moon in the command module while the other two landed in the lunar module.

Talanta, 1971, Vol. 18, pp. 1197 to 1208. Pergamon Press. Printed in Northern Ireland

A NEUTRON-ACTIVATION SCHEME DEVELOPED FOR THE DETERMINATION OF 42 ELEMENTS IN LUNAR MATERIAL

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Summary—A neutron-activation scheme designed for the determination of 42 elements in lunar rocks and fines is described. The scheme is based on seven different irradiations, four of which are followed by direct γ-spectrometry, and three by radiochemical separation systems. The total sample consumption for duplicate analysis is about 800 mg. The scheme has been tested on basalt BCR-1, and results for this standard rock are presented. Analytical experience obtained from analyses of lunar samples and BCR-1 is discussed.

Prof. Eiliv Steinnes is the Honorary Doctor of JINR

Proceedings of the Fourth Lunar Science Conference
(Supplement 4, *Geochimica et Cosmochimica Acta*)
Vol. 2, pp. 1209–1218

Geochemistry of Apollo 15 and 16 materials

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Abstract—Neutron activation analysis data are given for two soils, three breccias and one rock sample from the Apollo 16 and 17 missions together with analytical data on separated soil fractions. These results and data on Apollo 15 and 16 soils, breccias, rocks and minerals previously published by us, are discussed together with results from microprobe analyses of some mineral fractions. Apollo 15 soils and breccias can be derived from a mixture of mare and non-mare (KREEP) basalts and anorthositic rocks, the mare basalt content decreasing with decreasing distance from the Apennine Front. On the basis of chemical and mineral composition the Apollo 15 mare basalts are considered to be derived from at least two distinct lava flows. The Apollo 16 regolith is very homogeneous presumably representing material from the Cayley Formation only. Apollo 16 soils and breccias exhibit a marked enrichment in Al and Ca, and depletion in Mg and Fe compared to those from the other landing sites, reflecting the higher anorthosite content of the highland rocks. KREEP basalts similar to sample 14310 from the Fra Mauro landing site are present. The high Ni and Co contents in Apollo 16 breccias together with the unusually high contents of the volatile elements Cl, Zn and In in breccia 66095 may indicate a higher percentage of admixture of an extra-lunar component in the Descartes area than at the other landing sites.

Proceedings of the Fifth Lunar Conference
(Supplement 5, Geochimica et Cosmochimica Acta)
Vol. 2 pp. 981–990 (1974)
Printed in the United States of America

Elemental composition of Apollo 17 fines and rocks

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Abstract—Neutron activation analysis data for 33 elements in eight soils, five mare basalts, and one breccia from the Apollo 17 mission are discussed. A number of elements determined in the soils give linear plots versus the Al content, consistent with a simple two-component mixing of a basaltic and a plagioclase-rich end-member. The composition of each end-member is estimated assuming 4.8% Al in the mare basalt and 0.45% Ti in the "non-mare component." Elements associated with KREEP are low in soils from Stations 6 and 8 as compared to those from stations close to the South Massif, indicating a lower content of KREEP type material in the noritic rocks of the North Massif and/or Sculptured Hills. Soil 74261 is enriched in volatiles (Cu, Ga, Zn, alkali elements) relative to the other soils, probably due to a high content of "orange soil." Based on Cu and Ga data, the other soils probably contain <3% "orange soil." The Apollo 17 mare basalts are very similar to the Apollo 11 type B basalts. Two types of Apollo 17 basalt can be distinguished on the basis of the Ti content. The Apollo 17 "non-mare component" is lower in Al, Ca and higher in Fe, Mg, Mn, Cr than the typical Apollo 16 soils. Its composition corresponds to a 50%-50% contribution of noritic breccias and anorthositic rocks. Breccia 73235 is similar in composition to the "non-mare component."

Irradiation

Irradiations were carried out in the JEEP-II reactor (Kjeller, Norway). For short irradiations (groups *A–C*) the pneumatic tube facility, with a thermal neutron flux of $1{\cdot}5 \times 10^{11}$ $n.mm^{-2}.sec^{-1}$ was employed. The longer irradiations (groups *D–G*) were carried out at a position in one of the vertical isotope channels where the thermal neutron flux was about $1{\cdot}5 \times 10^{11}$ $n.mm^{-2}.sec^{-1}$ and the cadmium ratio of gold was about 3.

TABLE I.—SURVEY OF EXPERIMENTS INCLUDED IN THE SCHEME

Experiment	Irradiation	Irradiation time	Delay before start of experiment	Type†	Detector used	Approximate sample weight
A	Thermal*	30 sec	No delay	ND	Ge(Li)	10 mg
B	Thermal	5 min	2 hr	ND	Ge(Li)	Samples from (*A*)
C	Epithermal	2 d	3–5 d	ND	Ge(Li)	100 mg
D	Thermal	1 d	5 d	ND	Ge(Li)	Samples from (*C*)
E	Thermal	15 min	20 min	RC	NaI + Ge(Li)	50 mg
F	Thermal	20 hr	30 hr	RC	NaI + Ge(Li)	50 mg
G	Thermal	7 d	7 d	RC	NaI + Ge(Li)	200 mg

* Irradiation with the total reactor neutron energy spectrum.
† ND = Non-destructive; RC = Radiochemical.

Journal of Radioanalytical Chemistry, Vol. 18 (1973) 153–167

ELEMENTAL ABUNDANCES OF LUNAR SOILS BY NEUTRON ACTIVATION ANALYSIS

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Department of Chemistry, Cornell University, Ithaca, New York 14850 (USA)

Although a variety of analytical techniques have been employed for the determination of trace element abundances in lunar materials, one of the most useful has been neutron activation analysis.[1] This paper describes one such method developed by our laboratory for the determination of 42 elements in lunar soil and rock samples. It is based on the use of radiochemical group separations and high resolution gamma spectrometry.[2]

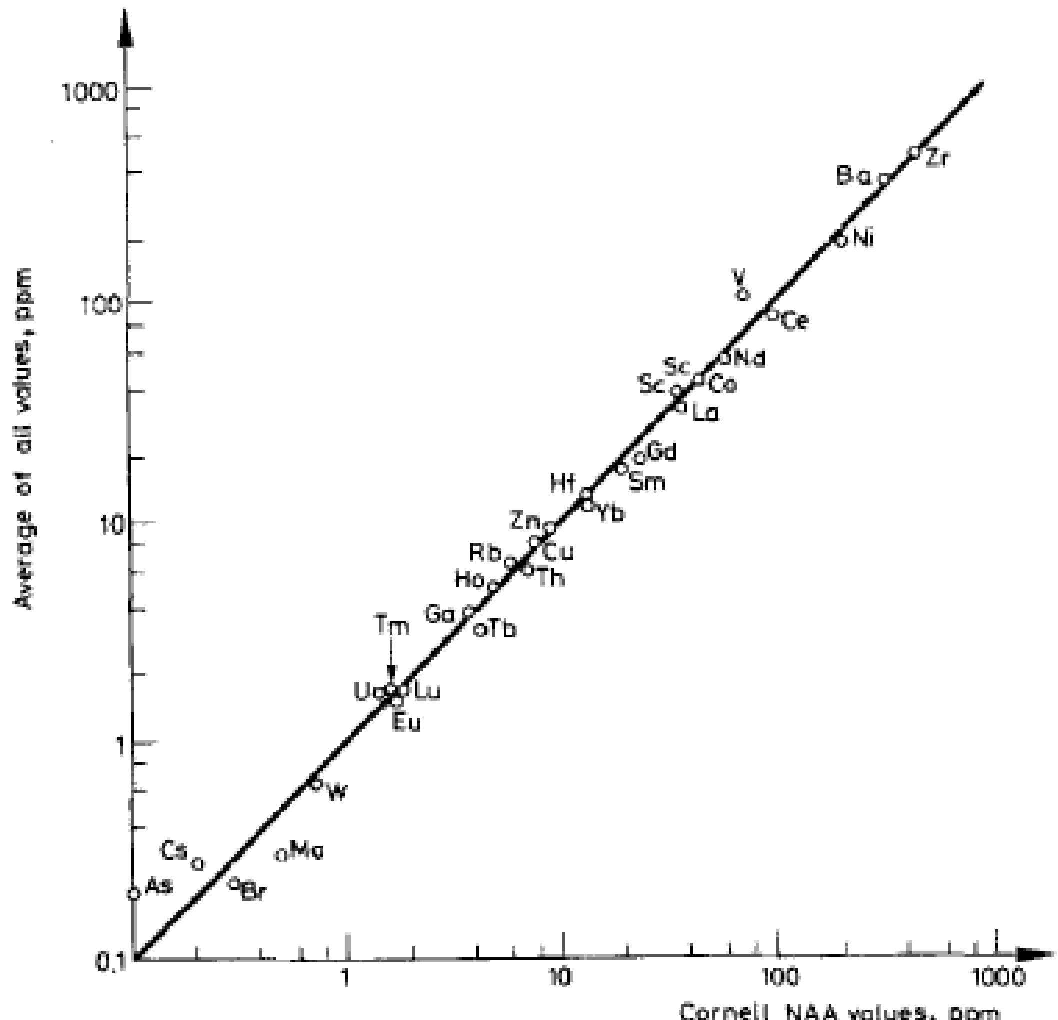


Fig. 2. Comparison of Cornell neutron activation analysis results and the means of all other investigators for trace elements in soil sample 12070

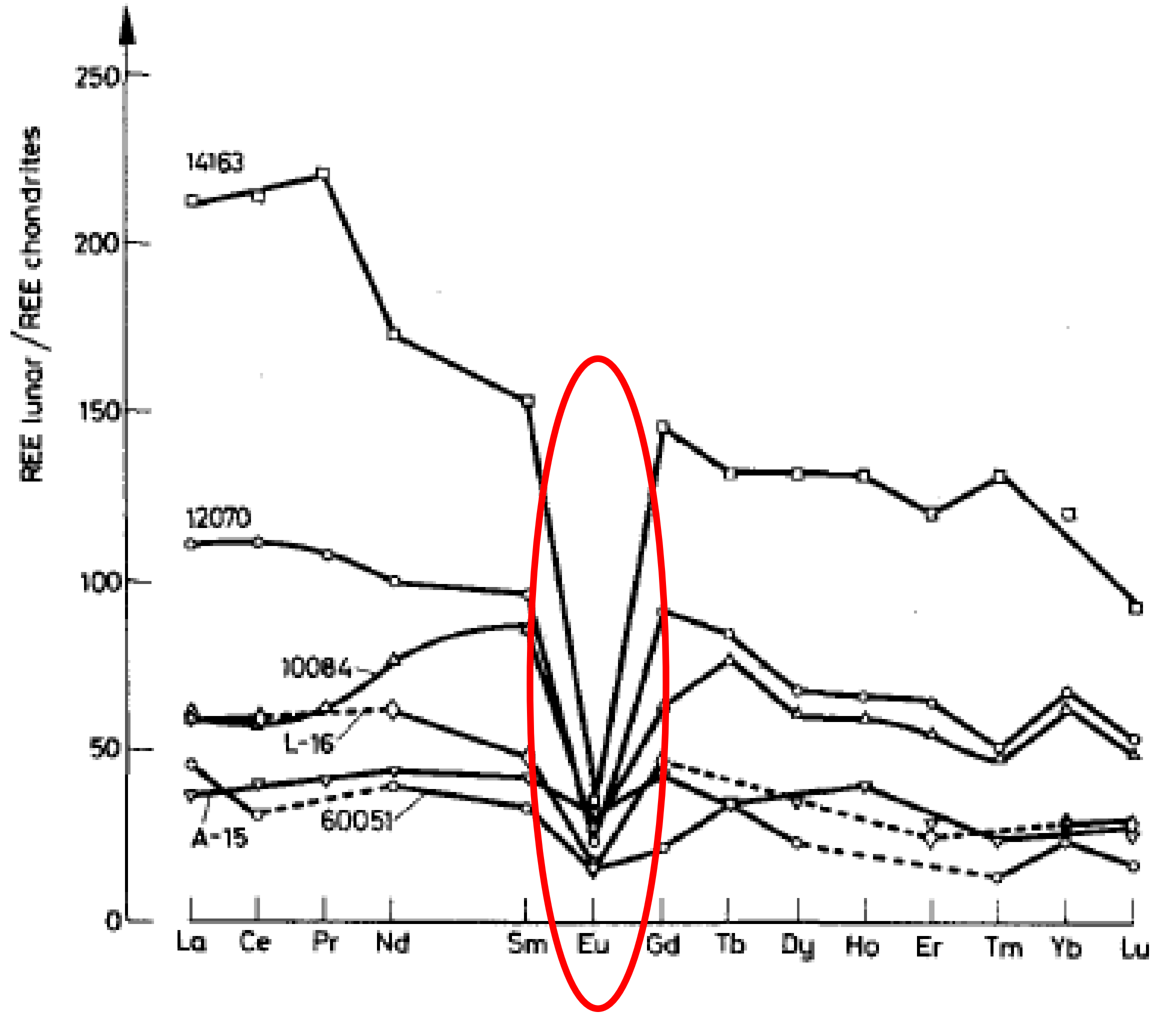
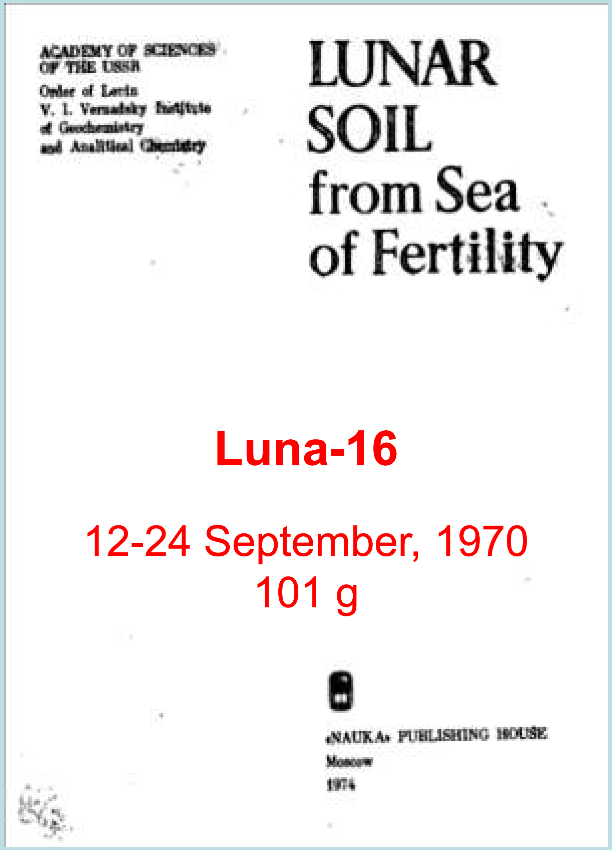


Fig. 6. Comparison of rare earth elements in various lunar sites

USSR LUNA return missions


ACADEMY OF SCIENCES OF THE USSR
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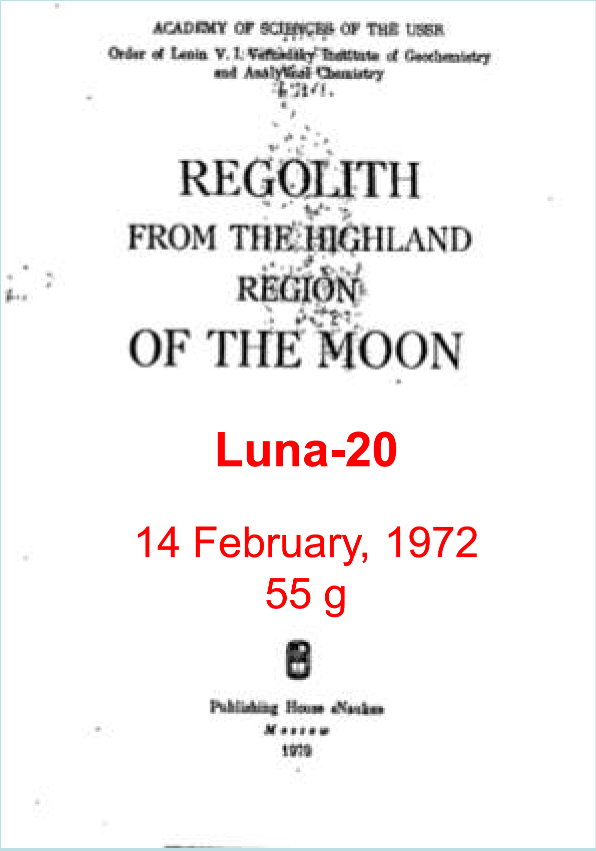
V. I. Vernadsky Institute
of Geochemistry
and Analitical Chemistry

