

JINR



Department of Neutron Activation Analysis & Applied Research

Division of Nuclear Physics

Frank Laboratory of Neutron Physics

Joint Institute for Nuclear Research

NAA FOR LIFE SCIENCES

AT FLNP JINR IN DUBNA, RUSSIA



Marina Frontasyeva

marina@nf.jinr.ru

ISINN-20. Alushta. 2012

Объединенный институт ядерных исследований
Joint Institute for Nuclear Research

Международная межправительственная организация
International Intergovernmental Organization



18 member states (former socialist countries) and 7 associated states
(Germany, Italy, Hungary, Japan, Serbia, South Africa and Egypt)
(Interest from India, China and Macedonia)

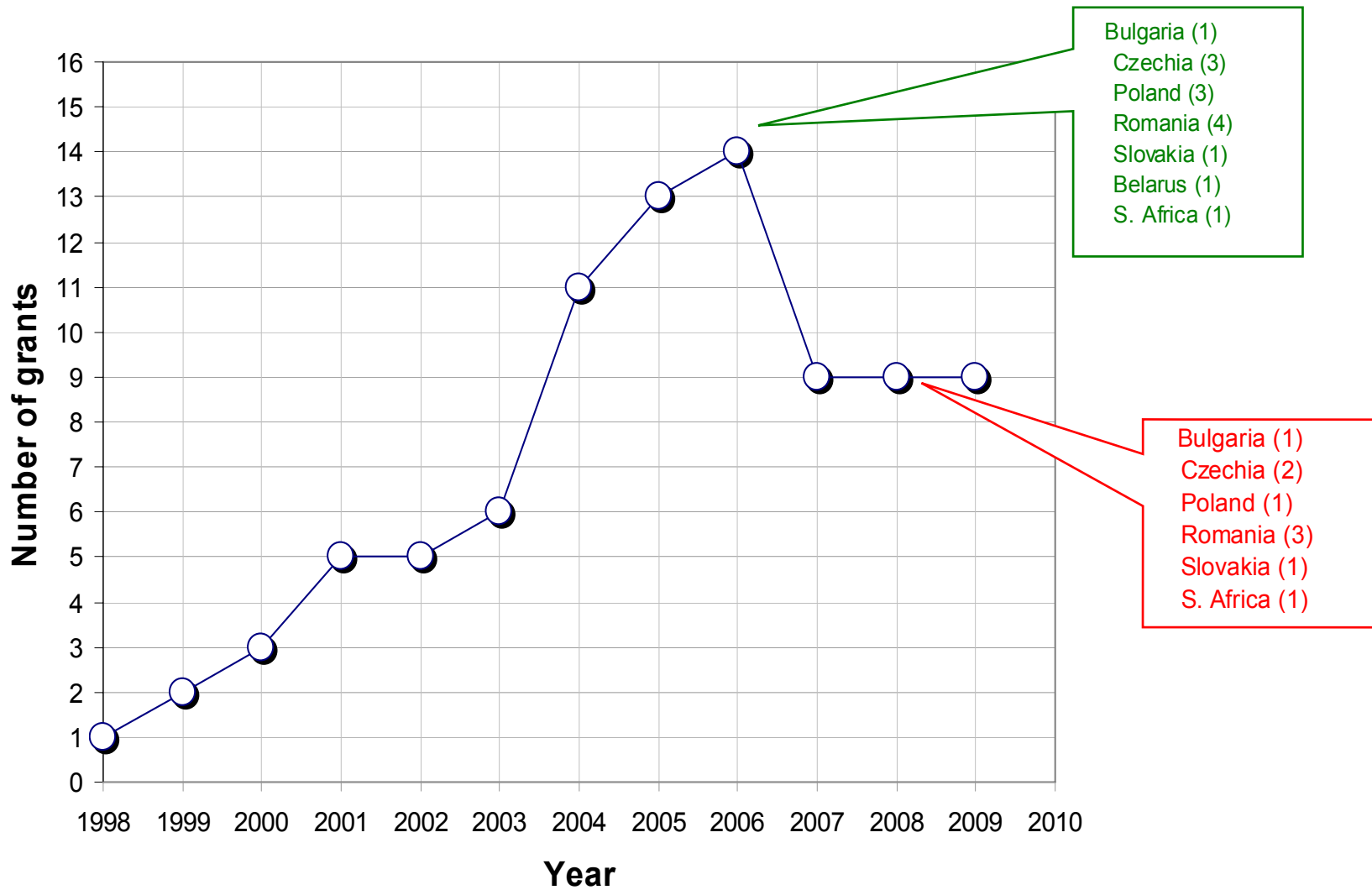
«Сегодня у физики две важнейшие задачи – забота о здоровье людей и об экологии. Во всем мире сейчас физика переориентируется на эти цели»

Декан физфака МГУ Владимир Трухин
(20 апреля 2005, «*МОСКОВСКИЙ КОМСОМОЛЕЦ*»)

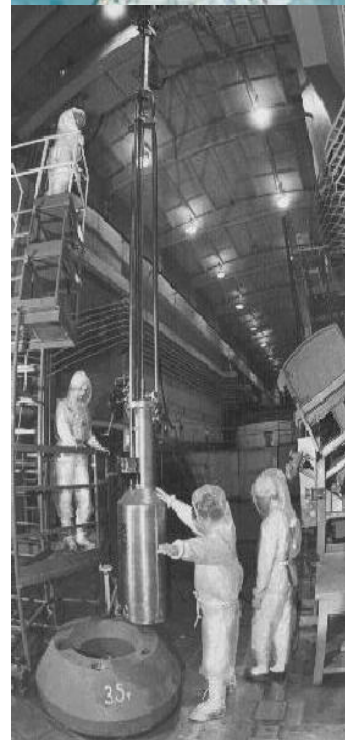
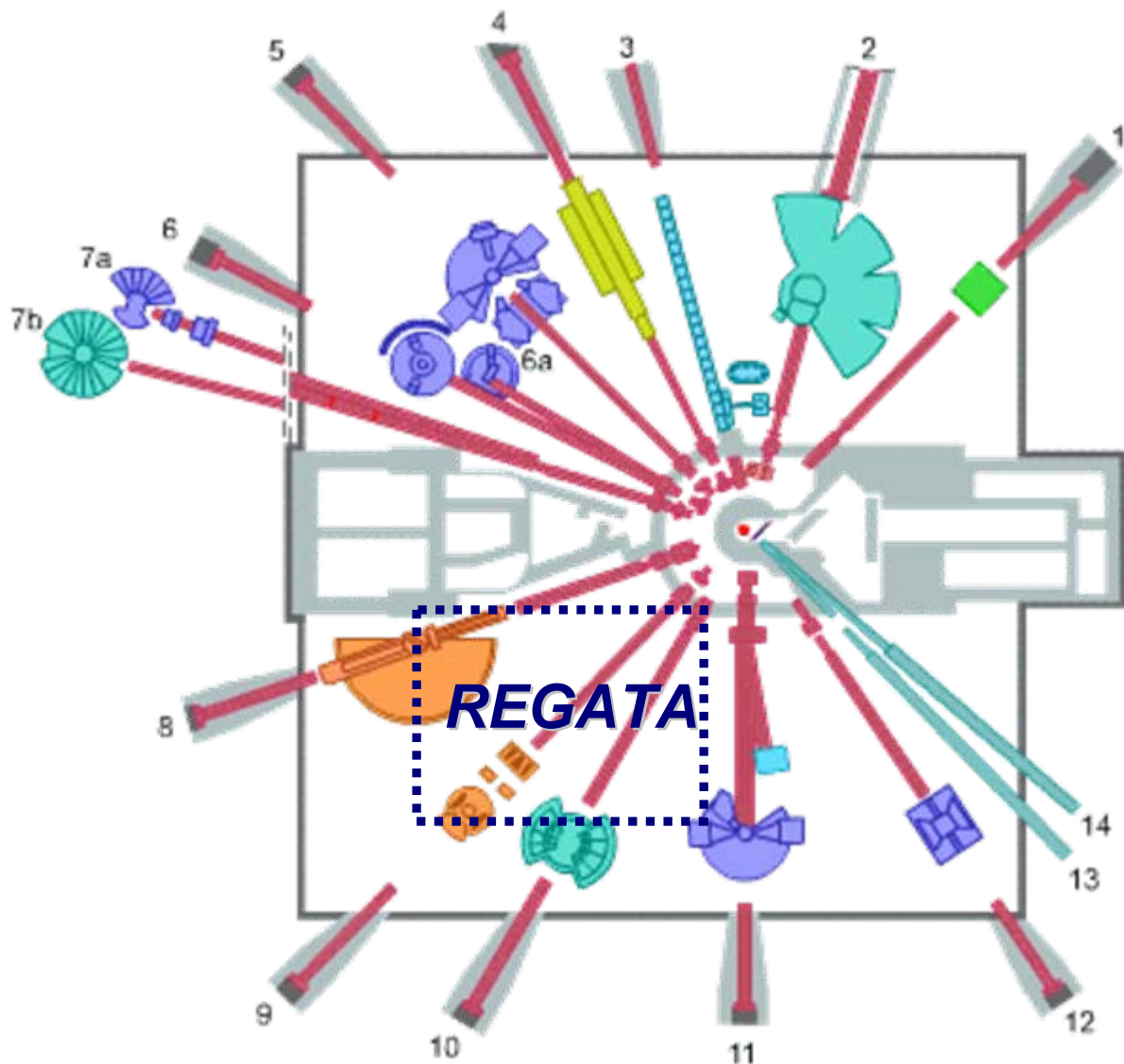
«At present physics has two very important tasks:
care for **people's health** and care for **the environment**.
All over the world, physics is being re-oriented to
meet these objectives»

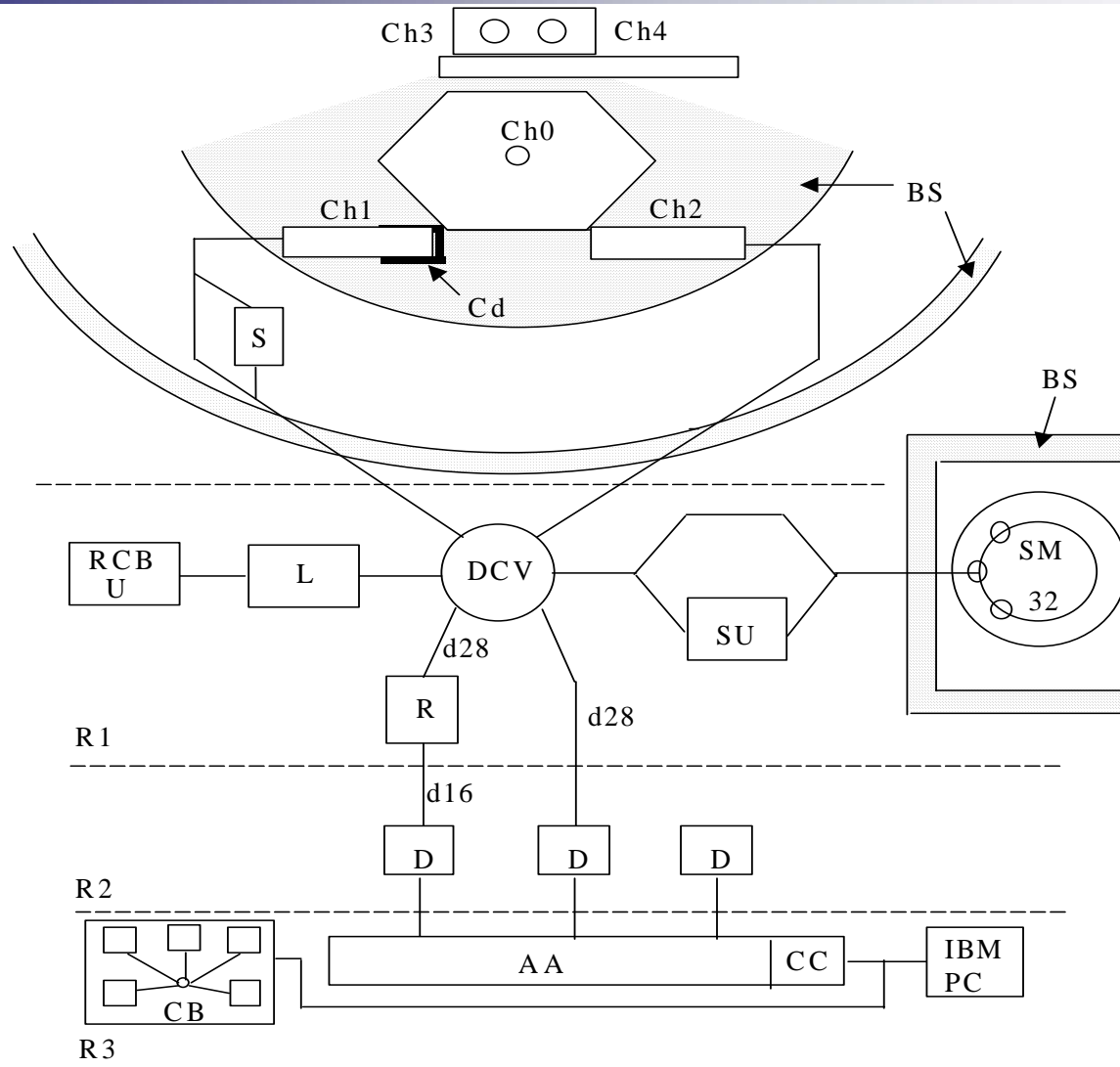
Dean of the MSU Faculty of Physics
Professor Vladimir Trukhin
(April 20, 2005, «*Mosckovsky Komsomolec*»)

Grants of Plenipotentiaries of JINR member-states



IBR-2 Pulst Fast Reactor 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

Hot-cells and loading of containers with samples for irradiation





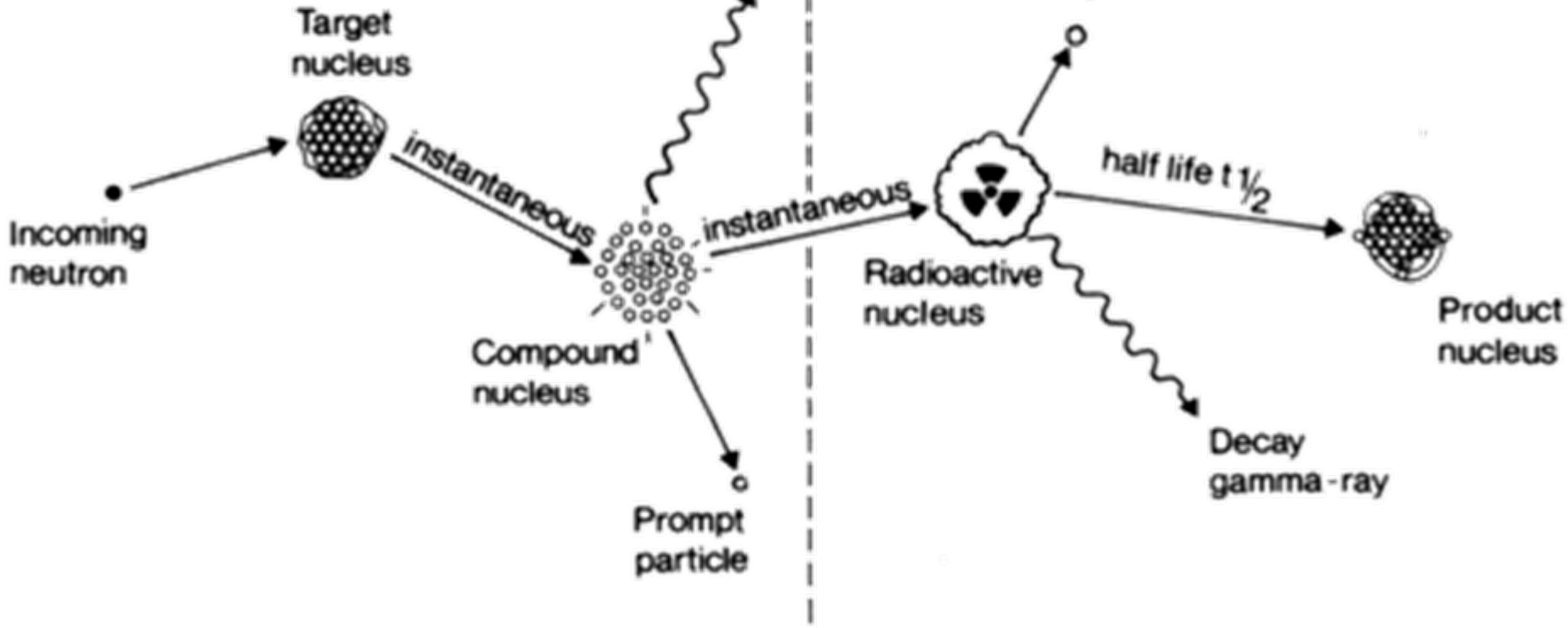
Principles of NAA.

Nuclear Reactions



PGNAA

DGNAA



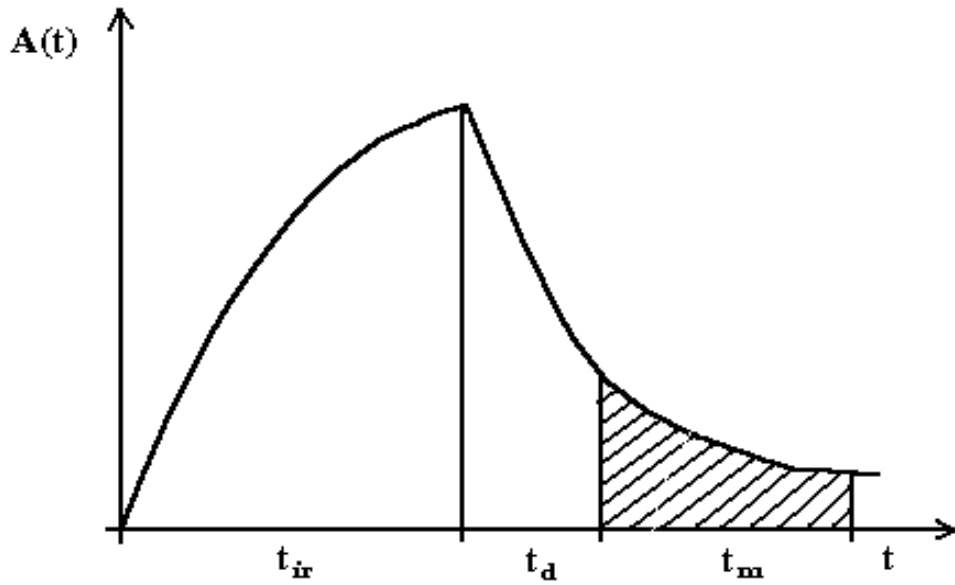
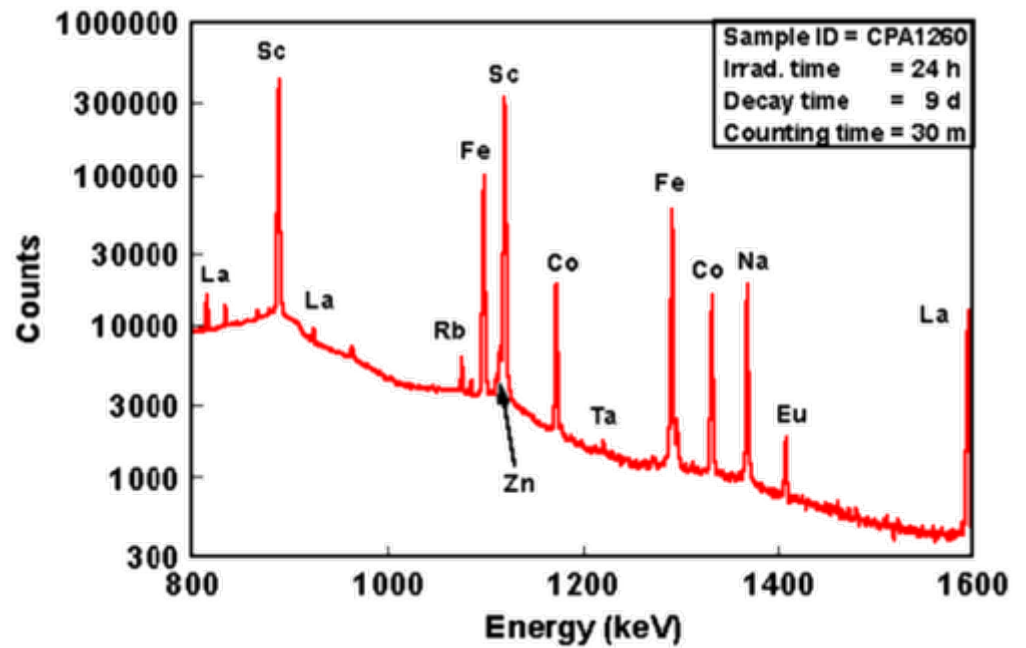
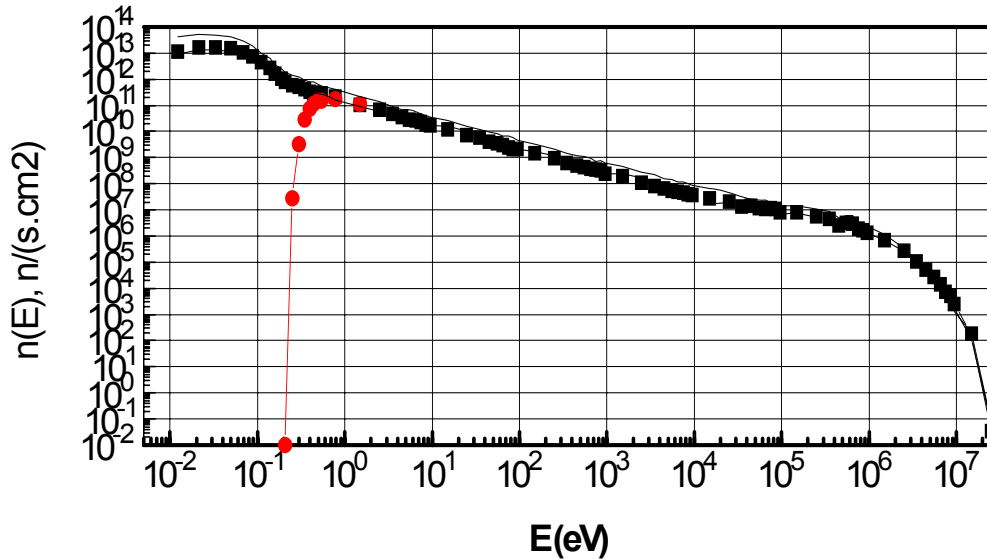


Fig. 1.1 The accumulation and the decay of a radioactive nuclei.