LUNAR SOIL from Sea of Fertility

«NAUKA» PUBLISHING HOUSE
Moscow
1974

Luna-16

12-24 September, 1970
101 g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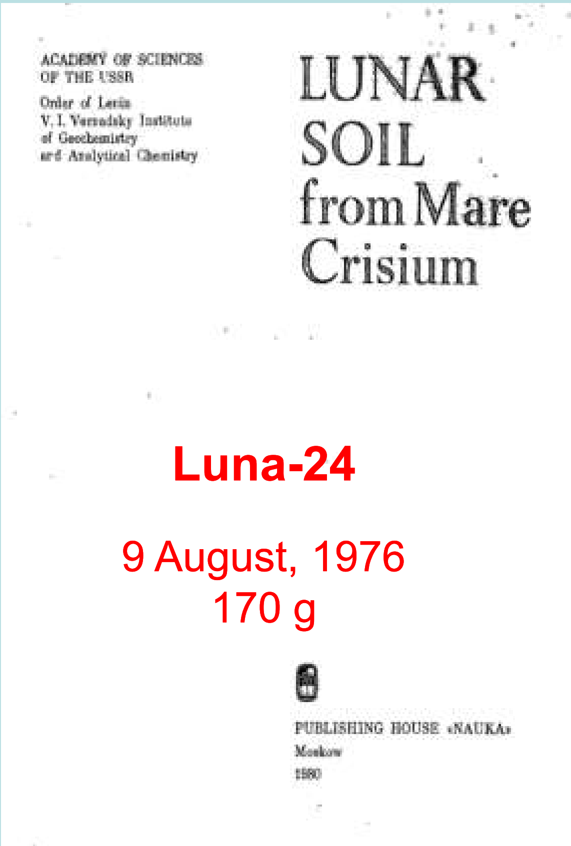
and Analytical Chemistry

REGOLITH FROM THE HIGHLAND REGION OF THE MOON

Publishing House «Nauka»
Moscow
1979

Luna-20

14 February, 1972
55 g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of Geochemistry
and Analytical Chemistry

LUNAR SOIL from Mare Crisium

PUBLISHING HOUSE «NAUKA»
Moskow
1980

Luna-24

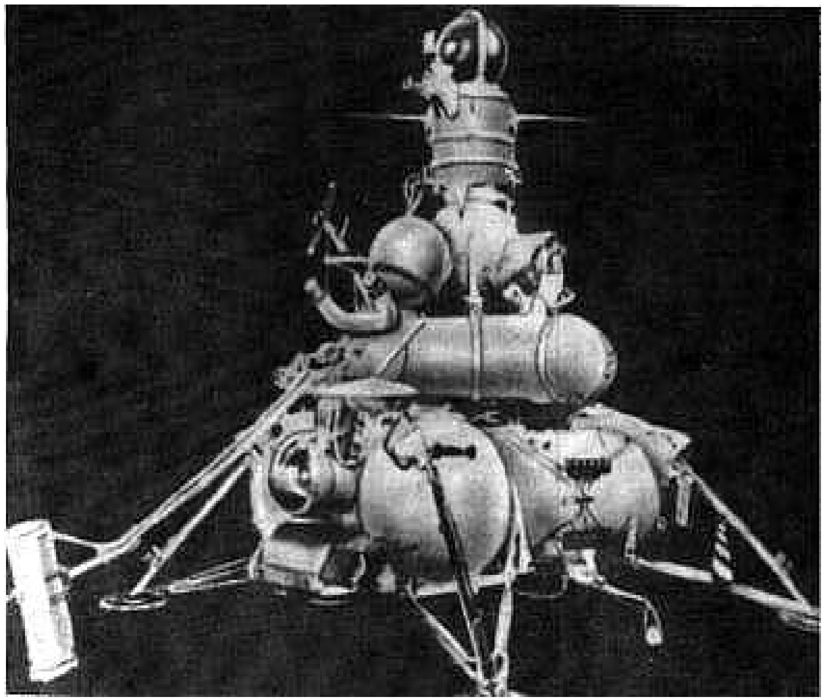
9 August, 1976
170 g

Luna 16

Soviet Union

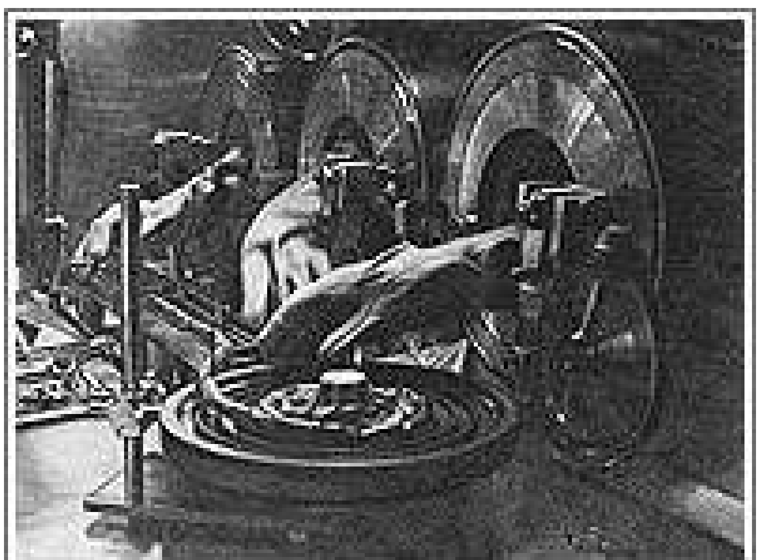
unmanned space mission (1970)

101 gram sample returned to Earth



Analysis of the dark basalt material indicated a close resemblance to soil recovered by the American Apollo 12 mission

A soil container with a flexible tube inside



The processing of soil samples inside a special glove box chamber. After removal from the flight container a flexible hose containing the lunar soil was placed on a special disk with a spiral groove for initial X-ray imaging

TABLE III

Elemental abundances in two Luna-24 samples

Element	123-11 29 mg	190-12 31 mg	BCR-1		TKT-1	
			This work 29 mg	Reported Laul & Schmitt (1973*b*)	This work 25 mg	Reported Reddy et al. (1976)
TiO_2%	001.100	001.100	002.400	002.200	000.600	000.560
Al_2O_3%	011.700	012.500	014.100	013.700	014.800	015.280
FeO%	020.100	019.600	012.300	012.300	004.000	003.670
MgO%	011.000	010.000	003.600	003.300	N.d	000.400
CaO%	012.500	011.700	007.100	006.900	001.600	001.620
Na_2O%	000.280	000.330	003.300	003.300	004.000	004.310
K_2O%	000.040	000.030	001.700	001.700	004.100	003.610
MnO%	000.280	000.250	000.170	000.180	000.150	000.180
Cr_2O_3%	000.496	000.503	000.003	000.002	000.002	N.R
Sc ppm	040.000	040.000	030.000	032.000	008.700	009.800
V ppm	150.000	150.000	410.000	410.000	011.000	N.R.
Co ppm	050.000	050.000	033.000	036.000	001.200	001.600
Hf ppm	002.000	003.000	005.200	004.900	019.100	020.000
La ppm	002.800	004.000	026.000	025.000	110.000	120.000
Sm ppm	001.800	002.600	007.000	006.900	013.000	N.R.
Eu ppm	000.610	000.800	001.940	001.950	002.680	003.200
Tb ppm	000.370	000.480	001.010	000.960	001.970	002.300
Dy ppm	003.400	004.200	006.900	006.400	012.000	N.R.
Yb ppm	001.600	002.200	003.200	003.400	009.700	N.R.
Lu ppm	000.270	000.350	000.600	000.520	001.400	N.R.

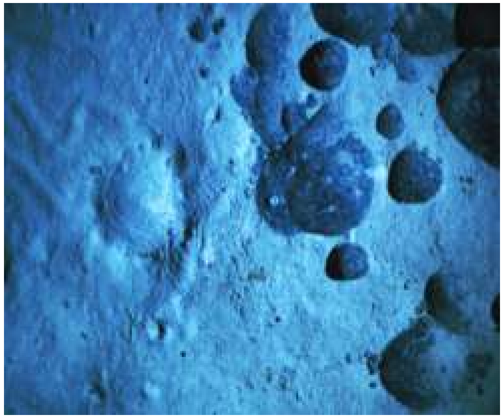
BCR — 1 — USGS Basalt Standard; N. d : Not detected
TKT — 1 — BARC Trachyte Standard; N.R : Not reported
Estimated errors due to counting statistics are :
Al_2O_3, FeO, Na_2O, MnO, Cr_2O_3, Sc, Co, Sm and Lu ± 1 - 5%; TiO_2, CaO, V, La, E_u and Y_b ± 5 - 10% and MgO, K_2O, Tb and D_y ± 10 - 25%.

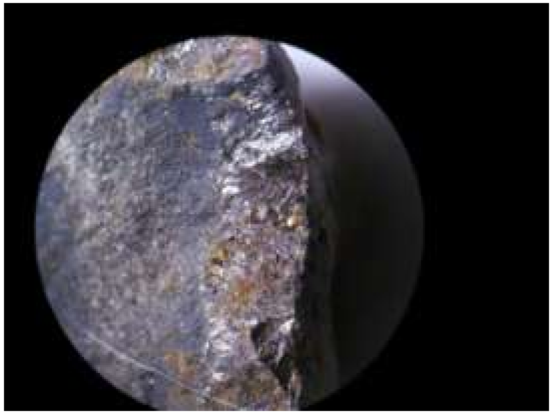
NAA + MS

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	*Cr*	Mn	*Fe*	Co	Ni	Cu	*Zn*	Ga	Ge	*As*	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**											Rf	Db	Sg	Bh	Hs
	*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
	**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw		

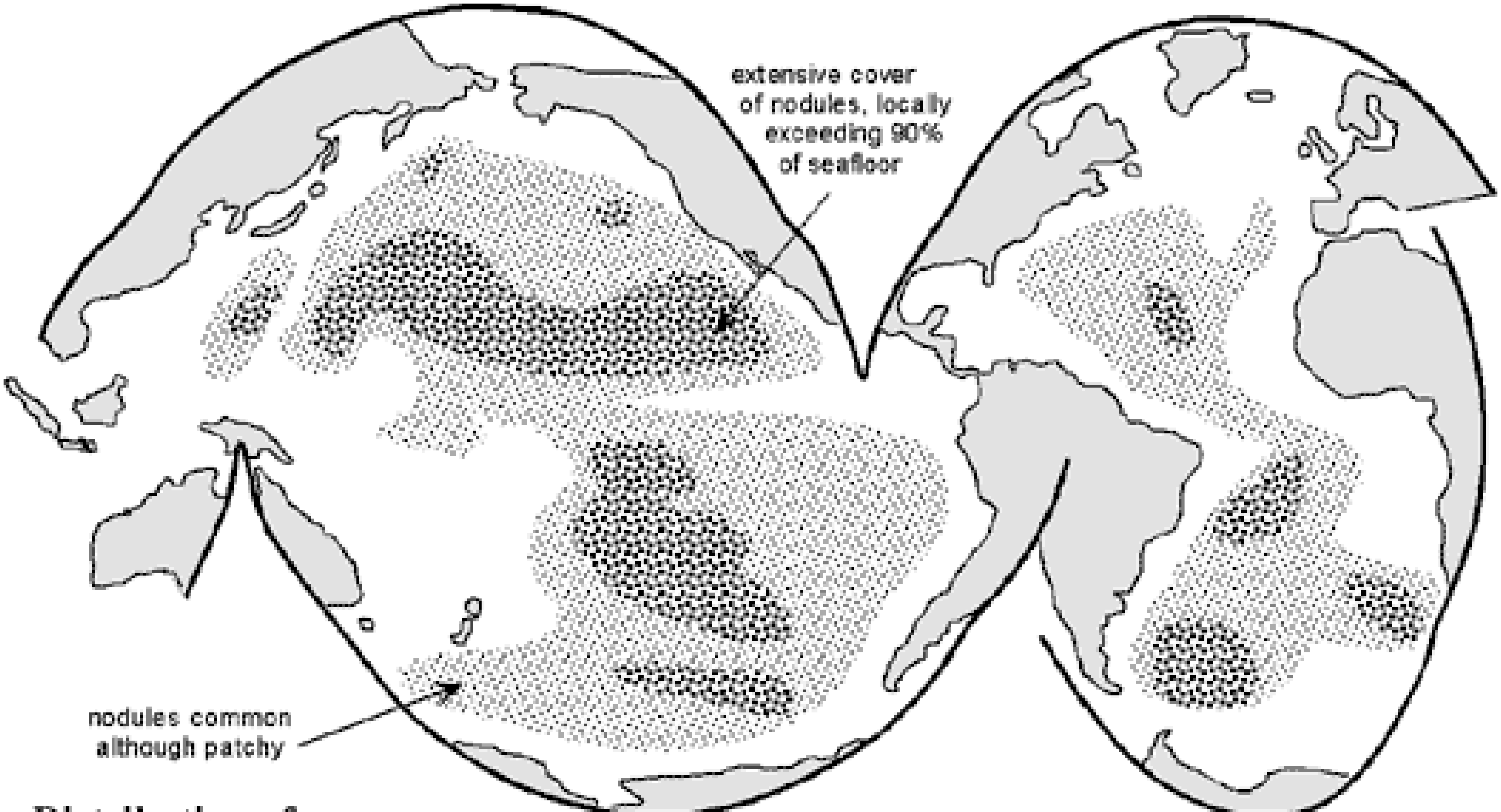
Epithermal NAA in JINR (Russia-Romania): nodules from the Pacific Ocean

Manganese nodules were first discovered on the ocean floor in 1803. They are rock concretions on the sea bottom formed of **concentric layers of iron and manganese hydroxides around a core or nucleus.** Nodules lie on the seabed sediment, often partly or completely buried. They vary greatly in abundance, in some cases touching one another and covering more than 70 per cent of the bottom. They may contain up to 70% manganese, around 15% iron, and further some copper, cobalt, zinc and nickel in small proportions.





Polymetallic nodules from the Clarion-Clipperton abyssal plane of the Pacific Ocean



Distribution of manganese nodules in the Pacific and Atlantic Oceans

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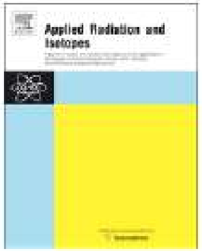

Epithermal neutron activation analysis investigation of Clarion-Clipperton abyssal plane clay and polymetallic micronodules

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(among top 10 papers in BioMed Lib domain, USA) (IF 4.37)

Abstract. The content of seven major (**Na, Al, Cl, Mn, K, Ca, Ti, Fe**) and 30 trace (**Sc, V, Cr, Ni, Co, Zn, Cu, As, Sr, Rb, Zr, Mo, Sn, In, Sb, Ba, Cs, La, Ce, Nd, Eu, Sm, Tb, Dy, Yb, Hf, Ta, W, Th, U**) elements determined by INAA in abyssal clay and samples of micronodules collected from the North Pacific Ocean Clarion-Clipperton abyssal plane is presented and discussed with respect to some rocks models.

Table 3
The average content as well as the corresponding standard deviations of 30 trace elements in abyssal clay (AC), micronodules (MN), (UCC) and Pacific and Indian MORBs (MORB-P and, respectively, MORB-I).