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

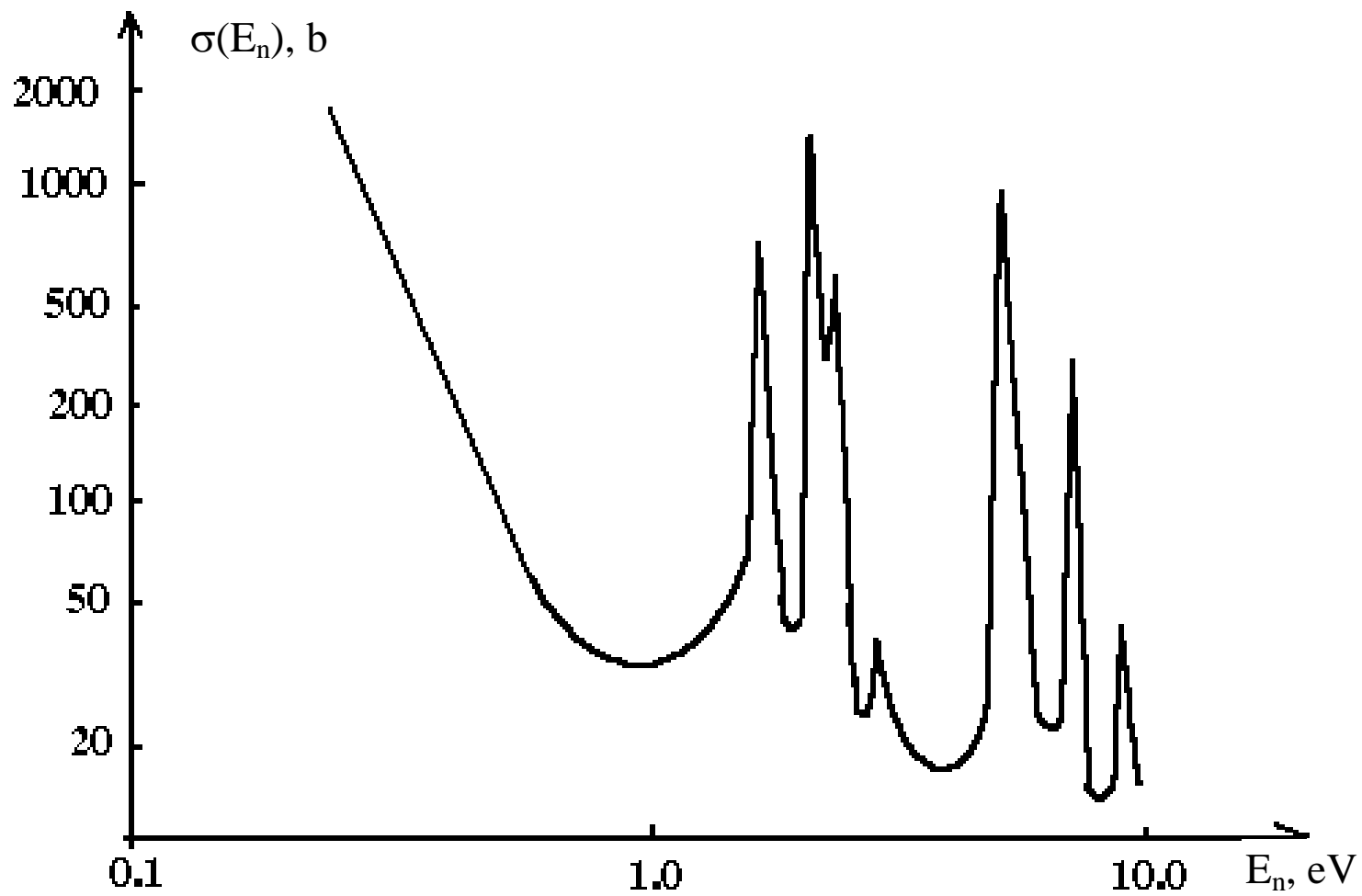
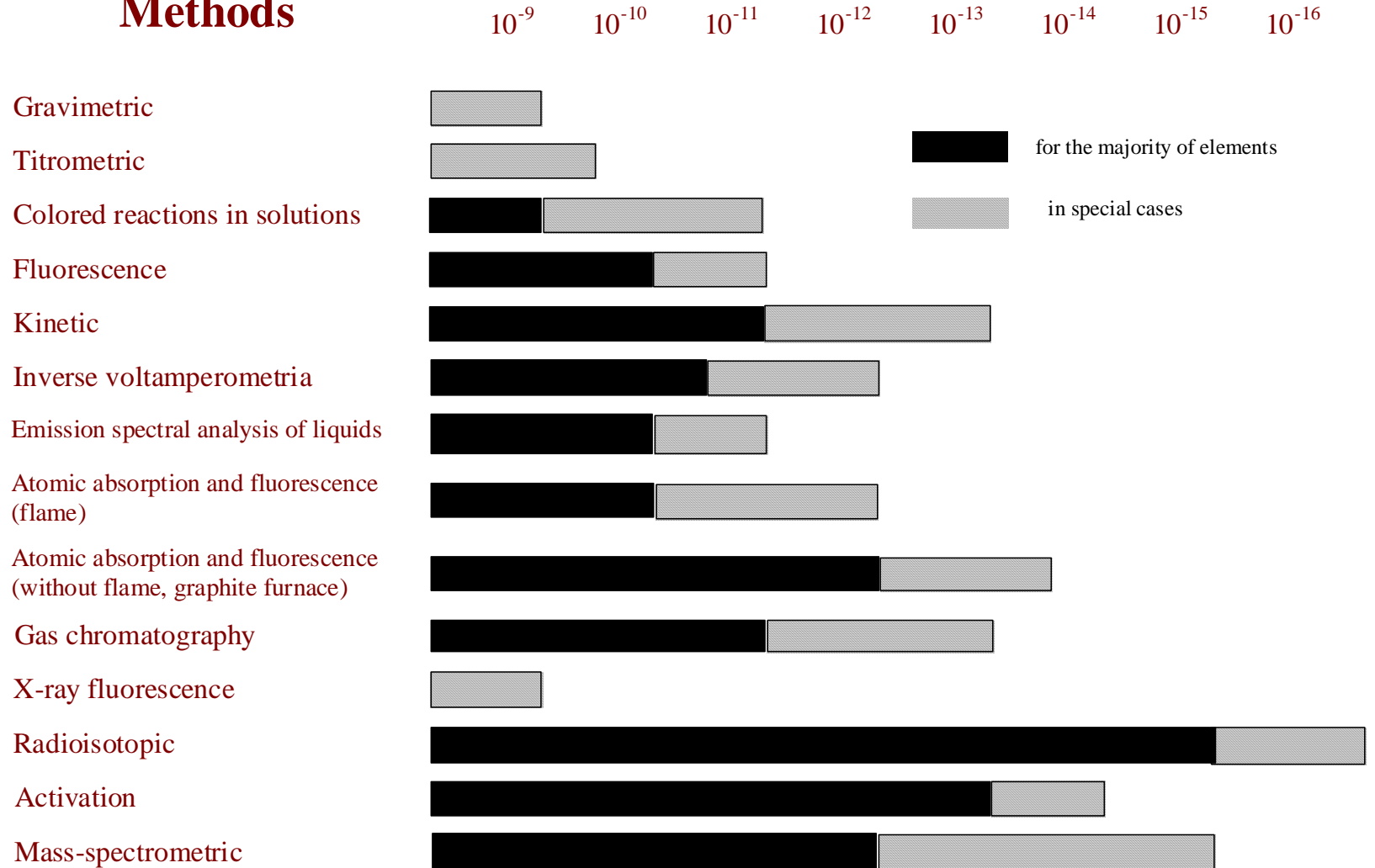


Fig. 1.3 Relation between neutron cross section and neutron energy [5].

Absolute detection limit, g

Methods



Neutron Activation Analysis: A Primary (Ratio) Method to Determine SI-Traceable Values of Element Content in Complex Samples



Peter BODE
Delft University
of Technology
The Netherlands



Robert GREENBERG
National Institute of Standards
and Technology, NIST
USA



Elisabete FERNANDES
Univer. de Sao Paulo Centro de
Energia Nuclear na Agricultura
Brazil

42

NAA + AAS

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		

Chemical laboratory of Dept. NAA & Applied Research

and some equipment for
sample preparation



Sample preparation



Sample preparation for NAA



ANALYTICAL INVESTIGATIONS AT IBR-2M REACTOR

*Instrumental
neutron activation analysis*
INAA

*Epithermal
neutron activation
analysis*
ENAA

*Cyclic
neutron activation
analysis*
CNAA

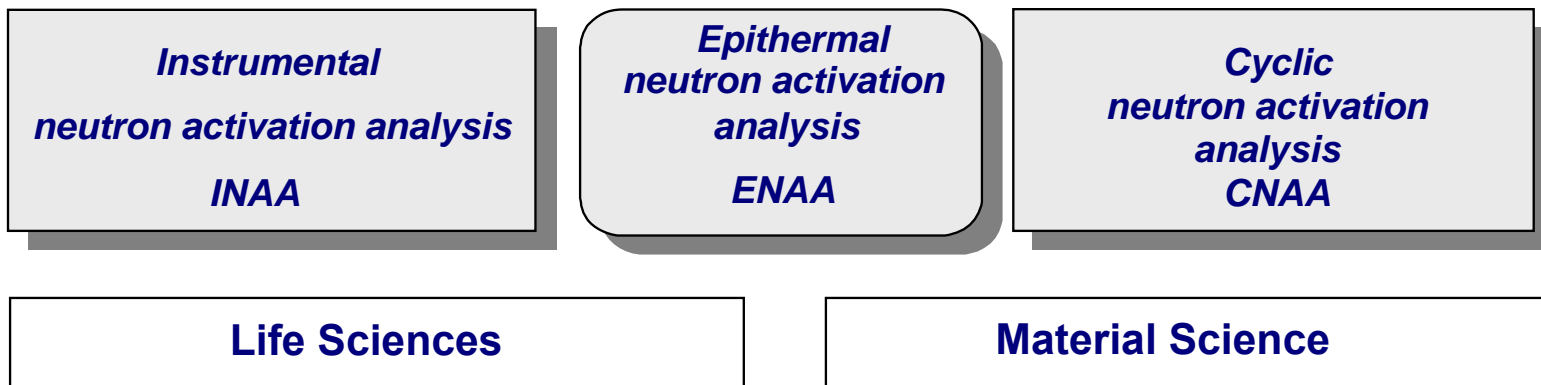
Life Sciences

- **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:** development of new pharmaceuticals, cleaning the environment from toxic elements (biosorption) and synthesis of nanoparticles
- 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**

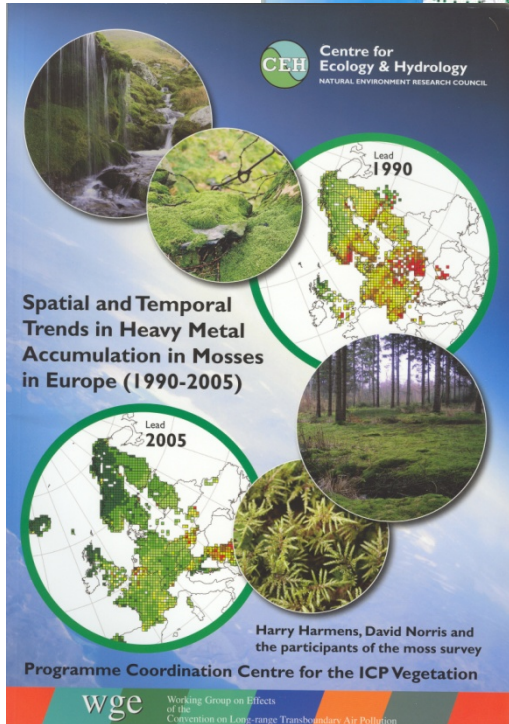
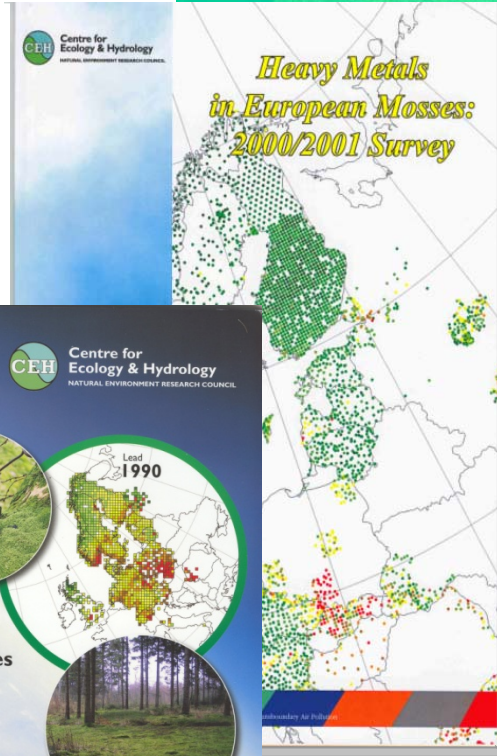
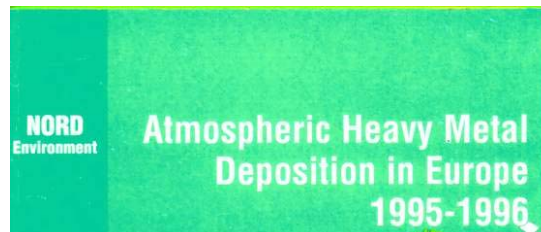
ANALYTICAL INVESTIGATIONS AT IBR-2M REACTOR



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Air pollution studies based on moss analysis



UNECE



United Nations Economic Commission for Europe

International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

Working Group on Effects - 1981



Project REGATA

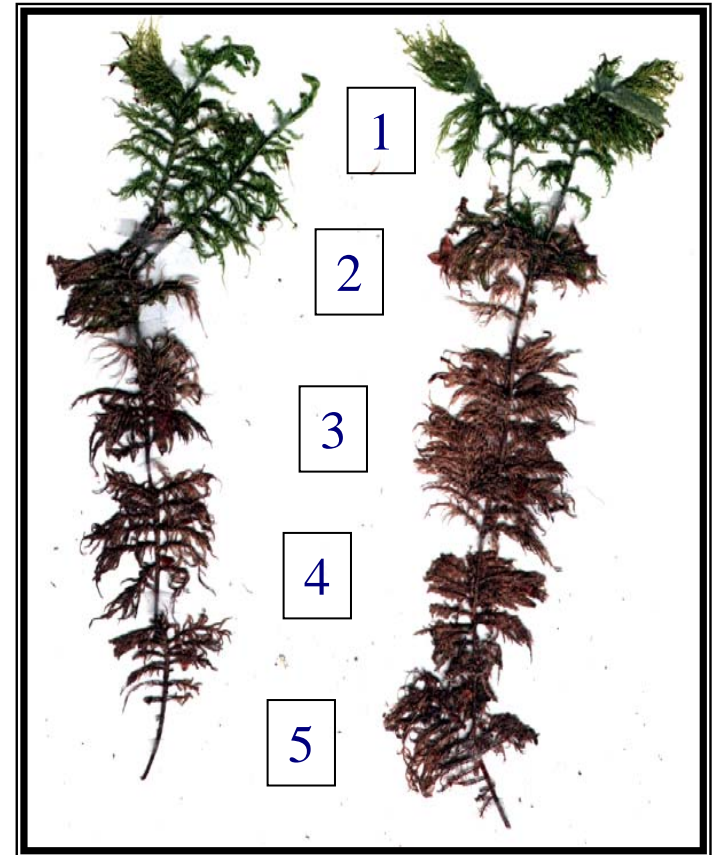
(1995-2000-2005-2010-2015)

Title

Heavy metal atmospheric deposition study in selected European and Asian countries using nuclear and related analytical techniques

Participating countries:

Russia, Ukraine, Belarus, Bulgaria, Croatia, Poland, Romania, Slovakia, Greece, Macedonia, Serbia, Croatia, Albania, Montenegro, Turkey, Mongolia, Vietnam, South Korea, Thailand



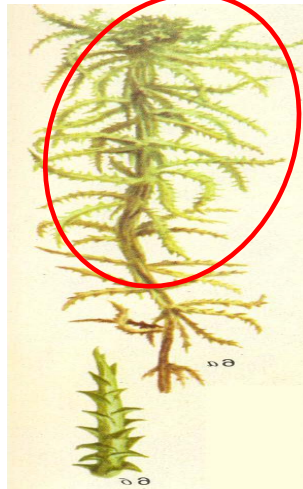
Annual segments

Most wide-spread moss types

Climacium dendroides



Green and greenish-brown moss segments, corresponding to a three year growth are taken for element determination



Sphagnum squarrosum

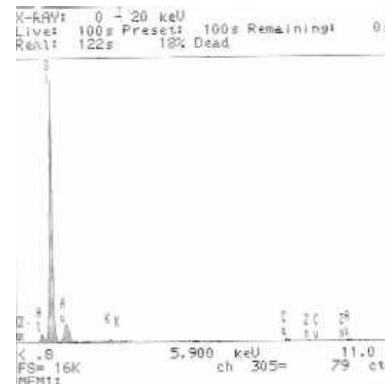
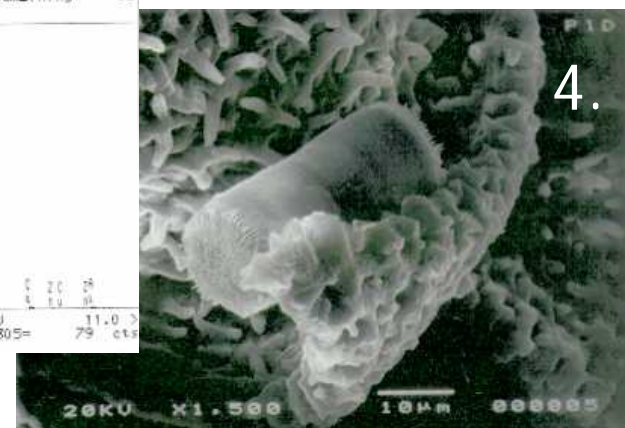
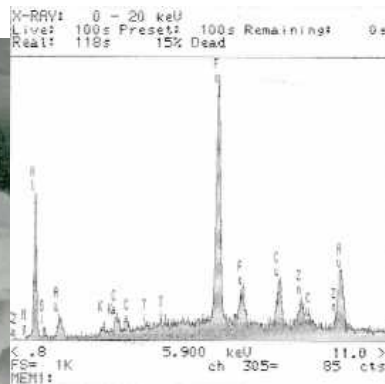
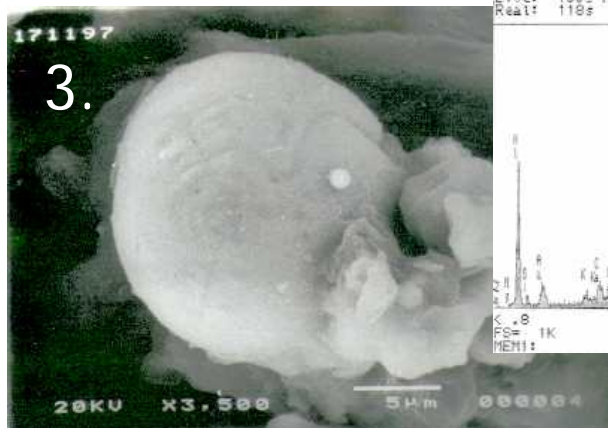
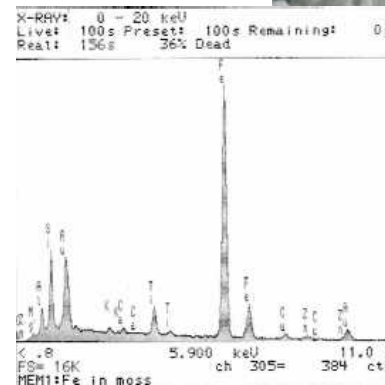
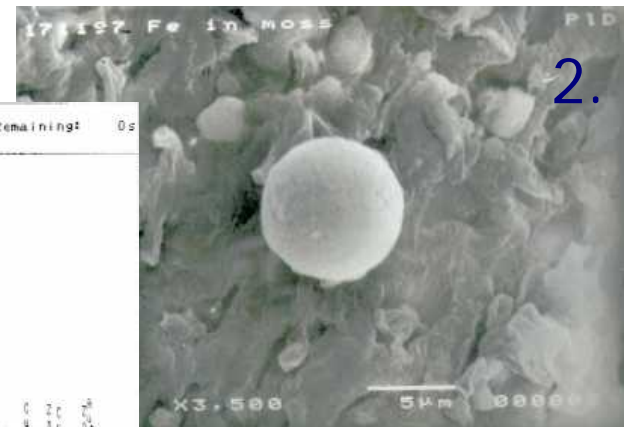
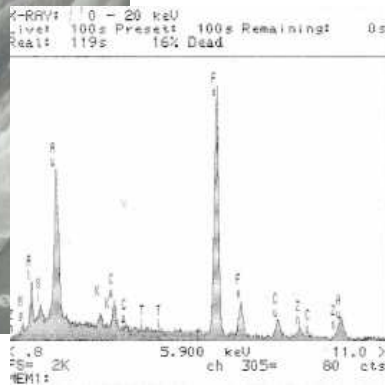


Hylocomium splendens




Pleurozium schreberi

Scanning electron microscope images of captured particles on the moss surface and corresponding spectrograms



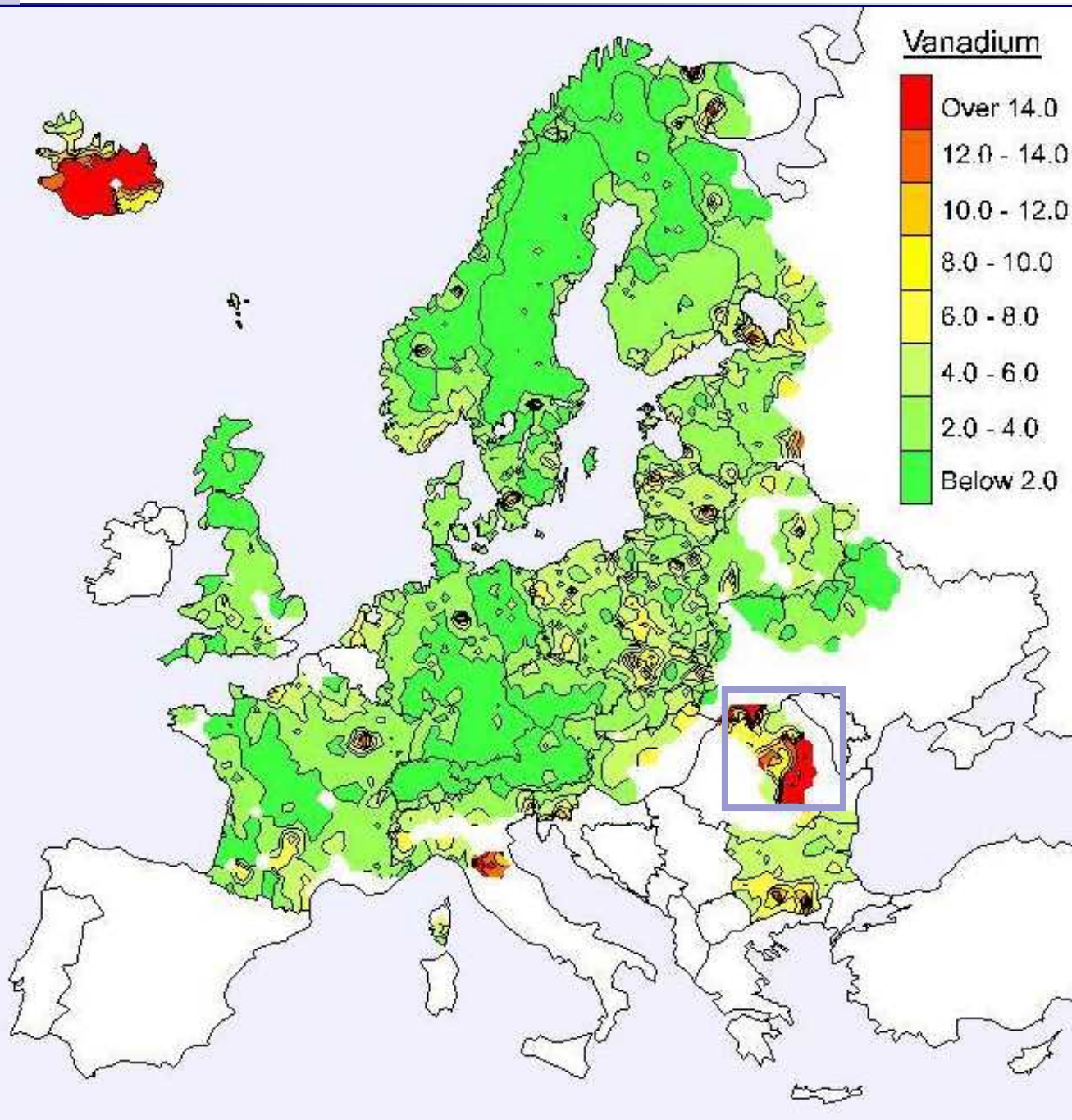
- 1 - Fe particle with Mg impurity; 2 - Spherule of pure iron;
3 - Al-Fe cluster particle with impurities of Zn, Cu, and Ti; 4 - Diatomic alga