	Element														
	Sc	V	Cr	Co	Ni	Cu	Zn	As	Rb	Sr	Zr	Mo	In	Sn	Sb
Average AC	24.2	75.1	58.9	144	773	827	853	6.21	75.4	912	351	16.3	0.73	20.8	4.13
St. dev. AC	15.7	41.7	30.0	127	837	723	761	3.17	40.7	843	174	17.3	0.78	15.5	3.44
Average MN	7.70	nd	70.6	955	0.11×10^6	nd	0.22×10^5	31.5	23.1	981	204	nd	nd	13.9	4.22
St. dev. MN	1.29	nd	3.66	10.6	285	nd	352	2.27	4.17	233	60.7	nd	nd	8.92	0.26
UCC	11.0	60	35.0	10.0	20.0	25.0	71.0	1.50	112	145	190	1.50	0.50	5.50	0.20
Average AC/UCC	2.20	1.25	1.68	7.22	77.3	33.1	12.0	4.14	0.67	6.29	1.85	10.9	1.46	3.79	20.6
Average MN/UCC	0.70	nd	2.02	95.6	546	nd	31.7	21.0	0.21	6.77	1.07	nd	nd	2.53	21.1
MORB-P	39.1	320	254	nd	95.6	85.8	nd	nd	6.53	146	122	nd	nd	nd	nd
MORB-I	31.8	nd	715	nd	175	86.0	nd	nd	nd	145	125.00	nd	nd	nd	nd
Average AC/MORB-P	0.62	0.24	0.23	nd	8.08	9.63	nd	nd	11.6	6.27	2.89	nd	nd	nd	nd
Average MN//MORB-P	0.20	nd	0.28	nd	114	nd	nd	nd	3.54	6.74	1.67	nd	nd	nd	nd

	Element														
	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb	Dy	Yb	Hf	Ta	W	Th	U
Average AC	5.98	0.61×10^4	88.7	99.2	130	24.1	6.33	5.74	27.0	14.7	3.97	0.87	19.6	13.1	1.39
St. dev. AC	3.81	0.49×10^4	41.6	60.8	76.0	12.7	3.65	4.06	23.7	9.45	1.99	0.55	14.5	10.7	0.73
Average MN	1.32	0.12×10^4	89.5	159	125	nd	5.35	4.33	nd	10.4	1.84	nd	nd	12.6	1.85
St. dev. MN	0.05	32.0	24.9	7.40	26.0	nd	1.02	1.22	nd	2.62	0.01	nd	nd	1.43	0.05
UCC	11.0	550	35.0	10.0	20.0	25.0	71.0	1.50	112	145	190	1.50	0.50	5.50	0.20
Average AC/UCC	1.62	11.0	2.96	1.55	5.02	5.36	7.04	9.56	7.73	6.71	0.68	0.40	8.89	1.22	0.50
Average MN/UCC	11.5	38.8	18.0	11.6	12.0	nd	4.16	5.52	nd	3.39	0.45	0.00	nd	22.2	6.50
MORB-P	39.1	319	254	nd	95.7	85.6	nd	nd	6.53	146	122	nd	nd	0.56	0.28
MORB-I	31.8	nd	715	155	Nd	86.0	nd	nd	nd	145	125	nd	nd	0.34	0.04
Average AC/MORB-P	52.0	193	17.8	nd	12.6	6.88	nd	nd	4.22	4.80	0.97	nd	nd	23.1	4.89
Average MN/MORB-P	11.5	38.8	18.0	nd	12.1	nd	nd	nd	nd	3.39	0.45	nd	nd	22.2	6.50

nd—not determined.
All concentrations are expressed in mg/kg. For a better comparison, both for abyssal clay and micronodules the ratio between average concentration of each element and UCC and MORB-P corresponding content are reproduced too.

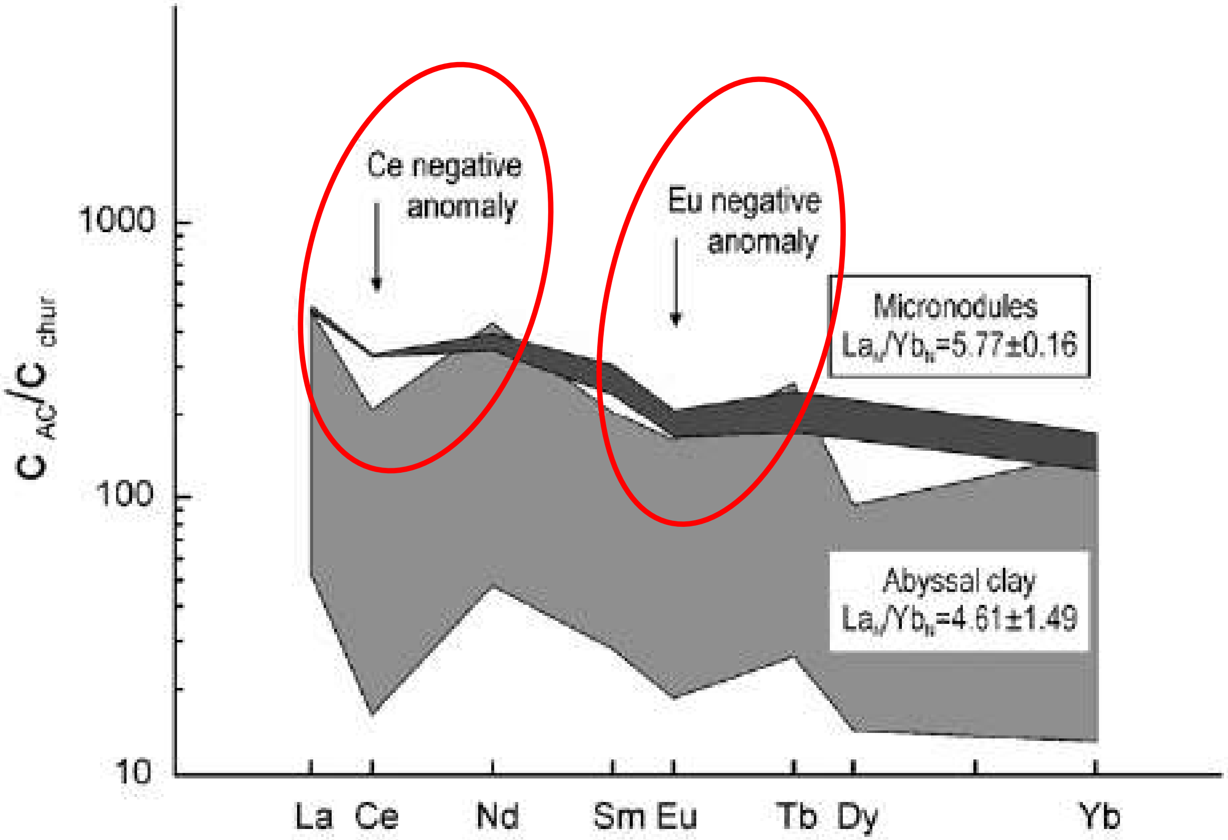


Fig. 3. Distribution of investigated REE (seven in abyssal clay, six in micronodules) normalized to Chondrite and illustrating both Cerium and Europium negative anomalies.

ENAA of two kind of meteorites from Italy

Elements determined

Na Mg Al Si Cl K Ca Sc Ti V Cr Mn Fe Ni
Co Cu Zn As Se Br Rb Mo Ag Sb Ba Cs
La Sm Tb Dy Yb Hf Ta W Au Hg Th U

	Na		Mg		Al		Si		Cl		K		Ca		Sc		Ti		V		Cr	
sample	mg/kg	%	mg/kg	%	mg/kg	%	weight %	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%
d-01	**126**	**5**	**630**	**20**	**129**	**5**	**< 3**		**132**	**10**	**274**	**15**	**160**	**12**	**1.8**	**5**	**123**	**15**	**0.33**	**5**	**405**	**6**
d-02	**193**	**5**	**988**	**20**	**807**	**5**	**< 3**		**347**	**10**	**208**	**15**	**662**	**12**	**1.9**	**5**	**167**	**15**	**27**	**5**	**361**	**6**
d-03	**69**	**5**	**675**	**20**	**232**	**5**	**< 3**		**107**	**10**	**314**	**15**	**348**	**12**	**2.0**	**5**	**129**	**15**	**0.40**	**5**	**377**	**6**
d-04	1660	5	225000	20	1770	5	19	25	93.2	10	553	15	639	12	1.21	5	478	15	10.5	5	310	6
d-05	684	5	43500	20	3030	5	22	25	364	10	1130	15	1570	12	0.8	5	495	15	39.8	5	3100	6
d-06	6780	5	134000	20	11200	5	28	25	753	10	856	15	10100	10	8.65	5	719	15	66.8	5	2420	6
d-07	4860	5	158000	20	11700	5	25	25	568	10	2280	15	14200	10	7.70	5	534	15	76.4	5	3730	6
d-08	5670	5	142000	20	10800	5	16	25	1520	10	1600	15	15100	10	8.43	5	683	12	67.2	5	3840	6
d-09	2070	5	155000	20	17800	5	18	25	429	10	602	15	23100	10	11.6	5	837	12	90.8	5	3510	6
d-10	1380	5	180000	20	13300	5	27	25	148	10	1540	15	23400	10	13.1	5	771	12	161	5	11000	6
d-11	6030	5	146000	20	10500	5	19	25	934	10	1130	15	22400	10	8.02	5	407	12	51.4	5	2880	6
d-12	7600	5	177000	20	12700	5	19	25	181	10	1650	15	14700	10	9.48	5	632	12	74.1	5	4020	6

Mn		Fe		Ni		Co		Cu		Zn		As		Se		Br		Rb	Mo		Ag		Sb	
mg/kg	%	weight %	%	weight %	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	mg/kg	%	mg/kg	%	mg/kg	%
35	**7**	**83**	**5**	**4.9**	**8**	**4000**	**5**	**145**	**25**	**244**	**10**	**19.1**	**5**	**< 3**		**1.2**	**30**	**< 20**	**10.7**	**30**	**3.6**	**25**	**0.522**	**4**
79	**6**	**87**	**5**	**4.6**	**8**	**4350**	**5**	**212**	**25**	**168**	**10**	**11.7**	**5**	**< 3**		**0.38**	**30**	**< 20**	**8.4**	**30**	**3.5**	**25**	**0.164**	**6**
35	**8**	**92**	**5**	**4.7**	**8**	**4540**	**5**	**176**	**25**	**140**	**10**	**11.4**	**5**	**< 3**		**0.24**	**30**	**< 20**	**6.8**	**30**	**3.8**	**25**	**0.098**	**9**
1590	5	19	5	1.3	8	533	5	86.3	25	37	10	4.95	5	1.55	10	0.22	30	< 20	2.7	30	0.92	25	0.077	5
389	5	38	5	3.3	8	1860	5	86.4	25	65	10	10.3	5	1.2	10	0.37	30	< 20	2.9	30	1.5	25	0.164	5
425	6	20	5	0.5	8	293	5	64	25	18.8	10	4.65	5	9.4	10	4.47	30	< 20	1.3	30	0.76	25	0.093	5
2680	5	22	5	1.2	8	516	5	294	25	77.5	10	3.12	5	12.3	10	0.40	30	< 20	2.3	30	1.2	25	0.297	4
2190	5	26	5	1.6	8	744	5	359	25	118	10	2.29	5	8.2	10	0.43	30	< 20	2.1	30	1.2	25	0.088	5
1410	5	23	5	1.3	8	594	5	145	25	120	10	1.88	5	6.8	10	0.78	30	< 20	2.2	30	1.1	25	0.090	5
3580	5	12	5	0.01	8	21.5	5	445	25	24.8	10	0.30	5	0.46	10	0.09	30	< 20	0.31	31	0.47	25	0.033	6
518	6	19	5	0.5	8	286	5	113	25	59.8	10	3.44	5	9.34	10	3.03	30	< 20	1.2	30	0.82	25	0.235	4
2550	5	20	5	1.2	8	571	5	159	25	52	10	1.7	5	4.83	10	0.11	30	< 20	0.51	31	1.0	25	0.049	7

Ba		Cs	La		Sm		Tb		Dy		Yb		Hf		Ta		W		Au		Hg	Th		U	
mg/kg	%	mg/kg	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	mg/kg	%	mg/kg	%
573	**10**	**ND**	**1.3**	**15**	**0.18**	**30**	**0.24**	**15**	**0.758**	**25**	**2.3**	**25**	**1.7**	**25**	**0.24**	**25**	**1.6**	**30**	**1.7**	**30**	**< 30**	**0.68**	**20**	**0.16**	**20**
86	**10**	**ND**	**1.3**	**15**	**0.19**	**30**	**0.22**	**15**	**0.966**	**25**	**2.2**	**25**	**1.6**	**25**	**0.23**	**25**	**1.2**	**30**	**1.5**	**30**	**< 30**	**0.57**	**20**	**0.07**	**20**
92	**10**	**ND**	**0.6**	**15**	**0.088**	**30**	**0.23**	**15**	**0.826**	**25**	**2.3**	**25**	**1.7**	**25**	**0.25**	**25**	**0.81**	**30**	**1.4**	**30**	**< 30**	**0.58**	**20**	**0.07**	**20**
22	10	0.105	0.4	15	0.087	30	0.057	15	2.34	25	0.63	25	0.41	25	0.057	25	0.24	30	0.6	30	ND	0.239	20	0.07	20
130	10	ND	1.1	15	0.13	30	0.089	15	1.47	25	0.98	25	0.45	25	0.087	25	0.34	30	0.7	30	ND	0.26	20	1.36	20
171	10	ND	0.2	15	0.041	31	0.052	15	2.21	25	0.52	25	0.40	25	0.051	25	0.35	30	0.2	30	ND	0.16	20	0.73	20
291	10	ND	0.8	15	0.25	30	0.084	15	4.12	25	0.90	25	0.66	25	0.088	25	0.74	30	0.2	30	ND	0.28	20	0.07	20
91	10	0.851	0.6	15	0.20	30	0.083	15	3	25	0.84	25	0.59	25	0.079	25	0.36	30	0.3	30	ND	0.25	20	0.05	20
113	10	0.573	0.7	15	0.32	30	0.065	15	3.06	25	0.78	25	0.56	25	0.074	25	0.57	30	0.2	30	ND	0.23	20	0.05	20
67	10	ND	0.4	15	0.19	30	0.022	15	3.65	25	0.28	25	0.29	25	0.031	25	0.14	30	0.1	31	ND	0.09	20	0.04	20
357	10	0.373	0.5	15	0.14	30	0.058	15	2.2	25	0.59	25	0.46	25	0.058	25	0.22	30	0.1	30	ND	0.18	20	0.43	20
44	10	0.453	0.4	15	0.26	30	0.066	15	3.46	25	0.69	25	0.47	25	0.064	25	0.17	30	0.2	30	ND	0.20	20	0.03	20