Our different backgrounds apparently to some extent influence our thinking about moss biomonitoring. **A physicist** regards the moss mainly as a collection substrate for particles, **a chemist** is more concerned about the sorption/ion exchange properties of the moss surface affecting dissolved chemical species, and **a biologist** is concerned about the vitality of the moss and its relevance for intracellular processes. In the end I believe all these aspects are important in order to understand completely how the moss works as a biomonitor of air pollutants.

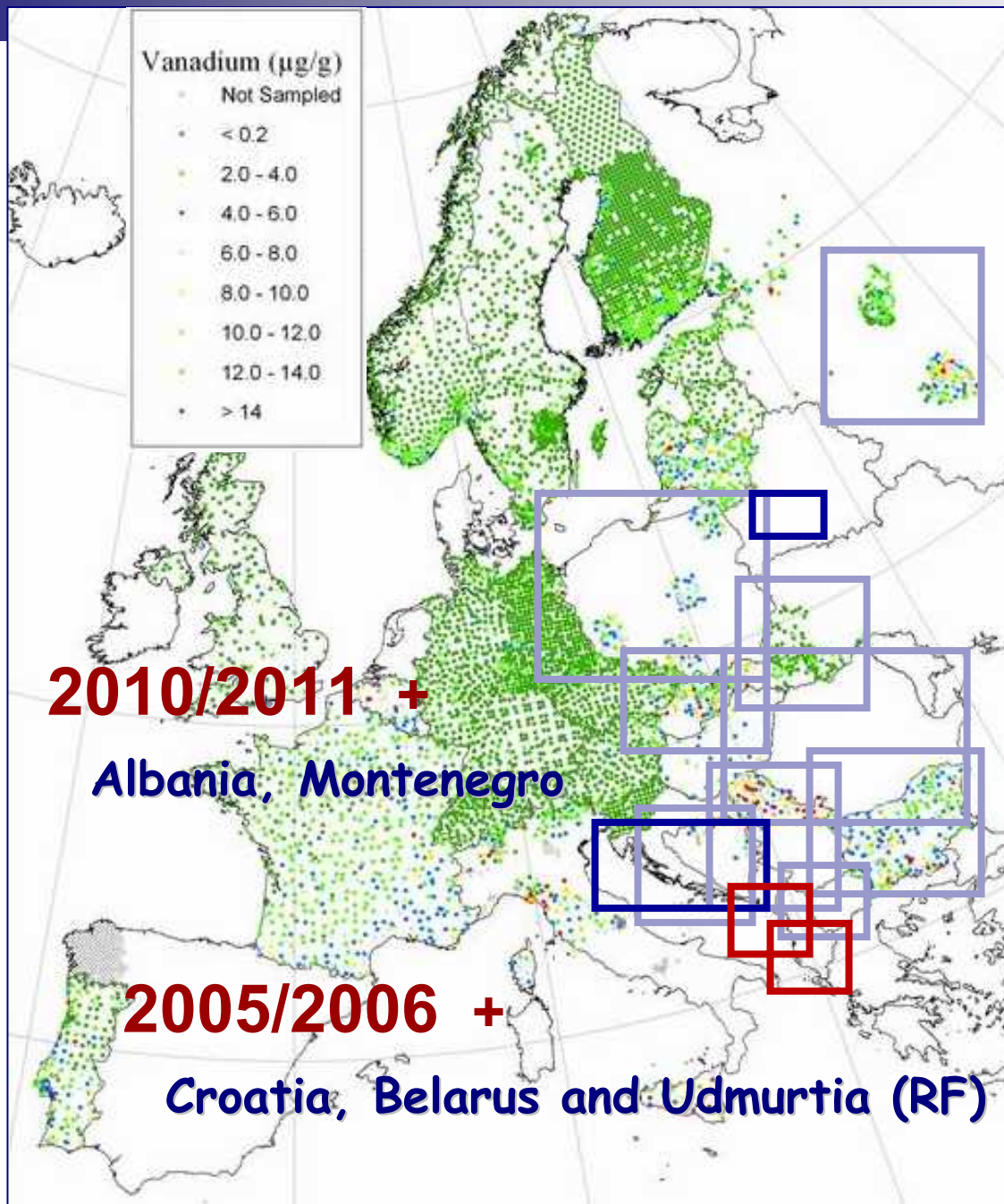
Eiliv Steinnes

March 11, 2009



1995

Romania



2000/2001

Russia

Poland

Slovakia

Ukraine

Romania

Serbia

Bosnia

Bulgaria

Macedonia

Moss surveys 2010/2011 – 2015

Leningradskaya Region, Tikhvin

Yekaterinburg, the Urals

Kostroma Region

Smolensk Region

Ivanovo Region

Kola Peninsula

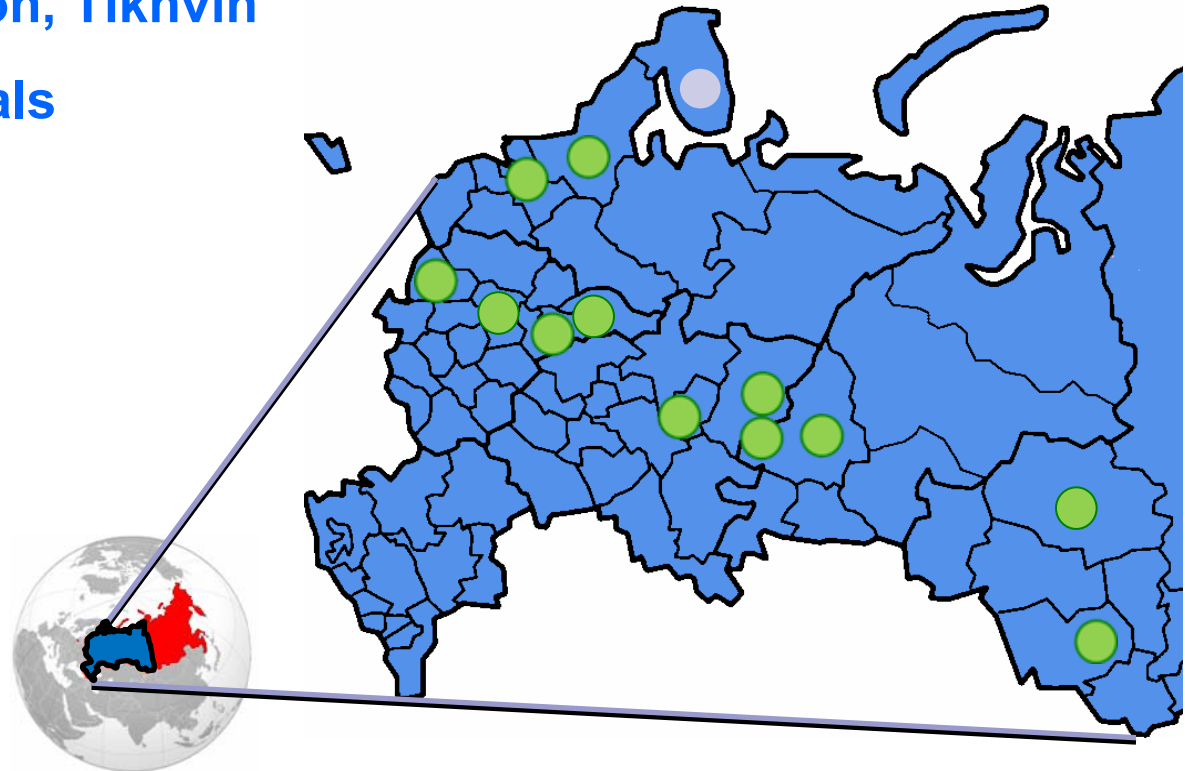
Moscow

Tomsk

Dubna

Altay

.....





Inna Vikhrova, teacher of physics,
Livceum No. 8, Tikhvin,
Leningradskaya Region

Kostroma Region, near town of Volgorechensk

Мои карты — Яндекс... x
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Поиск | Почта | Карты | Маркет | Новости | Словари | Блоги | Видео | Картины | еще ▾

volgorech | Выход | Помощь

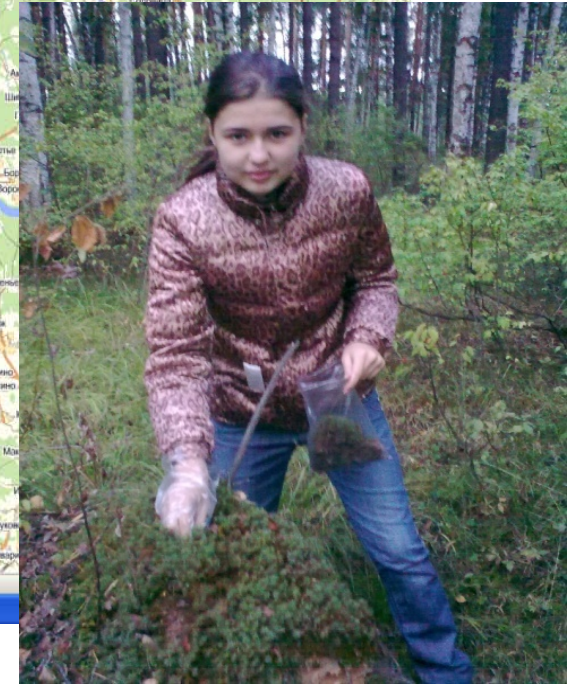
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Пробки | Показать на карте ▾ | Схема ▾