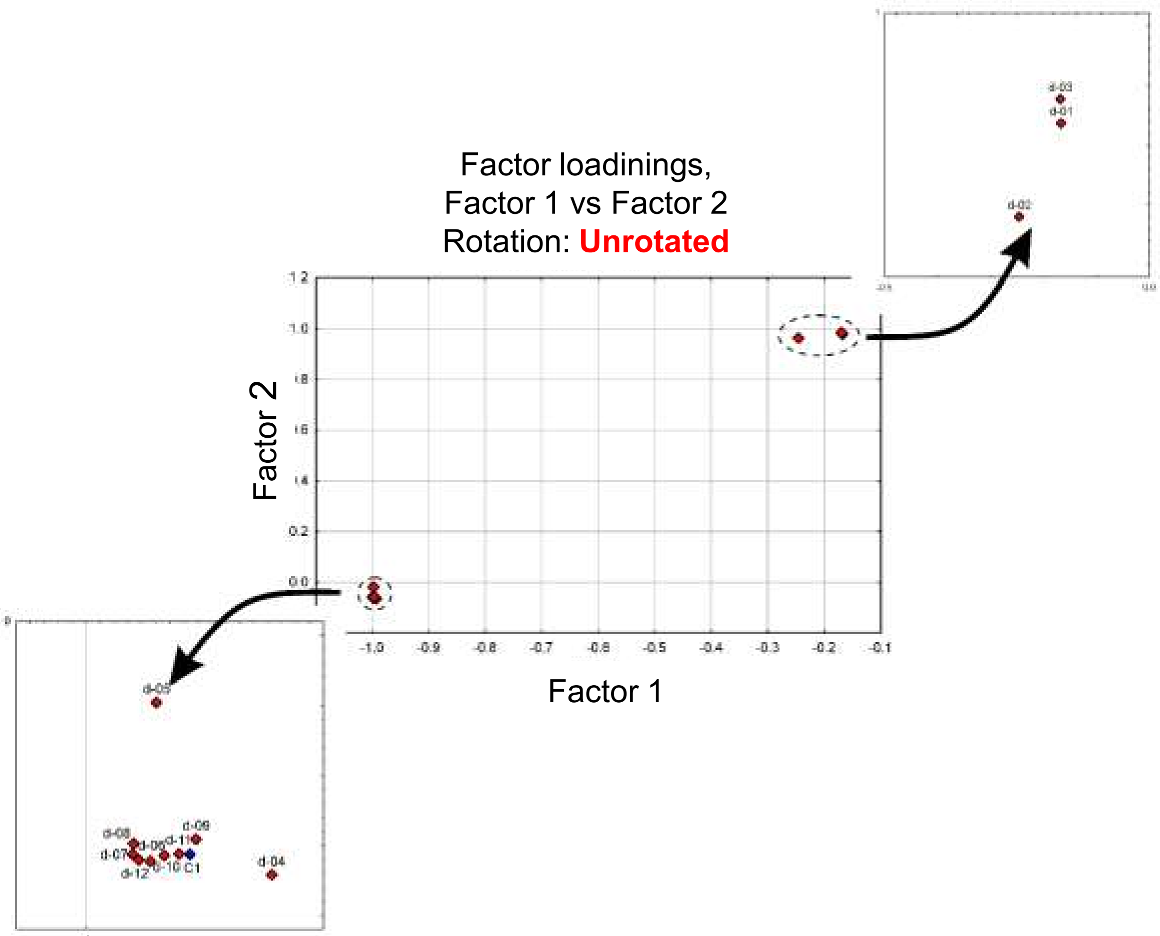
Chondritic (CI) Abundances of the Elements

H 2.02 %																	He 56 nL/g
Li 1.50 µg/g	Be 24.9 ng/g											B 870 ng/g	C 3.45 %	N 3180 µg/g	O 46.4 %	F 60.7 µg/g	Ne 203 pL/g
Na 5000 µg/g	Mg 9.89 %											Al 8680 µg/g	Si 10.64 %	P 1220 µg/g	S 6.25 %	Cl 704 µg/g	Ar 751 pL/g
K 558 µg/g	Ca 9280 µg/g	Sc 5.82 µg/g	Ti 436 µg/g	V 56.5 µg/g	Cr 2660 µg/g	Mn 1990 µg/g	Fe 19.04 %	Co 502 µg/g	Ni 1.10 %	Cu 126 µg/g	Zn 312 µg/g	Ga 10.0 µg/g	Ge 32.7 µg/g	As 1.86 µg/g	Se 18.6 µg/g	Br 3.57 µg/g	Kr 8.7 pL/g
Rb 2.30 µg/g	Sr 7.80 µg/g	Y 1.56 µg/g	Zr 3.94 µg/g	Nb 246 ng/g	Mo 928 ng/g	Tc	Ru 712 ng/g	Rh 134 ng/g	Pd 560 ng/g	Ag 199 ng/g	Cd 686 ng/g	In 80 ng/g	Sn 1720 ng/g	Sb 142 ng/g	Te 2320 ng/g	I 433 ng/g	Xe 8.6 pL/g
Cs 187 ng/g	Ba 2340 ng/g	REE	Hf 104 ng/g	Ta 14.2 ng/g	W 92.6 ng/g	Re 36.5 ng/g	Os 486 ng/g	Ir 481 ng/g	Pt 990 ng/g	Au 140 ng/g	Hg 258 ng/g	Tl 142 ng/g	Pb 2470 ng/g	Bi 114 ng/g	Po	At	Rn
Fr	Ra	Ac *et al.*															
		REE:	La 234.7 ng/g	Ce 603.2 ng/g	Pr 89.1 ng/g	Nd 452.4 ng/g	Pm	Sm 147.1 ng/g	Eu 56.0 ng/g	Gd 196.6 ng/g	Tb 36.3 ng/g	Dy 242.7 ng/g	Ho 55.6 ng/g	Er 158.9 ng/g	Tm 24.2 ng/g	Yb 162.5 ng/g	Lu 24.3 ng/g
			Ac	Th 29.4 ng/g	Pa	U 8.1 ng/g											

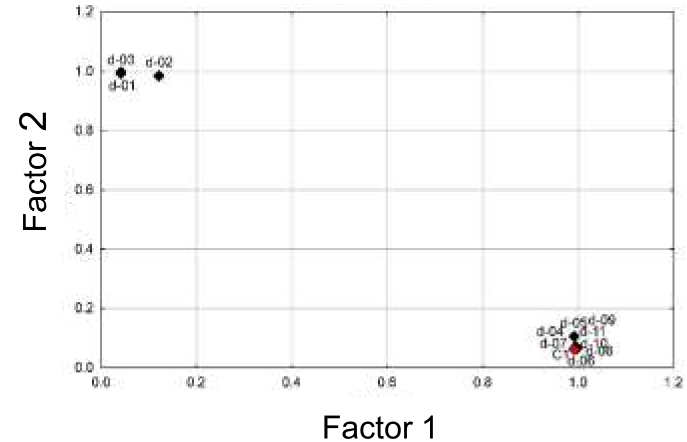
Anders E. and Grevesse N. Abundances of the elements: Meteoritic and solar.

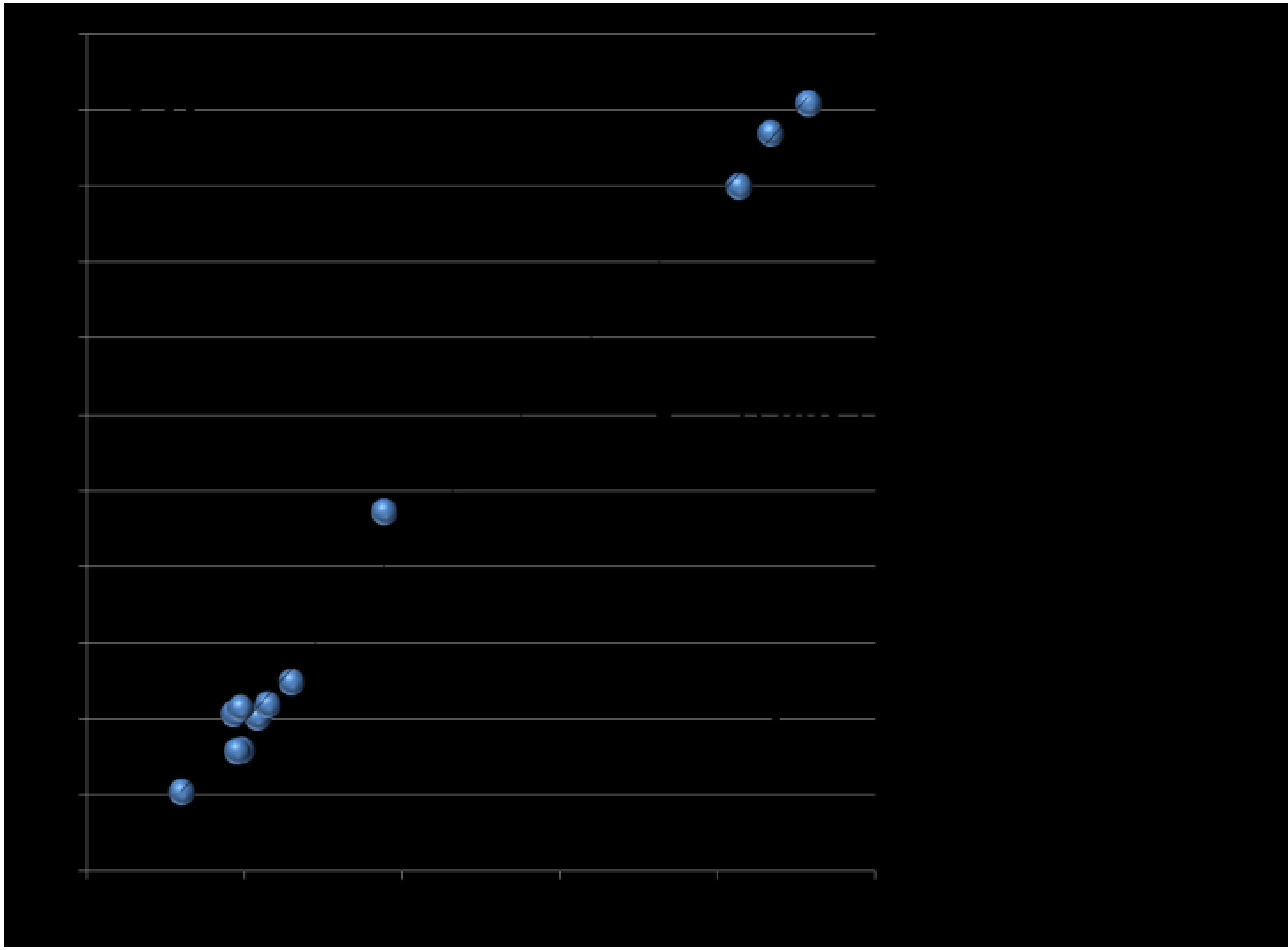
Geochimical at Cosmochimica Acta (1989) 53, 197-214

Principle Component Analysis (Factor Analysis)



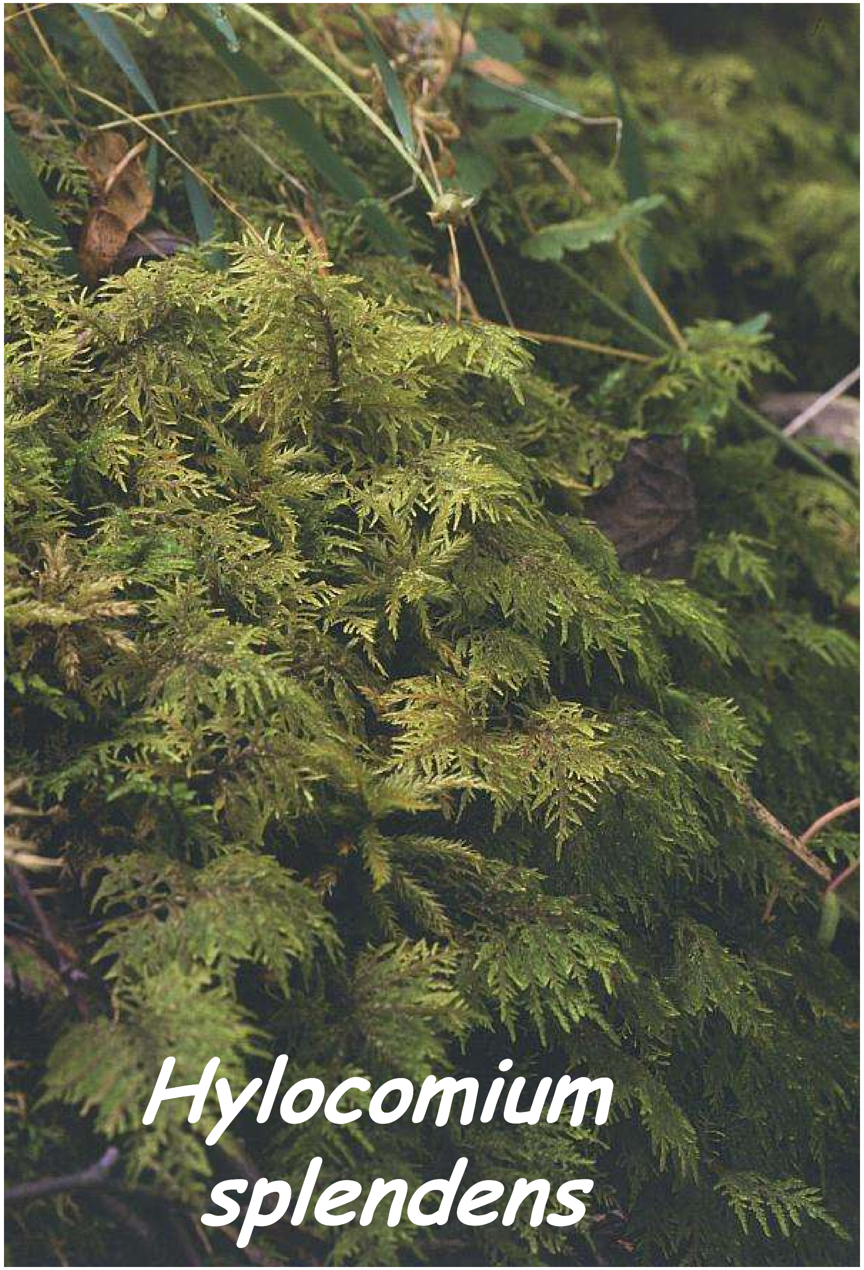
Factor loadings,
Factor 1 vs Factor 2
Rotation: **Varimax normalized**





Terrestrial moss as natural planchette for deposition of cosmic dust

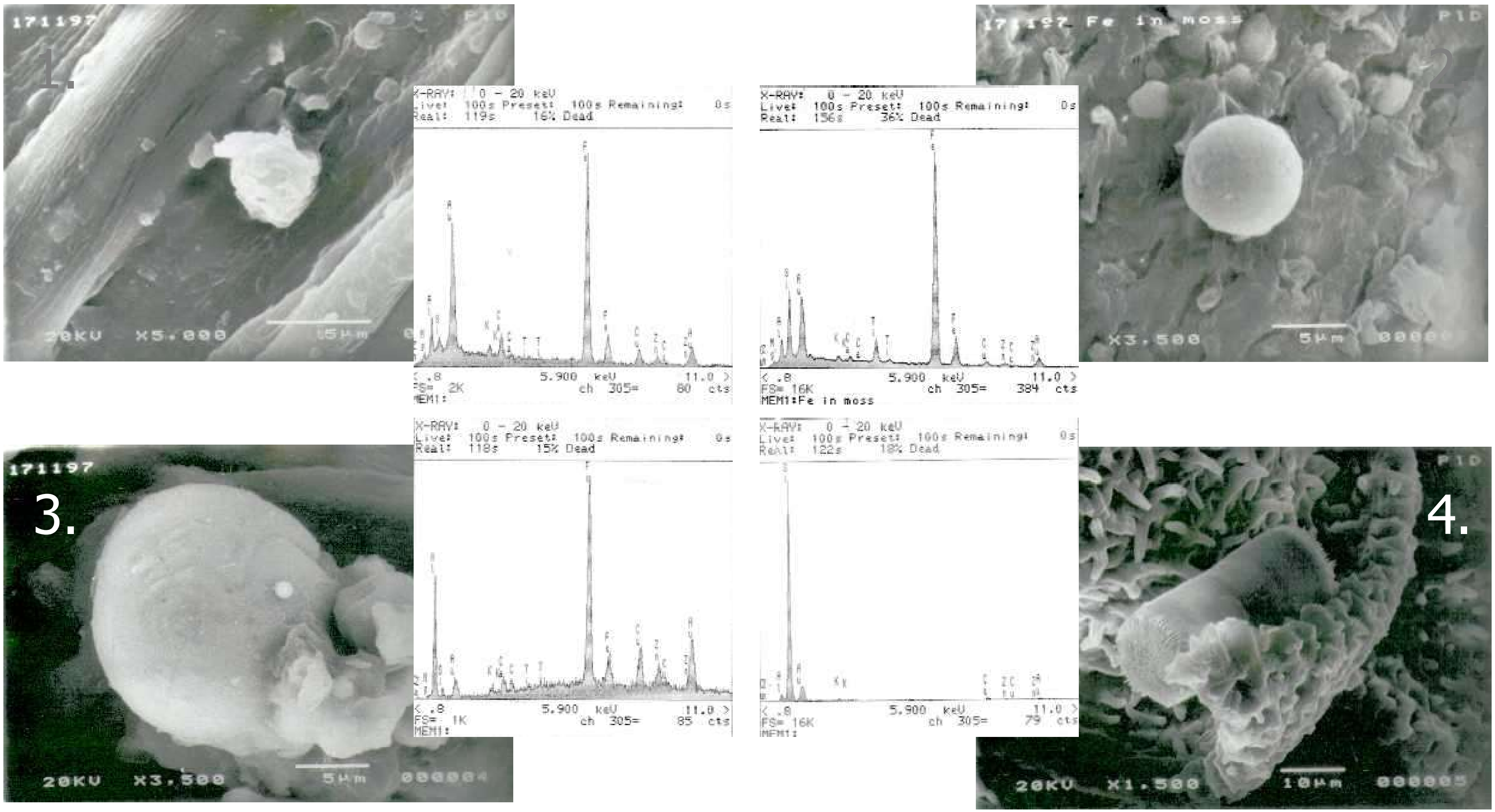

REGATA
Ukraine
Belorussia
Poland
Slovakia
Russia
Czech Republic
Bulgaria
Mongolia
Serbia
Vietnam
Macedonia
Armenia
Greece
China
Turkey
Romania
South Korea
RUSSIAN-EUROPEAN GATE TO ASIA


Hylocomium
splendens

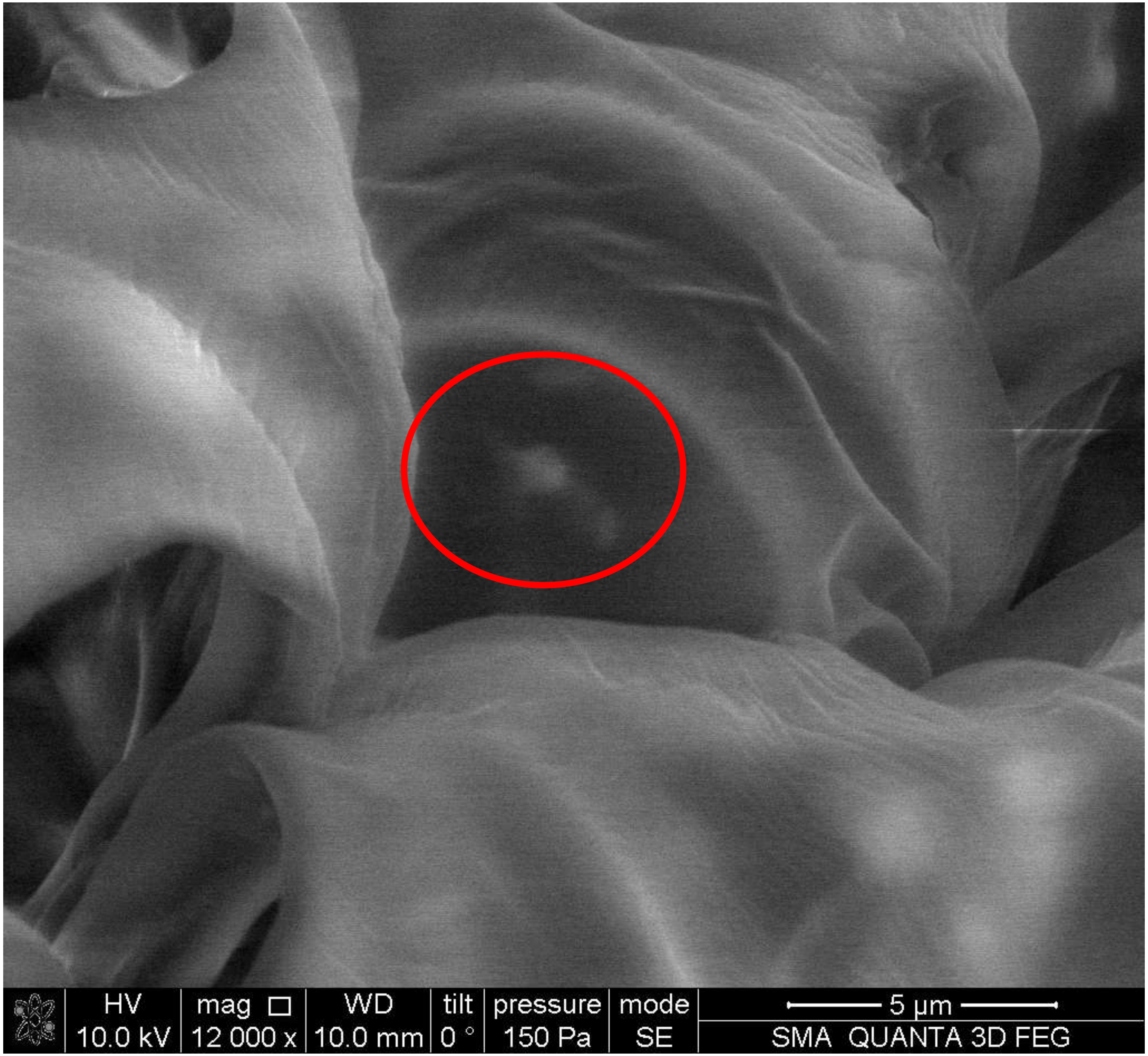

Sphagnum

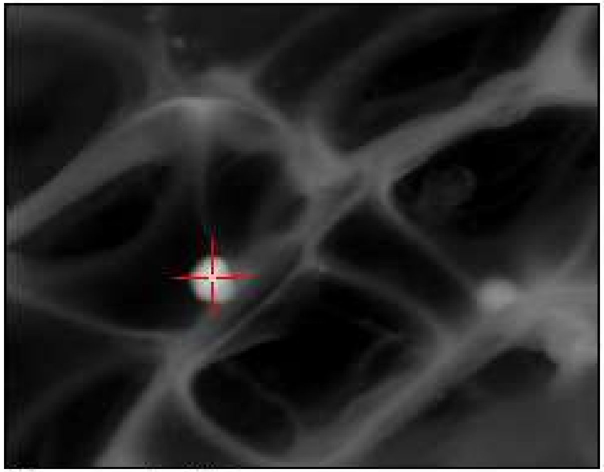
SEM images of aerosol particles trapped by moss

South Ural Mountains



1 - Fe particle with Mg impurity; **2** - Spherule of pure iron;
3 - Al-Fe cluster particle with impurities of Zn, Cu, and Ti; **4** - Diatomic alga


HV
10.0 kV
mag ☐
12 000 x
WD
10.0 mm
tilt
0 °
pressure
150 Pa
mode
SE
5 µm
SMA QUANTA 3D FEG

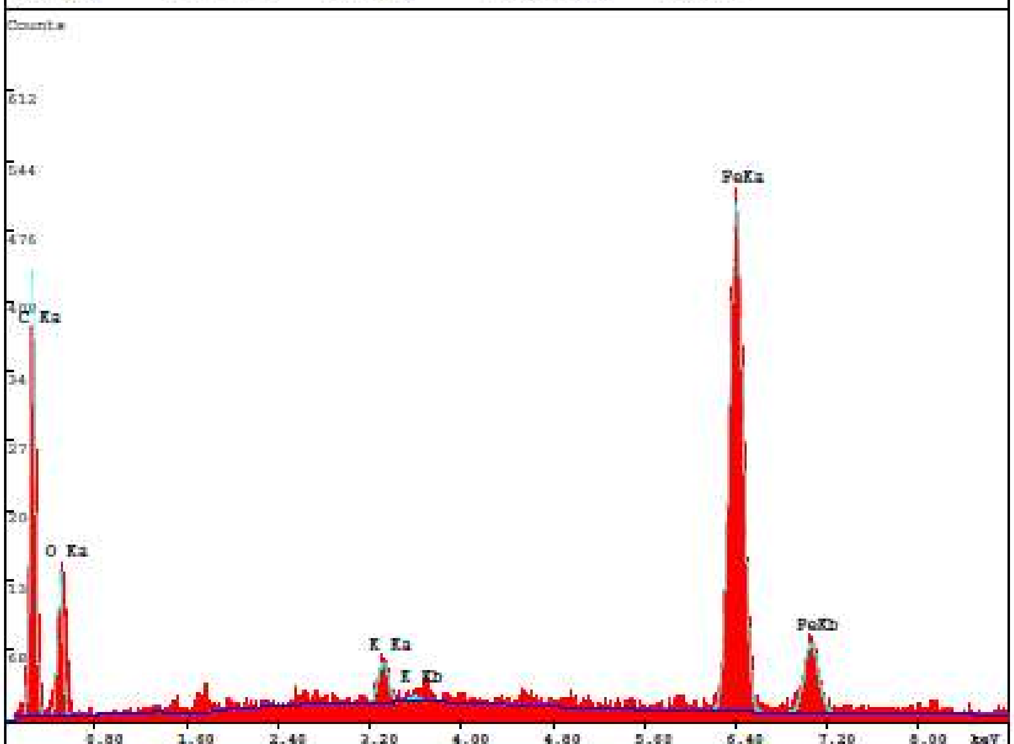


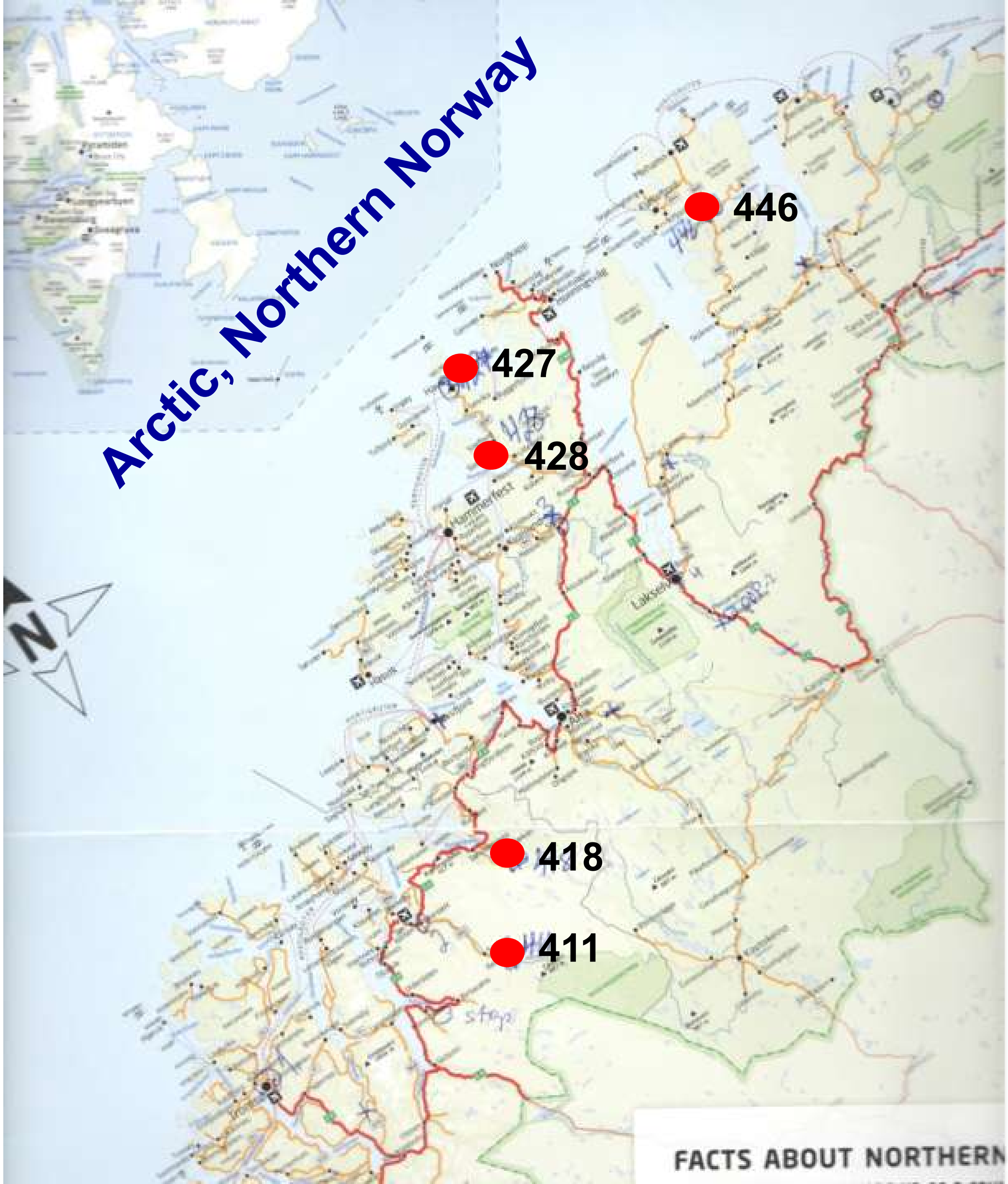
Matrix:	1024x800
Data Type:	SE1(ADC)
Magnification:	8569x
Image Size:	0.0329x0.0257mm
kV:	20.0
Tilt:	0

\\IR46_D8943\DATA (D)\2012\DUBNA-LNF\MOSS1-1-6-4.SPC

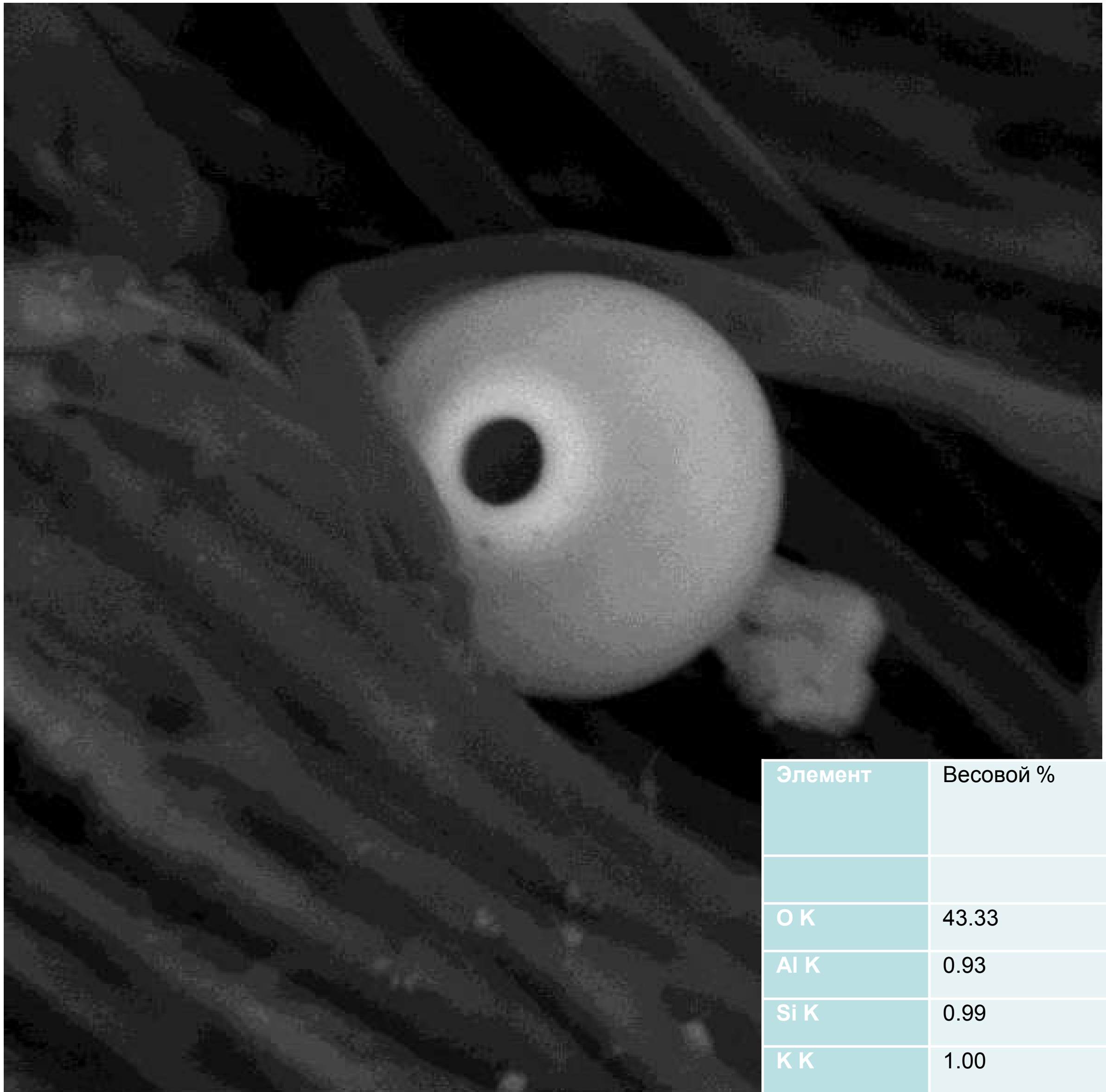
kV:20.0 Tilt:0.00 Tkoff:35.01 Det:SUTW Reso:132.4 Amp.T:102.4