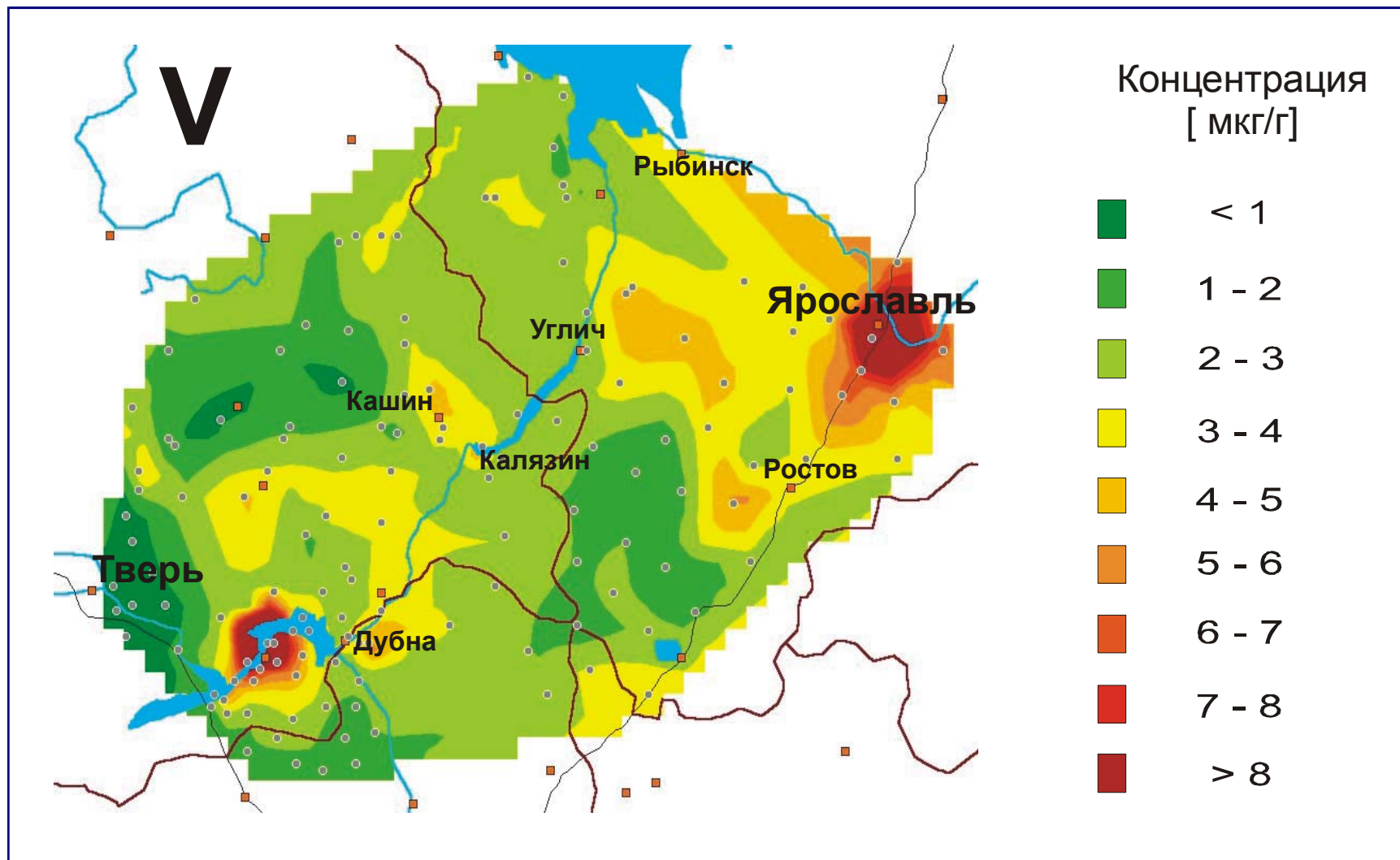
10 Метка
11 Метка
12 Метка
13 Метка
14 Метка
15 Метка
16 Метка

ПУСК | Mail.Ru Агент (L... | Мои карты — Ян...





Tver' and Yaroslavl' Regions



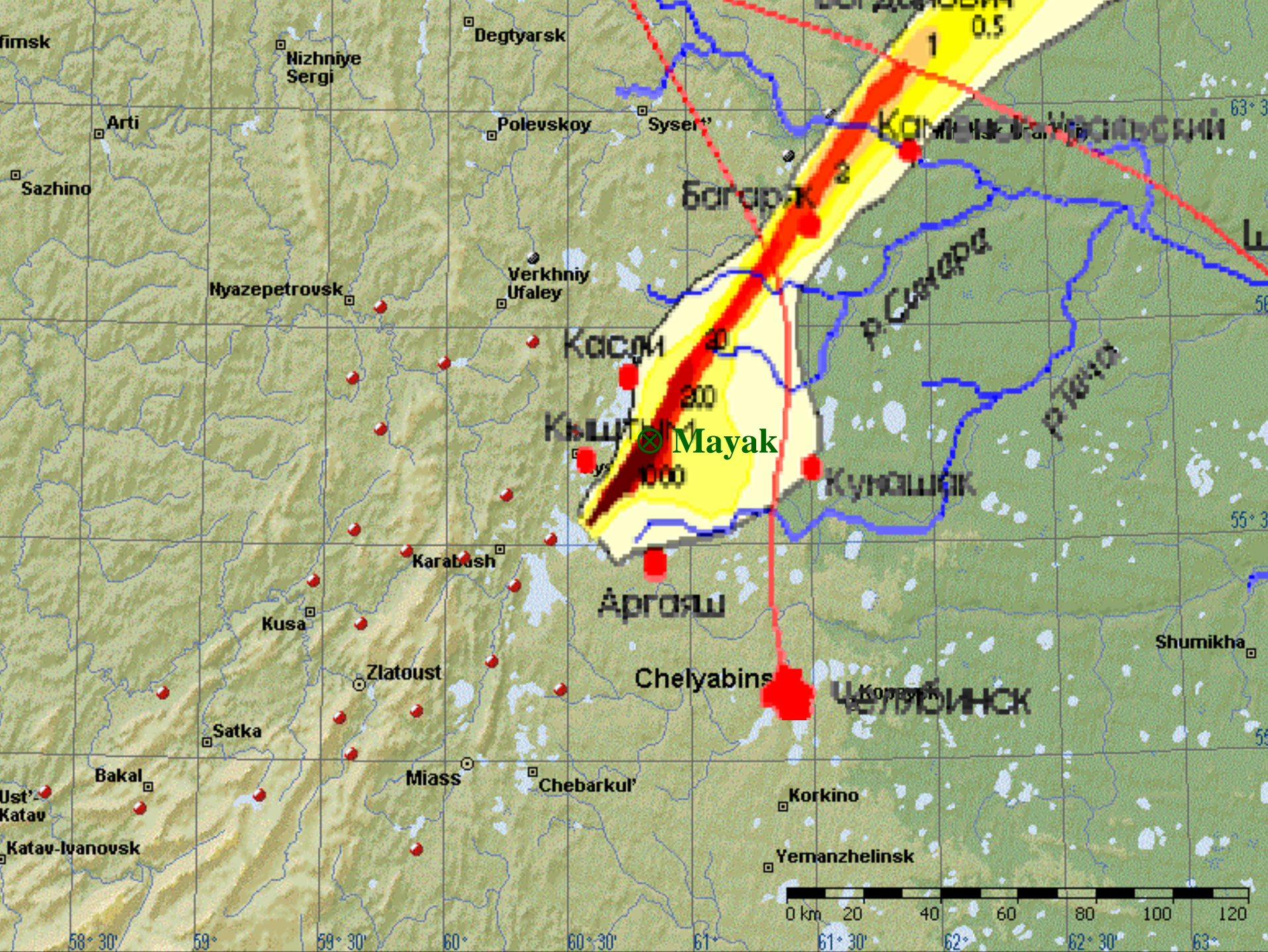


IAEA coordination research project

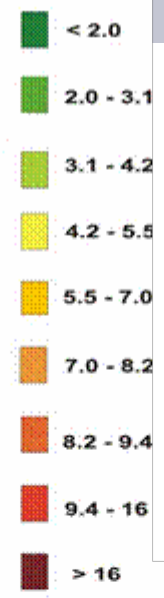
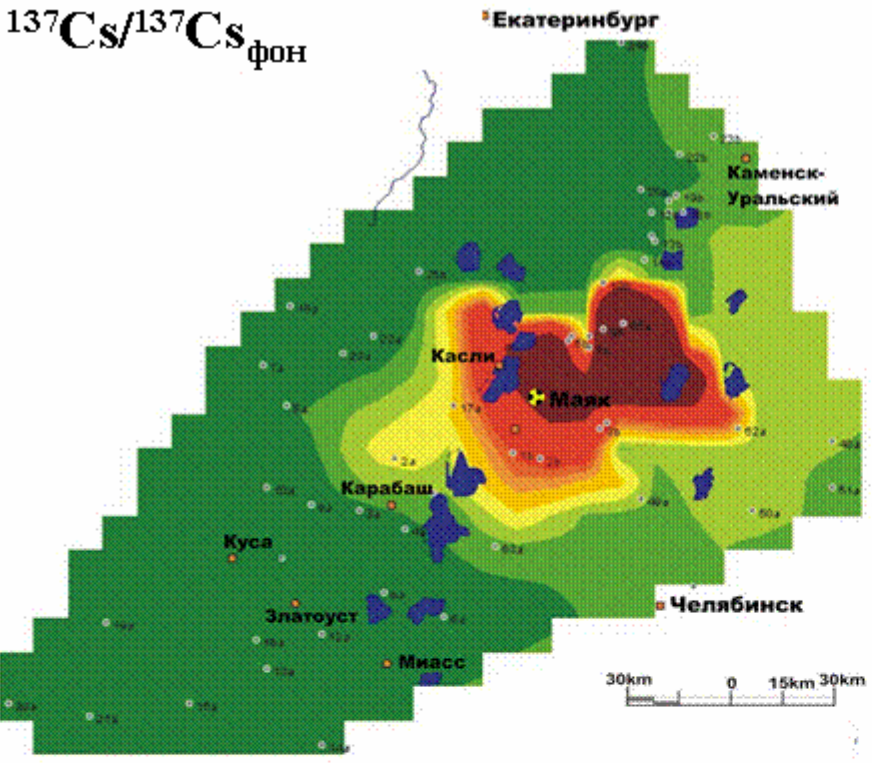
1997-2002

Biomonitoring air pollution in Chelyabinsk region (South Ural Mountains, Russia) through trace elements





$^{137}\text{Cs}/^{137}\text{Cs}_{\text{фон}}$



1995 (Arkog et al.) +
1998 (our sampling)

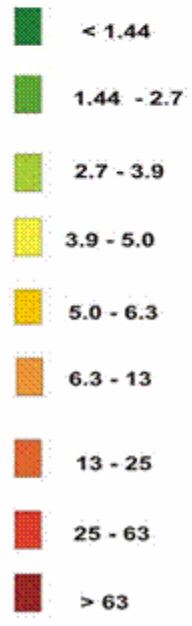
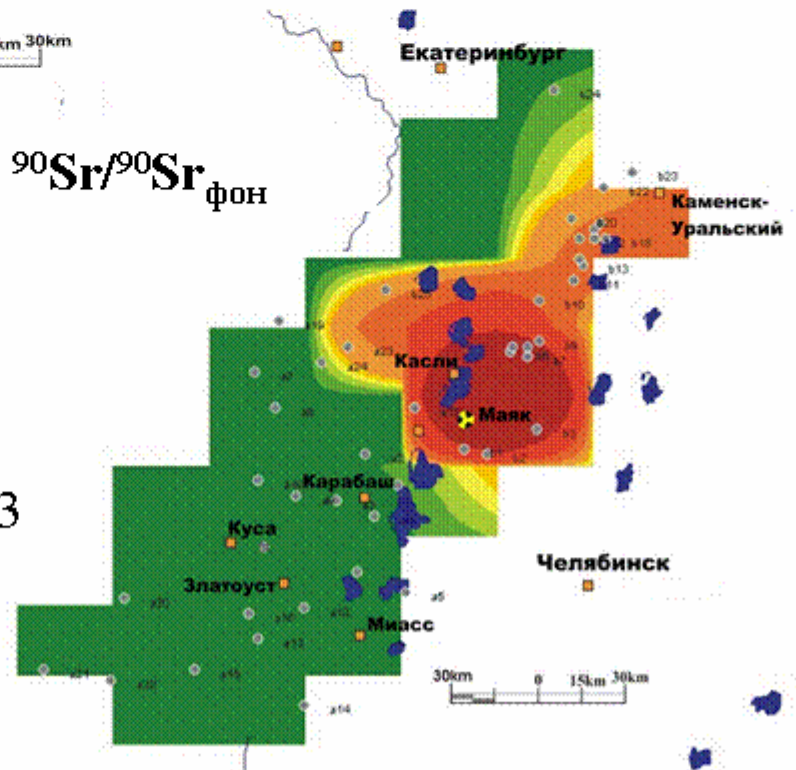
^{90}Sr local baseline value
1.6 KBq /m²


^{137}Cs local baseline value
2.56 KBq /m²

1957: Kyshtym accident: Sr/Cs= 70

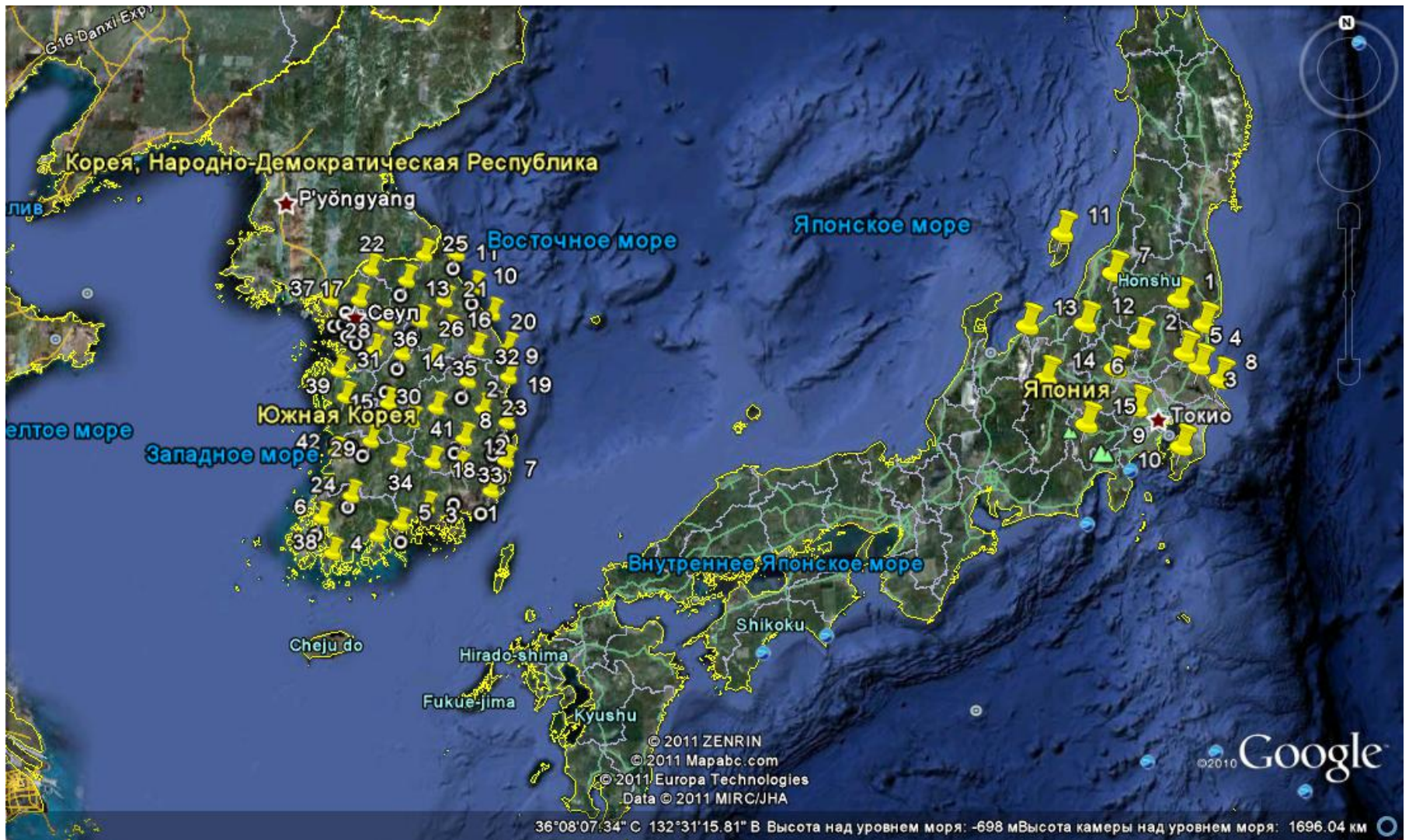
1967: Karachai emissions: Sr/Cs=0.3

$^{90}\text{Sr}/^{90}\text{Sr}_{\text{фон}}$





The moss technique is supposed to be used for assessing **sequences of the Fukushima disaster in the Far East** of Russia (mapping of radionuclide distribution around the city of Vladivostok).





Other environmental projects



BSEC

ORGANIZATION OF THE BLACK SEA ECONOMIC COOPERATION



BSEC Project

Grant from the Black Sea
Economic Cooperation Council

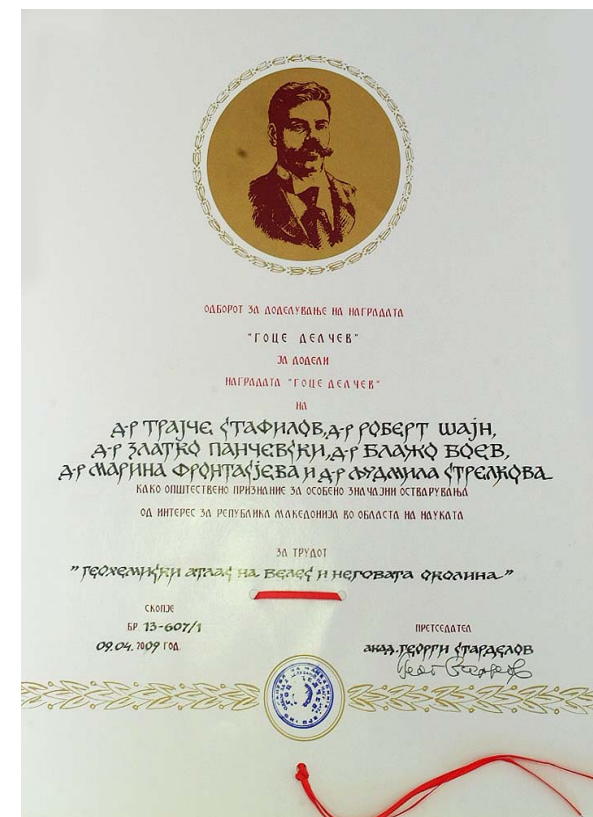
(2008-2010)

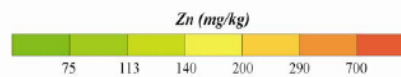
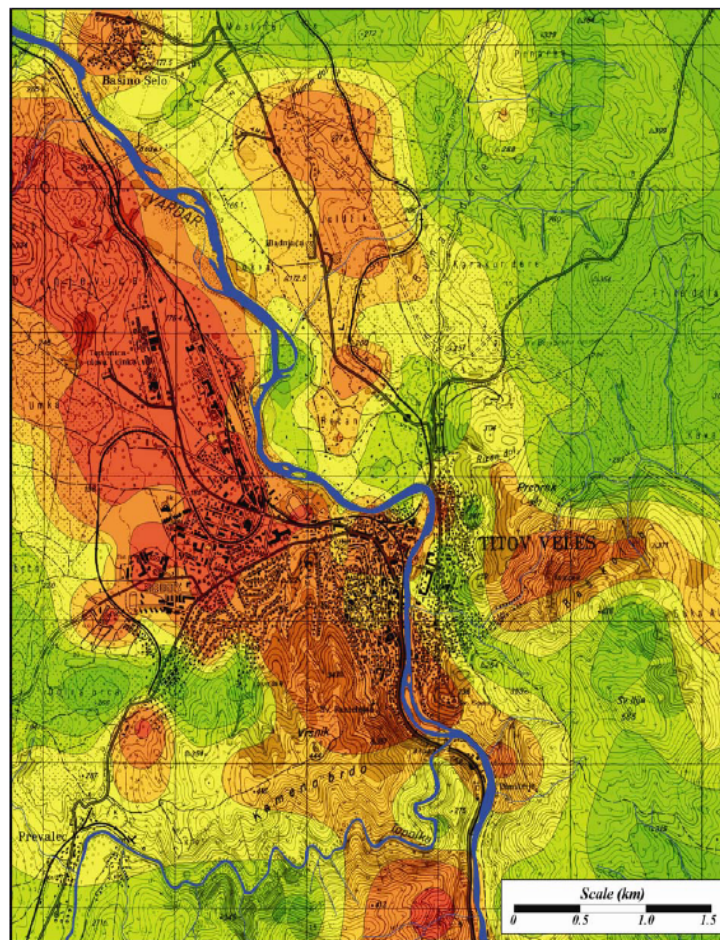
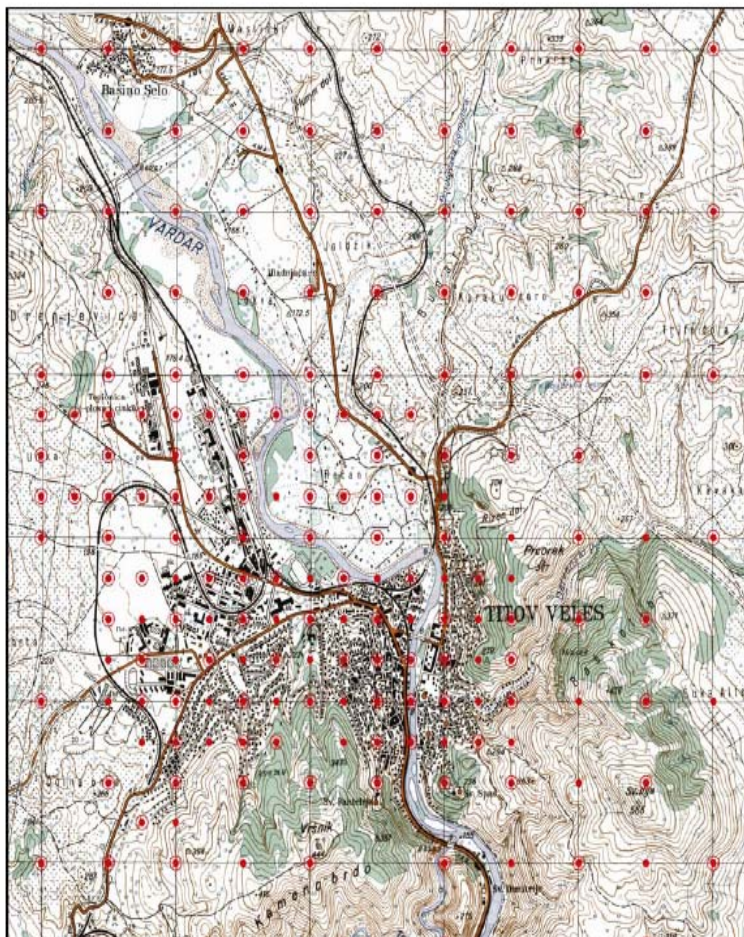
GARDEN CITY: Revitalization of urban ecosystems through vascular plants: assessment of technogenic pollution impact (*Bulgaria, Greece, Romania, Russia, Serbia, Turkey*)

Resume: The following tree species can be used as accumulators of a number of elements originating from anthropogenic pollution: *Populus nigra* – Mn, Fe, Ni, Zn, Cd, and Pb; *Acer platanoides* – Mn and Fe; *Aesculus hippocastanum* – Ni, Cu, As, and Pb; *Tilia cordata* – Al, Fe, and Cu, and *Betula pendula* – Mn, Ni, Zn, Cd, and Pb.