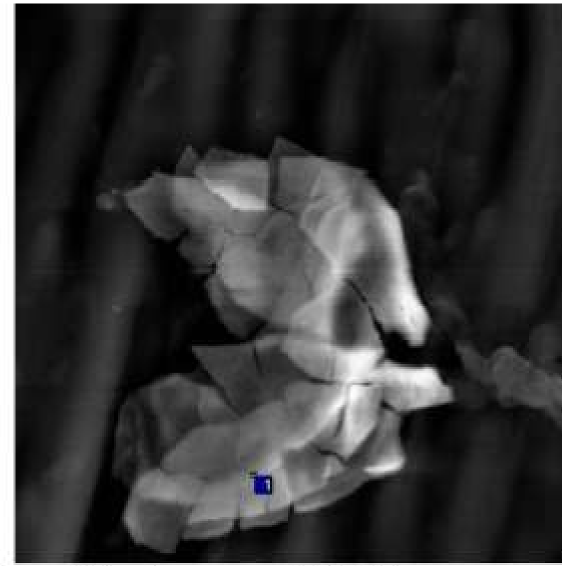
FS : 684 Lsec : 21.5 Prst:50C 27-Feb-2012 16:36:21




Arctic, Northern Norway
446
427
428
418
411
FACTS ABOUT NORTHERN

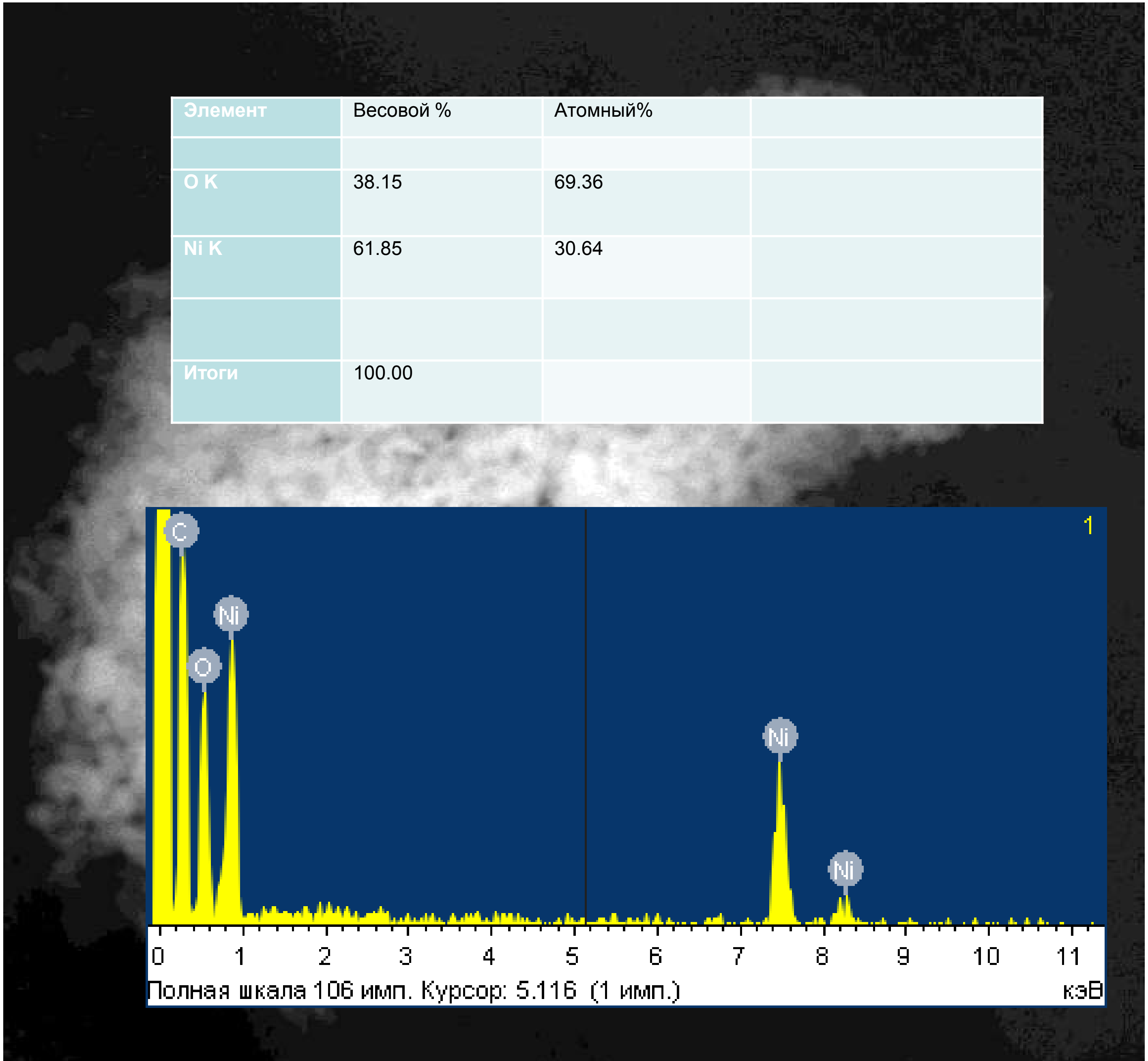
No. 428





Элемент	Весовой %	Атомный%	
O K	43.33	71.62	
Al K	0.93	0.91	
Si K	0.99	0.93	
K K	1.00	0.67	
Mn K	53.76	25.88	
Итоги	100.00		

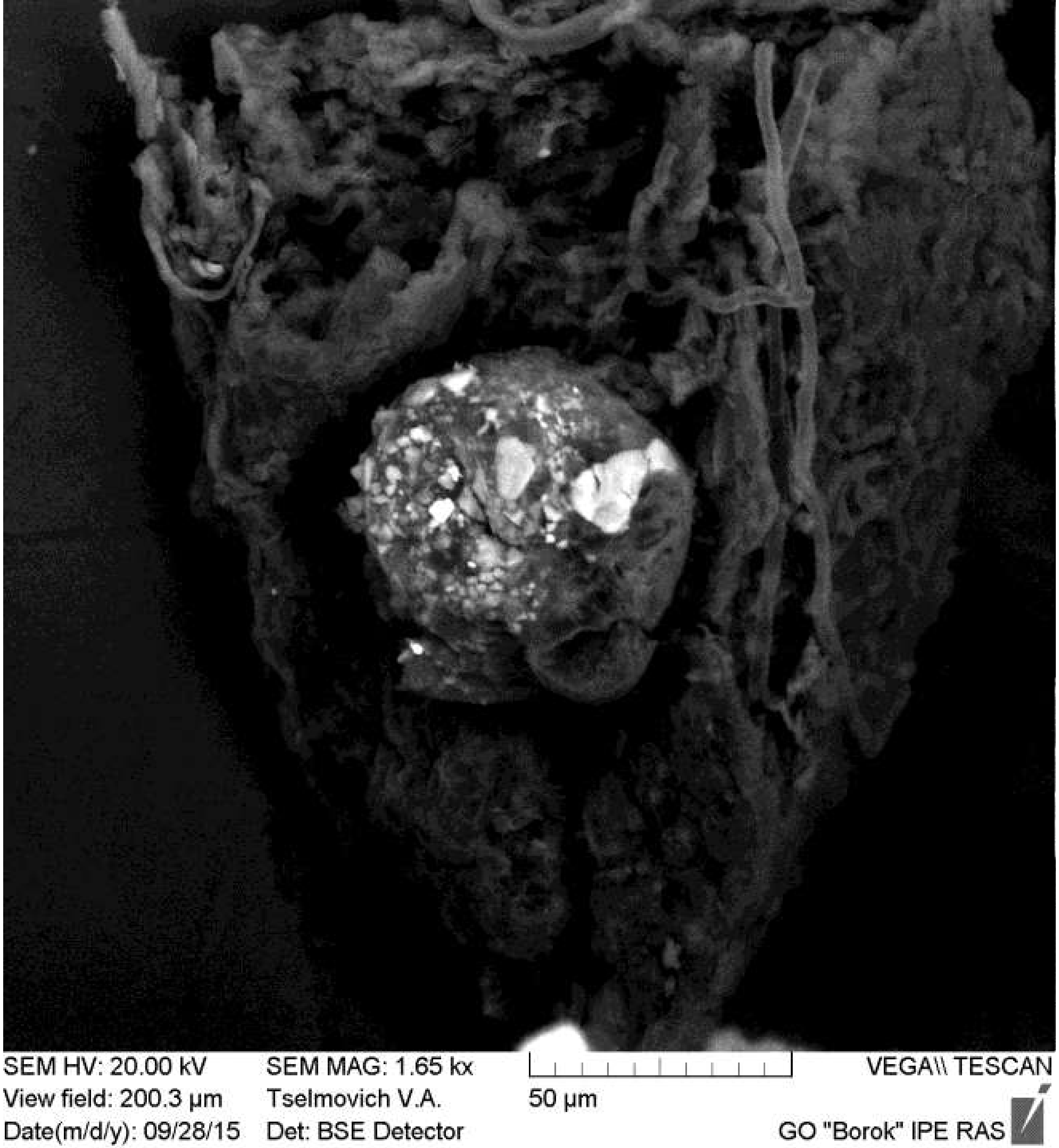
No. 411



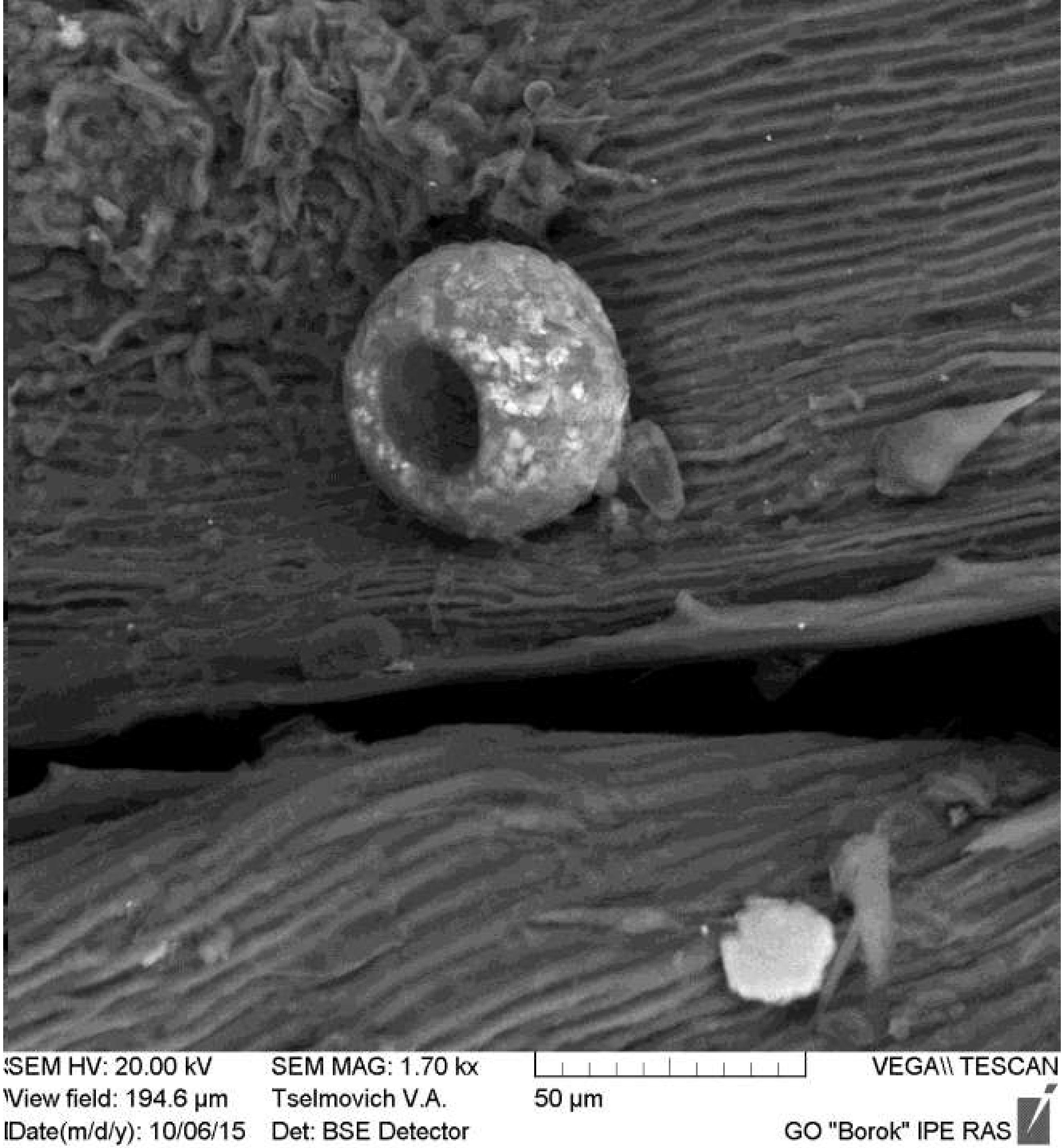
Элемент	Весовой %	Атомный%	
O K	38.15	69.36	
Ni K	61.85	30.64	
Итоги	100.00		

SEM HV: 20.00 kV | SEM MAG: 84.00 kx | VEGA\\ TESCAN
View field: 3.937 µm | Tselmovich V.A. | 1 µm
Date(m/d/y): 09/28/15 | Det: BSE Detector | GO "Borok" IPE RAS

No. 418


SEM HV: 20.00 kV
SEM MAG: 1.65 kx
VEGA\\ TESCAN
View field: 200.3 µm
Tselmovich V.A.
50 µm
Date(m/d/y): 09/28/15
Det: BSE Detector
GO "Borok" IPE RAS

No. 428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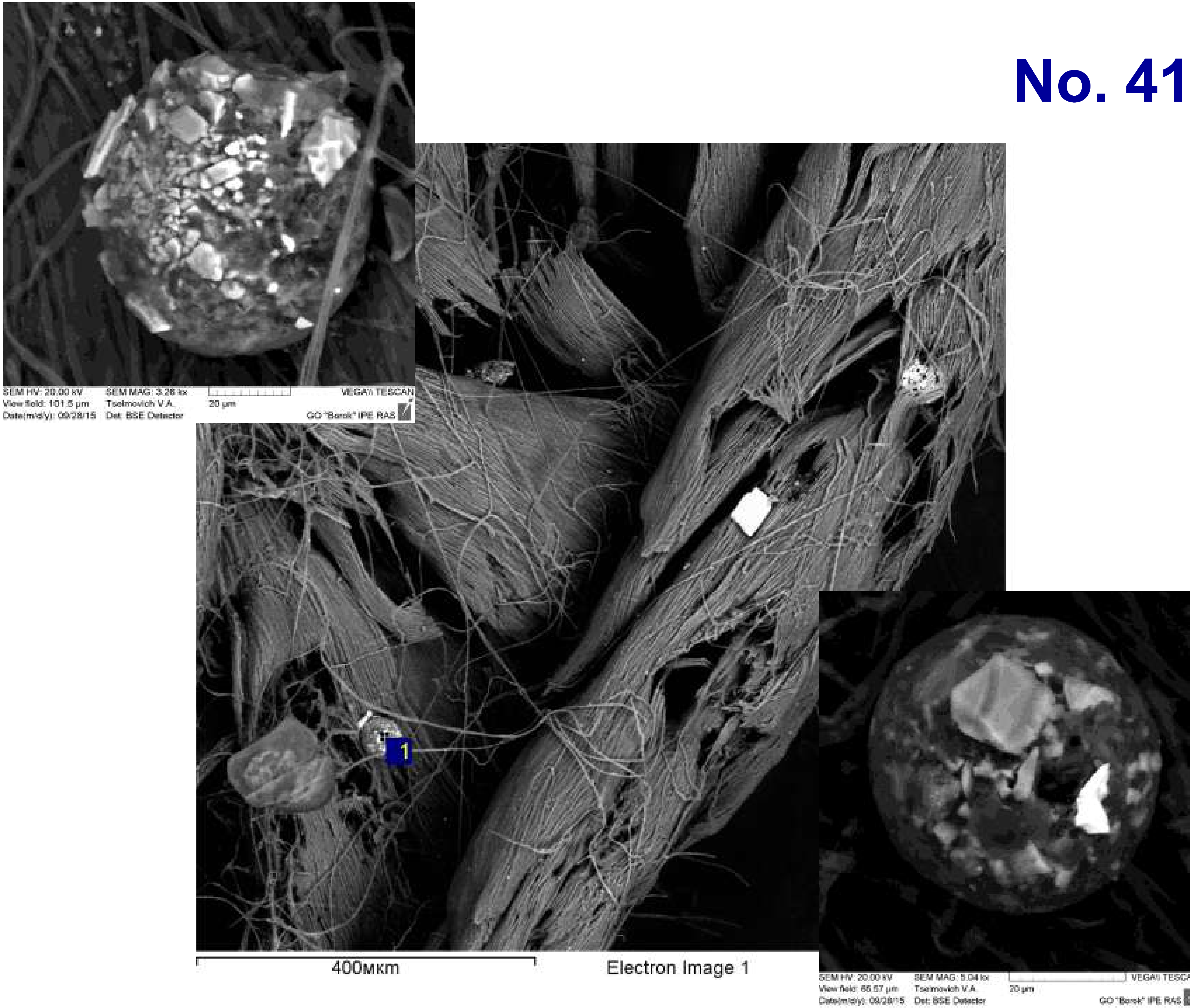
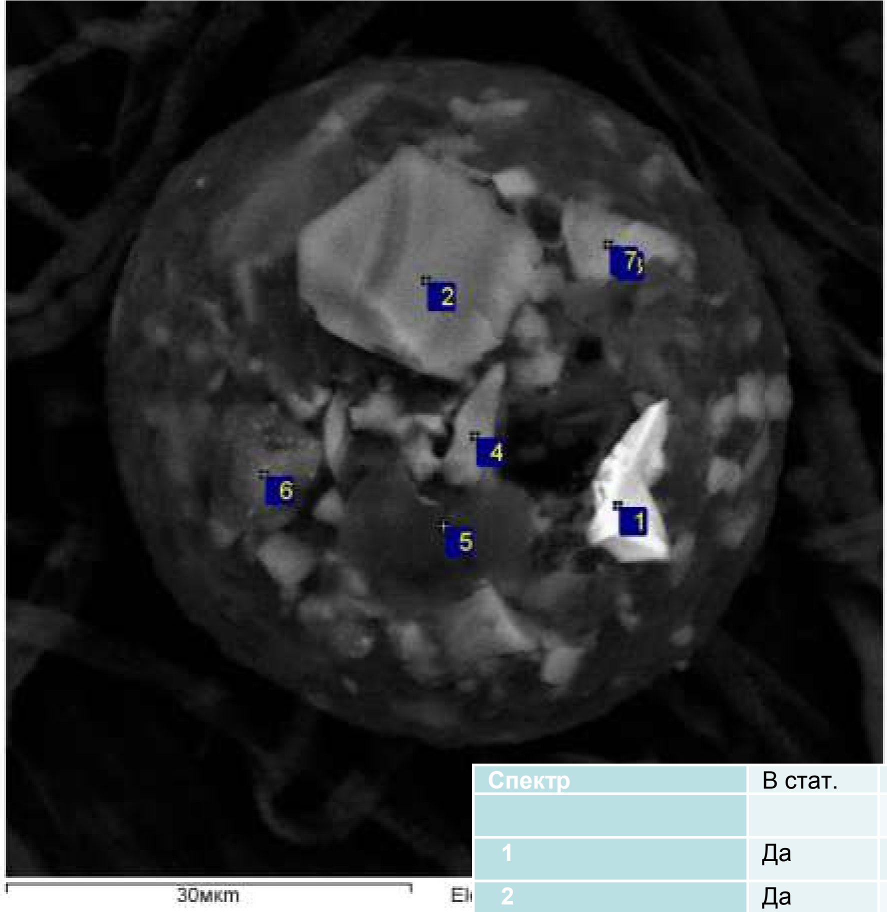
Date(m/d/y): 10/06/15
SEM MAG: 1.70 kx
Tselmovich V.A.
Det: BSE Detector
50 µm
VEGA\\ TESCAN
GO "Borok" IPE RAS

No. 411


SEM HV: 20.00 kV
SEM MAG: 3.26 kx
VEGA\\ TESCAN
View field: 101.5 μm
Tselmovich V.A.
20 μm
Date(m/d/y): 09/28/15
Det: BSE Detector
GO "Borok" IPE RAS
1
400мкм
Electron Image 1
SEM HV: 20.00 kV
SEM MAG: 5.04 kx
VEGA\\ TESCAN
View field: 65.57 μm
Tselmovich V.A.
20 μm
Date(m/d/y): 09/28/15
Det: BSE Detector
GO "Borok" IPE RAS



No. 411

Testate amoebae (TA), *Centropyxis aerophila* and *Phryganella acropodial*

Раковинные амебы

Спектр	В стат.	O	Al	Si	K	Fe	Итог
1	Да	15.72	0.00	0.00	0.00	84.28	100.00
2	Да	56.28	0.00	43.72	0.00	0.00	100.00
3	Да	54.78	10.01	24.32	10.90	0.00	100.00
4	Да	53.88	0.00	46.12	0.00	0.00	100.00
5	Да	79.29	0.00	20.71	0.00	0.00	100.00
6	Да	65.93	10.96	23.11	0.00	0.00	100.00
7	Да	55.55	9.80	26.95	7.71	0.00	100.00
Среднее		54.49	4.40	26.42	2.66	12.04	100.00
Станд. отклонение		19.38	5.49	15.46	4.63	31.85	
Макс.		79.29	10.96	46.12	10.90	84.28	
Мин.		15.72	0.00	0.00	0.00	0.00	

Water Air Soil Pollut (2015) 226:97
DOI 10.1007/s11270-015-2338-1

Peatland Microbial Communities as Indicators of the Extreme Atmospheric Dust Deposition

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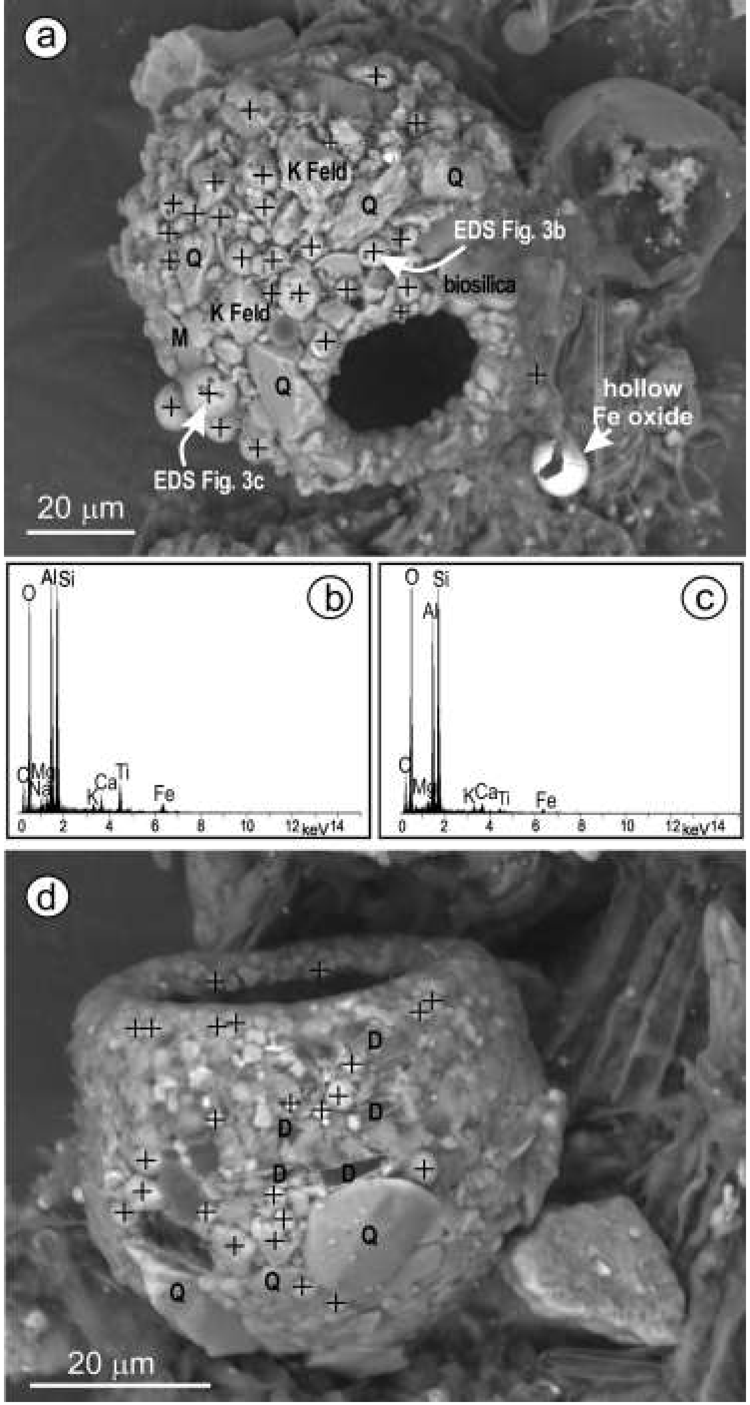
T. M. Ostrovnaya · M. Frontasyeva · A. Siemińska ·
M. Lamentowicz

Received: 2 September 2014 / Accepted: 2 February 2015

Abstract We investigated a peat profile from the Izery Mountains, located within the so-called Black Triangle, the border area of Poland, Czech Republic, and Germany. This peatland suffered from an extreme atmospheric pollution during the last 50 years, which created an exceptional natural experiment to examine the impact of pollution on peatland microbes. Testate amoebae (TA), *Centropyxis aerophila* and *Phryganella acropodia*, were distinguished as a proxy of atmospheric pollution caused by extensive brown coal combustion. We recorded a decline of mixotrophic TA and development of agglutinated taxa as a response for the extreme concentration of Al (30 g kg^{-1}) and Cu (96 mg kg^{-1}) as well as the extreme amount of fly ash particles determined by scanning electron microscopy (SEM) analysis, which were used by TA for shell con-



Scanning electron microscope images and EDS spectra of TA shells:

a shell of ***Difflugia sp.*** covered by fly ashes;

b and **c** EDS spectra of anthropogenic aluminosilicates from (**a**);

d ***Phryganella sp.*** — anthropogenic particles that are built into the test. Anthropogenic particles are indicated by crosses, the identified natural particles are Q quartz, F feld – potassium feldspar, M muscovite, D diatom fragments.

Peat-bog cores for retrospective studies of deposition of micrometeorites and cosmic dust

Journal of Radioanalytical and Nuclear Chemistry, Vol. 265, No. 1 (2005) 11–15

Distribution of 35 elements in peat cores from ombrotrophic bogs studied by epithermal neutron activation analysis

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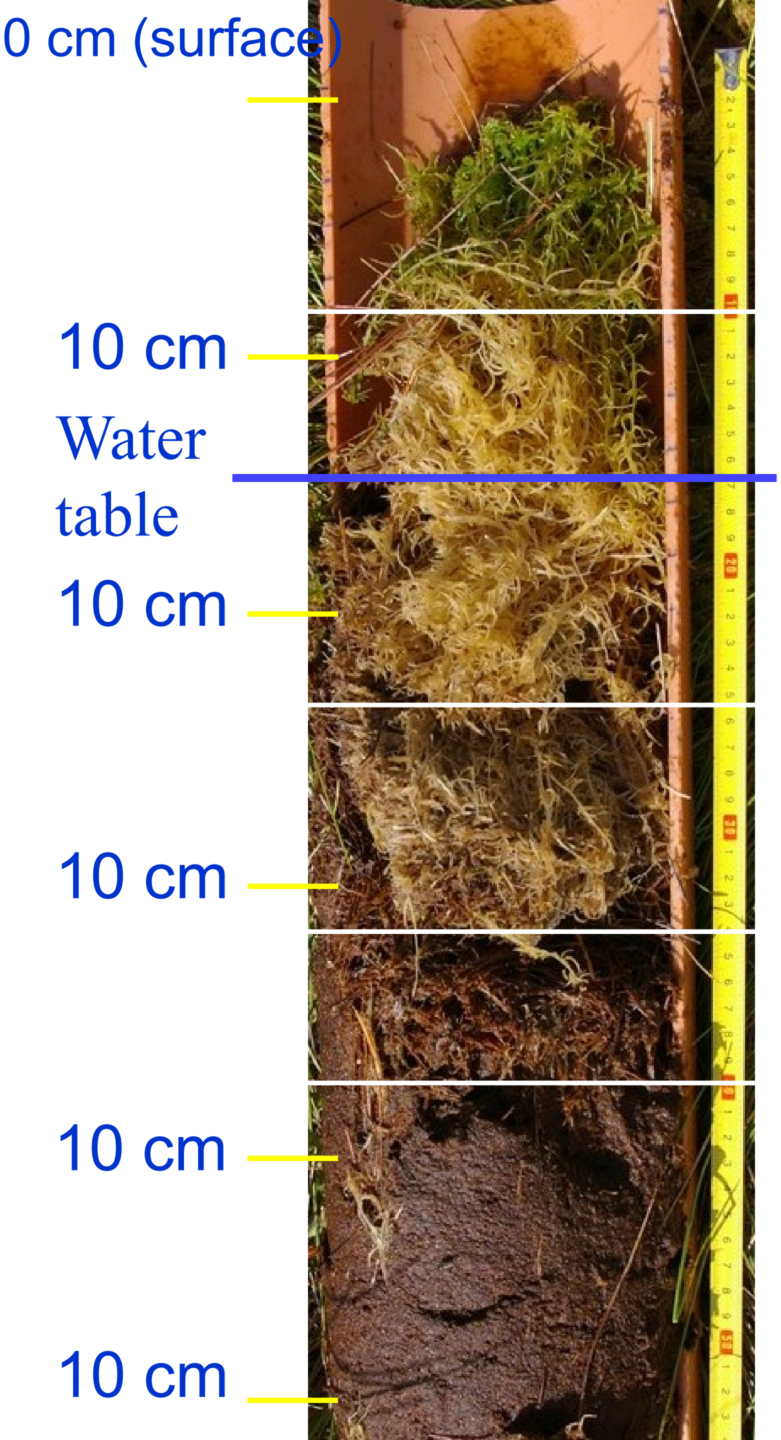

Living *Sphagnum*

Dead *Sphagnum*

Forming *Sphagnum* peat

Warnstorfia felt

Remnant (old) peat

Limit between the fen peat (left) and the organic sediment

Table 1. Vertical distribution of 36 elements in surface peat cores from two ombrotrophic bogs in northern Norway (in μg/g)

Element	Radionuclide	Bog A (Kistrand)				Bog B (Svanvik)			
		0–2.5 cm	5–10 cm	10–20 cm	20–40 cm	0–2.5 cm	5–10 cm	10–20 cm	20–40 cm
Na	^{24}Na	698	300	345	298	306	167	152	153
Mg	^{27}Mg	2210	1770	1890	1350	1500	960	1080	1000
Al	^{28}Al	3920	560	602	617*	1210	356	176	123
Cl	^{38}Cl	862	773	677	838	366	1096	971	719
K	^{42}K	1465	639	413	283*	1345	636	390	262
Ca	^{49}Ca	3830	2290	2600	2620	2780	2540	2350	2020
Sc	^{46}Sc	0.52	0.11	0.17	0.19	0.32	0.090	0.045	0.030
V	^{52}V	3.75	0.72	0.61	0.91	4.41	1.31	0.42	0.29
Cr	^{51}Cr	12.5	3.07	1.60	0.87	8.8	0.94	0.37	0.39
Mn	^{56}Mn	75.4	6.8	3.6	3.6	243	78	8.7	10.5
Fe	^{59}Fe	2050	807	1130	489	2920	976	956	813
Co	^{60}Co	0.93	0.79	0.59	0.50	8.47	2.32	1.06	0.49
Ni	^{58}Co	4.30	2.22	1.07	1.50*	251	123	31.9	4.20
Cu	^{64}Cu	<5	<5	<5	<5	161	22	15	<5
Zn	^{65}Zn	48	34	11	5	30	22	20	10
As	^{76}As	0.50	0.40	0.23	0.14	4.24	2.03	1.05	0.32
Se	^{75}Se	0.37	0.31	0.36	0.42	1.17	0.32	0.24	0.18
Br	^{82}Br	44	66	120	97	12.7	21.2	33.8	22.4
Rb	^{86}Rb	6.01	1.91	0.84	0.25	1.85	1.05	0.58	0.20
Mo	^{99m}Tc	0.85	0.84	1.59	1.00	1.56	1.40	0.97	1.07
Ag	^{110m}Ag	0.064	0.022	0.041	0.037	0.076	0.046	0.035	0.041
Sb	^{122}Sb	0.194	0.137	0.051	0.017	0.420	0.189	0.106	0.031
I	^{128}I	8.0	7.7	13.3	10.4	3.0	6.2	5.3	5.4
Cs	^{134}Cs	0.141	0.043	0.026	0.012	0.076	0.029	0.013	0.006
La*	^{140}La	1.14	0.39	0.70	0.62	0.36	0.23	0.18	0.11
Ce*	^{141}Ce	8.7	3.2	2.0	2.5	1.42	0.41	0.35	0.21
Sm*	^{153}Sm	0.245	0.078	0.101	0.097	0.072	0.033	0.016	0.011
Eu*	^{152}Eu	0.025	0.040	0.031	0.020	0.015	0.014	0.009	0.008
Tb*	^{160}Tb	0.044	0.012	0.017	0.011	0.012	0.004	0.004	0.004
Yb*	^{175}Yb	0.182	0.042	0.045	0.033	0.042	0.011	0.011	0.005
Hf	^{181}Hf	0.861	0.069	0.036	0.046	0.148	0.026	0.007	0.016
Ta	^{182}Ta	0.0502	0.0057	0.0056	0.0063	0.0193	0.0065	0.0020	0.0026
Au	^{198}Au	0.001	0.006	0.003	0.002	0.009	0.011	0.001	0.002
Th	^{233}Pa	0.330	0.107	0.164	0.174	0.076	0.048	0.024	0.015
U	^{239}Np	0.067	0.085	0.235	0.156	0.044	0.015	0.032	0.014

* Suspected groundwater contribution (minerotrophic layer) below 37.5 cm in Bog A.

Tunguska phenomenon (meteorite) again…

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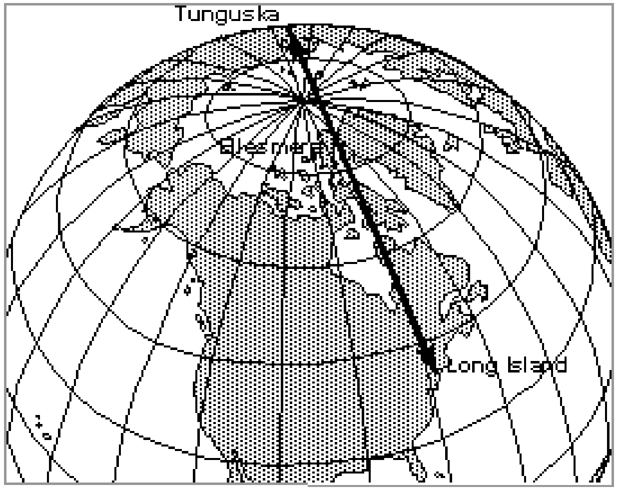
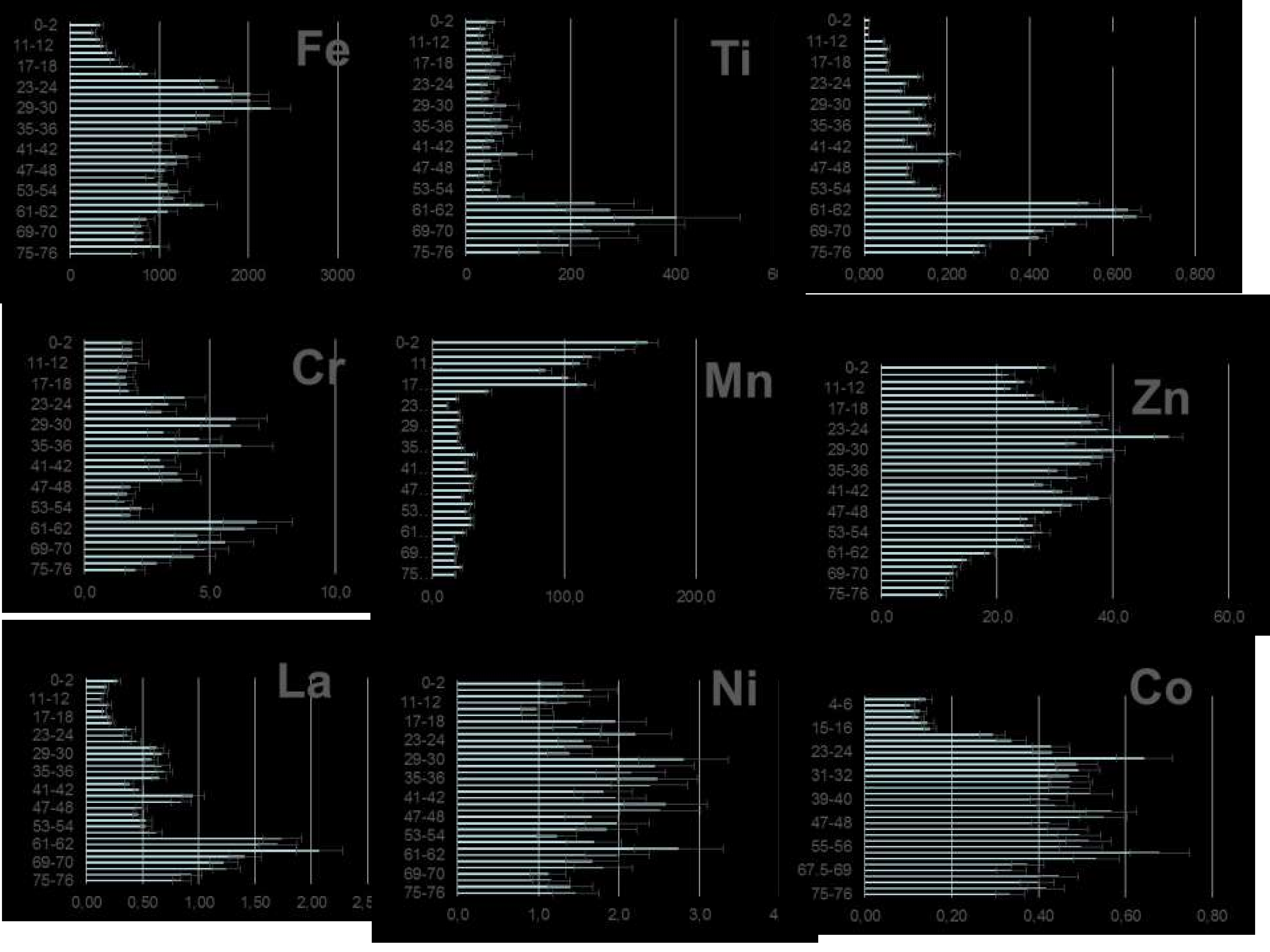
http://tunguska.tsc.ru/ru/science/tv/11/8/



Magnifying Transmitter's Test Path

In Russian

http://www.bastabalkana.com/2013/12/%D0%BF%D1%80%D0%B8%D1%87%D0%B0%D1%81%D1%82%D0%B5%D0%BD-%D0%BB%D0%B8-%D0%BD%D0%B8%D0%BA%D0%BE%D0%BB%D0%B0-%D1%82%D0%B5%D1%81%D0%BB%D0%B0-%D0%BA-%D1%82%D1%83%D0%BD%D0%B3%D1%83%D1%81%D1%81%D0%BA%D0%BE-2/


Fe
0-2
11-12
17-18
23-24
29-30
35-36
41-42
47-48
53-54
61-62
69-70
75-76
0
1000
2000
3000
Ti
0-2
11-12
17-18
23-24
29-30
35-36
41-42
47-48
53-54
61-62
69-70
75-76
0
200
400
0-2
11-12
17-18
23-24
29-30
35-36
41-42
47-48
53-54
61-62
69-70
75-76
0,000
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Cr
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Mn
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Zn
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La
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35-36
41-42
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61-62
69-70
75-76
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0,50
1,00
1,50
2,00
Ni
0-2
11-12
17-18
23-24
29-30
35-36
41-42
47-48
53-54
61-62
69-70
75-76
0,0
1,0
2,0
3,0
4
Co
4-6
15-16
23-24
31-32
39-40
47-48
55-56
67,5-69
75-76
0,00
0,20
0,40
0,60
0,80

Factor Analysis

	Factor 1	Factor 2	Factor 3
Na	**0,91**	-0,19	-0,18
Mg	**0,89**	0,21	0,00
Cl	0,34	-0,03	**-0,86**
K	-0,11	-0,15	**-0,92**
Ca	-0,07	**0,80**	0,03
Sc	**0,98**	-0,13	0,09
Ti	**0,94**	-0,24	0,00
Cr	**0,70**	0,49	-0,05
Mn	-0,46	-0,42	**-0,64**
Fe	0,14	**0,80**	0,19
Ni	0,14	**0,82**	0,05
Co	0,39	**0,74**	0,41
Zn	-0,54	**0,69**	-0,12
As	-0,25	**0,87**	0,16
Se	0,63	0,37	0,16
Br	**0,86**	0,22	-0,01
Rb	-0,05	-0,17	**-0,94**
Sr	0,57	**0,61**	0,43
Mo	**0,82**	0,34	-0,02
Cd	-0,14	0,12	0,15
In	-0,45	0,34	-0,06
Sb	-0,23	**0,82**	0,18
I	**0,89**	-0,09	0,24
Cs	0,41	-0,31	-0,02
Ba	0,53	**0,73**	0,36
La	**0,97**	0,10	0,10
Ce	**0,92**	0,19	0,09
Sm	**0,95**	0,19	0,15
Tb	**0,97**	0,13	0,11
Hf	**0,81**	-0,27	0,08
Ta	**0,96**	-0,19	0,04
W	0,47	**0,52**	0,36
Au	-0,36	-0,10	-0,59
Th	**0,98**	-0,04	0,12
U	**0,98**	-0,03	0,08
Expl.Var	*16,02*	*6,95*	*4,19*
Prp.Totl	*0,46*	*0,20*	*0,12*

Factor 1 - light and heavy crust component

Factor 2 - anthropogenic or **something else**, not of soil origin!

Factor 3 - vegetation (tht is obvious - turf, or moss)

Latest preliminary results of NAA of meteorites from NASA, USA

MICROPALEONTOLOGY INVESTIGATIONS AND NEUTRON ACTIVATION ANALYSIS OF CARBONACEOUS METEORITES

Richard B. Hoover[1], Alexei Yu. Rozanov[2,3], Marina Frontasyeva[4], Sergey Pavlov[4]

To be delivered at ISIN-24 in Dubna, May 2016

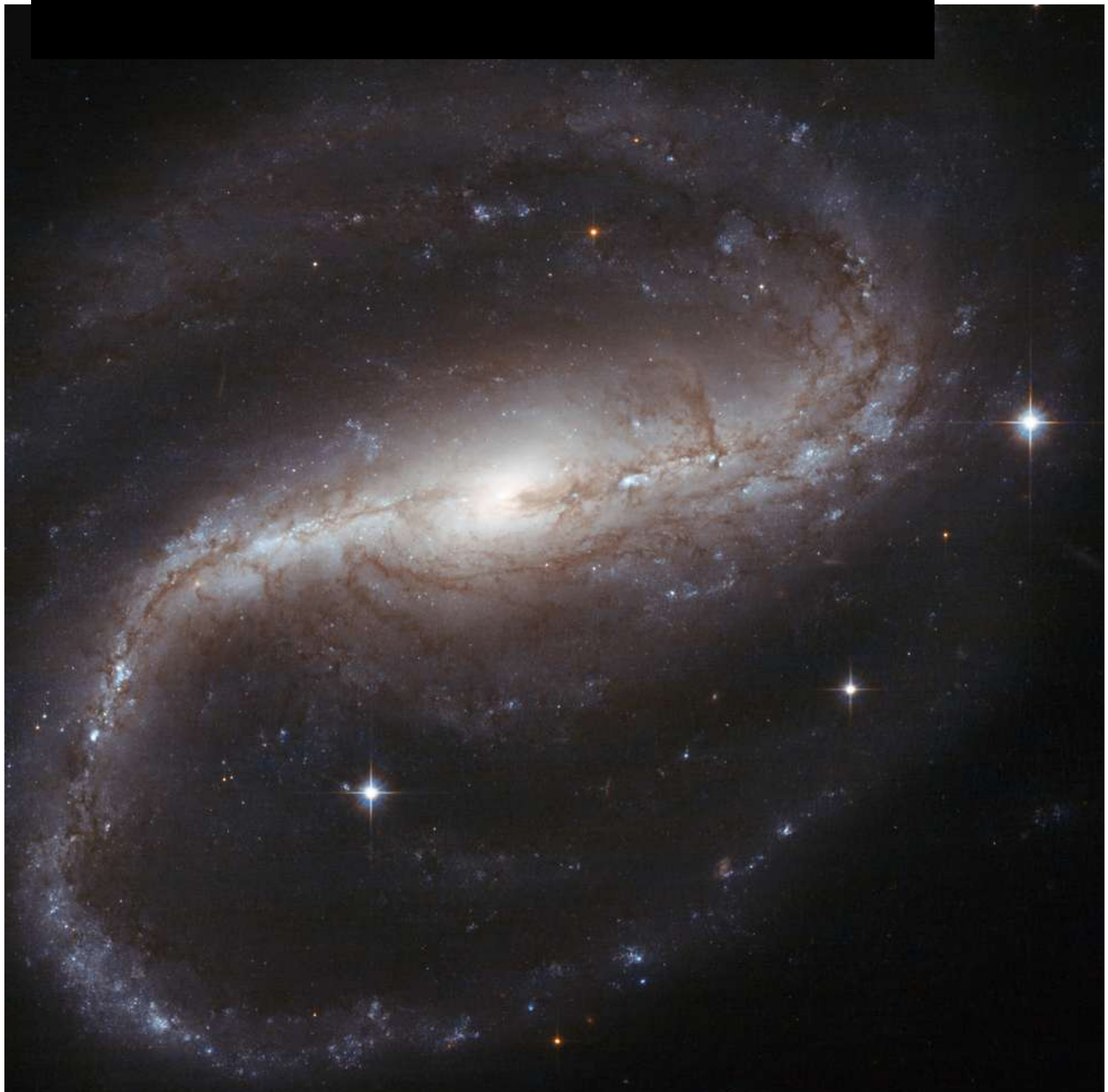
Richard HOOVER:
The purpose of this study is to understand the nature of these most unusual stones. Aside from volatiles - is the distribution of their elements similar to the Solar Photosphere, to other carbonaceous meteorites, or to some type of known Earth rocks (?). If these stones are non-terrestrial, they will provide direct and incontrovertible evidence of biology on the parent body.

Na Mg Al Si Cl K Ca
Sc Ti V Cr Mn Fe Co
Ni Cu Zn Ga As Se Br Rb
Sr Mo Zr Ru Cd Sn Sb
Te Cs Ba La Ce Nd Eu Sm Gd
Tb Dy Yb Tm Lu Hf Ta W Re
Ir Au Hg Th U

Herschel Detects Cosmic Dust From Supernova

Posted on: Friday, 8 July 2011, 07:06 CDT

[redacted]



The Butterfly Nebula from Hubble (cosmic dust)