Heavy metal contamination of topsoils around a lead and zinc smelter in the Republic of Macedonia

Trajce Stafilov, Robert Sajn, Zlatko Pancevski, Blazo Boev,
Marina V. Frontasyeva, Lydmila P. Strelkova





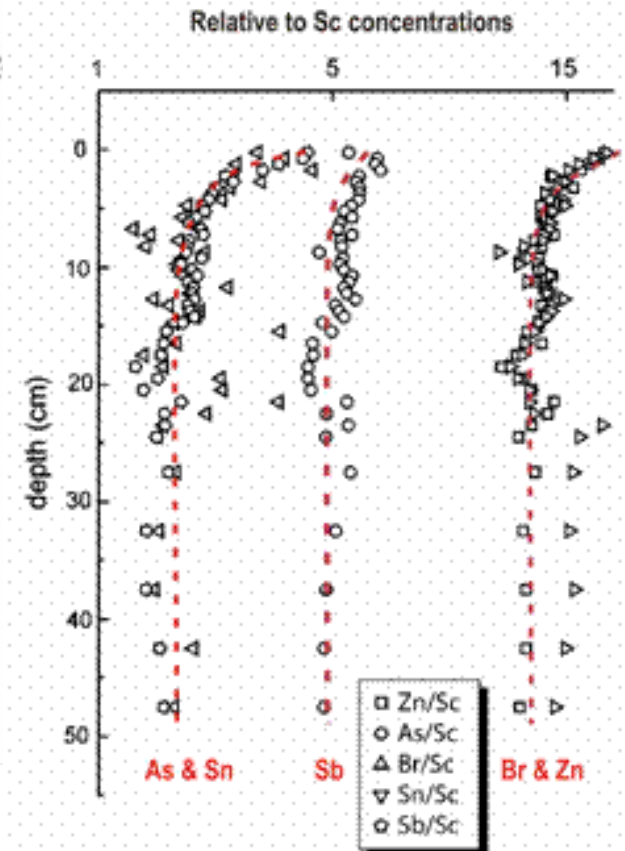
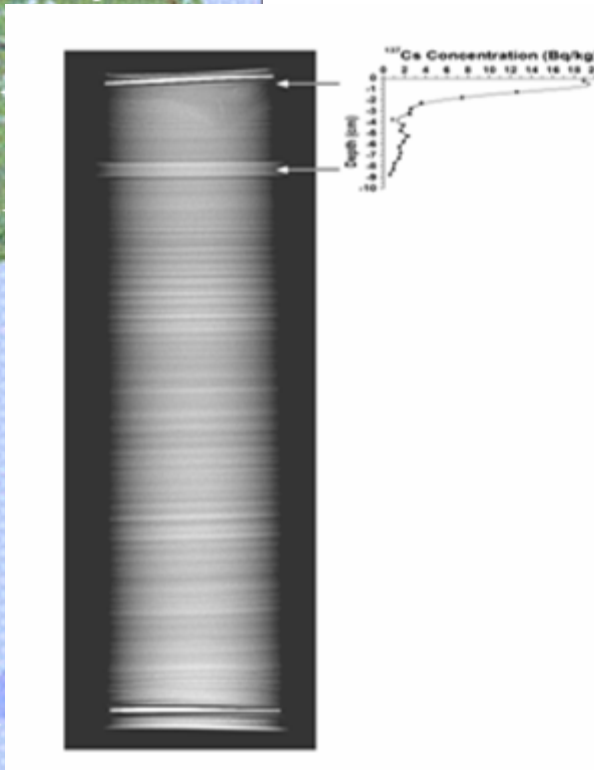
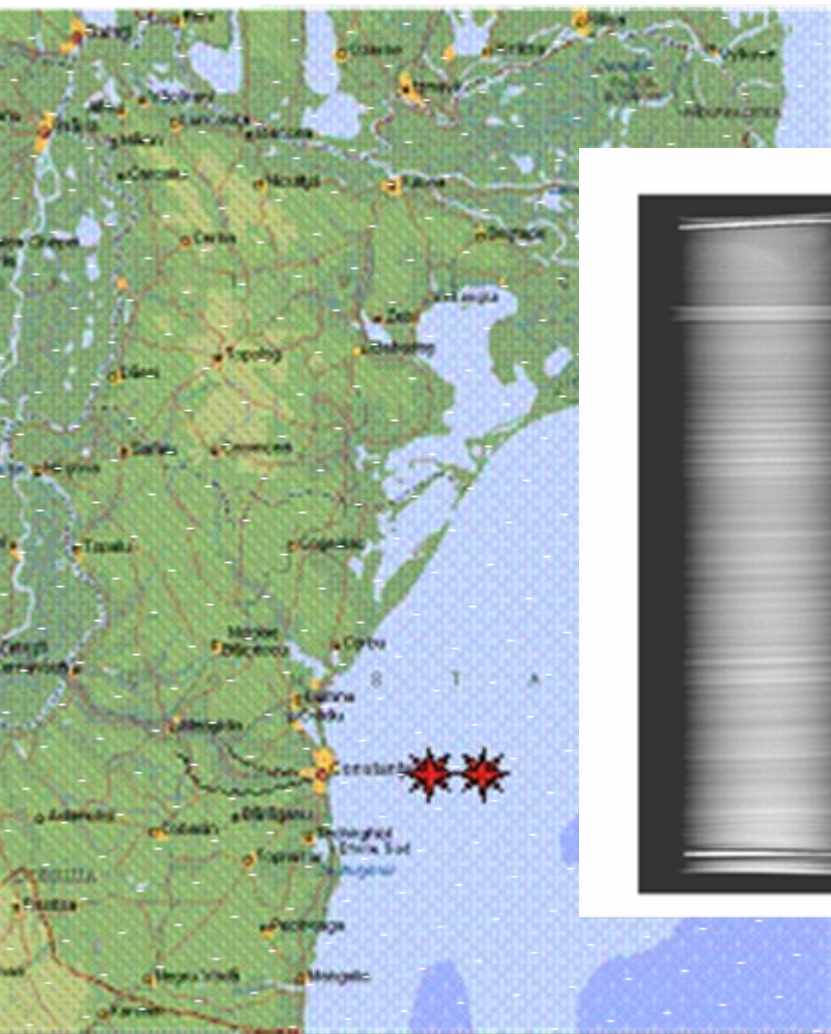


Russian Fund for Basic Research - Romanian Academy
(RFBR-Romania) 2008-2009

**Geochronology and retrospective study of pollution of
unconsolidated sediments from oxygenated and
anoxic territories of the Western Black Sea**

University of Bucharest, National Institute of
Geoecology and Marine Geology, Bucharest, Romania

Geochronology and retrospective study of pollution of unconsolidated sediments from oxygenated and anoxic territories of the Western Black Sea





Assessment of the environmental situation in the delta of the River Nile using nuclear and related analytical techniques



The effect of a rise in sea level on the Nile Delta due to global warming

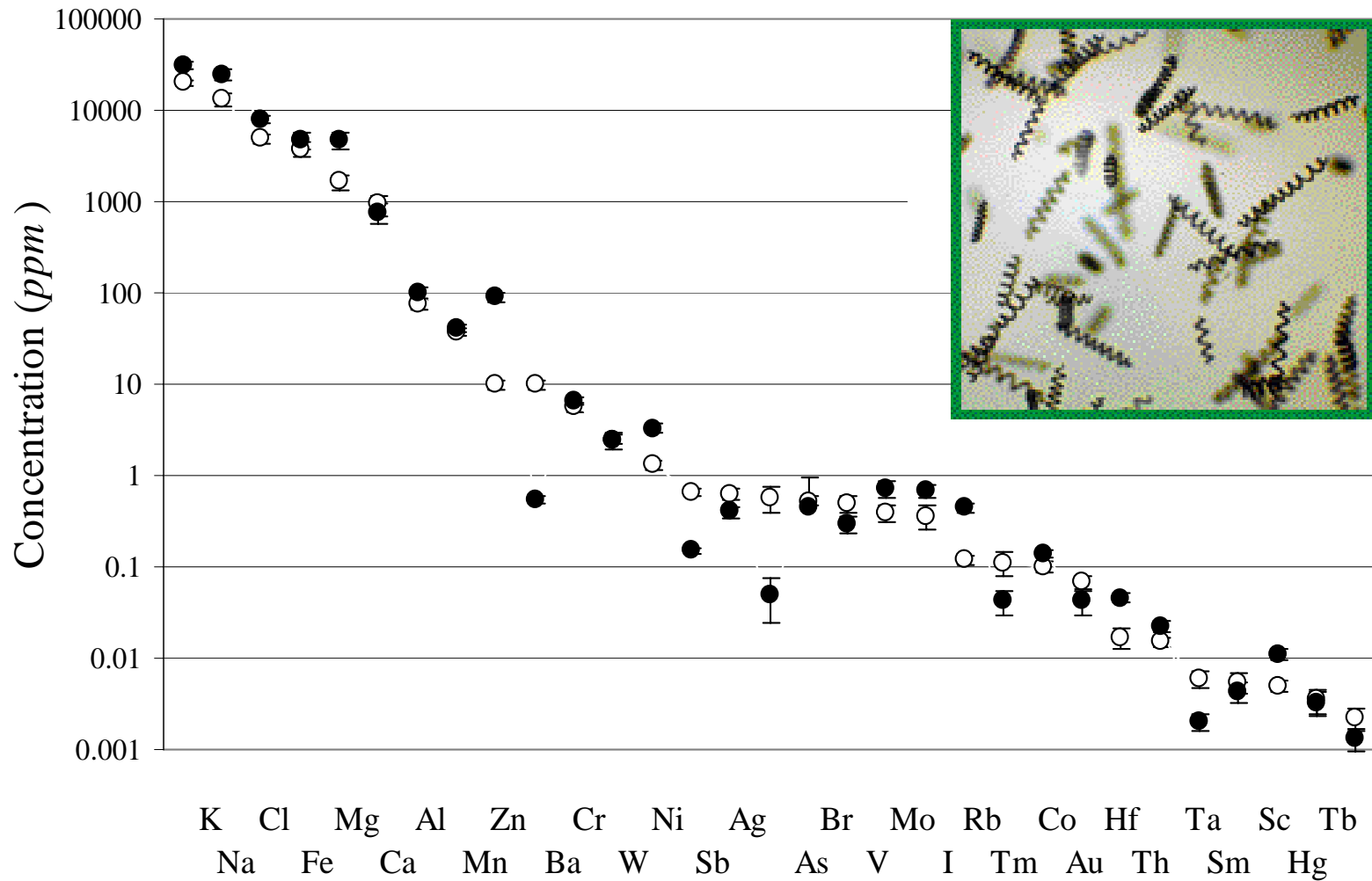


Biotechnology:

**new pharmaceuticals based on
blue-green alga *Spirulina platensis***

Microbial synthesis of nanoparticles

ENAA of blue-green alga *Spirulina platensis*



Elemental distribution in lyophilized samples of *Spirulina platensis* cultivated in distilled (o) and drinking water (●)

РОССИЙСКАЯ ФЕДЕРАЦИЯ



ПАТЕНТ

НА ИЗОБРЕТЕНИЕ

№ 2209077

Российским агентством по патентам и товарным знакам на основании Патентного закона Российской Федерации, введенного в действие 14 октября 1992 года, выдан настоящий патент на изобретение

**СПОСОБ ПОЛУЧЕНИЯ СЕЛЕНСОДЕРЖАЩЕГО ПРЕПАРАТА
БИОМАССЫ СПИРУЛИНЫ**

Патентообладатель(ли):

Объединенный институт ядерных исследований (RU)

по заявке № 2001106901, дата поступления: 15.03.2001

Приоритет от 15.03.2001

Автор(ы) изобретения:

см. на обороте

Патент действует на всей территории Российской Федерации в течение 20 лет с 15 марта 2001 г. при условии своевременной уплаты пошлины за поддержание патента в силе

Зарегистрирован в Государственном реестре изобретений Российской Федерации

г. Москва, 27 июля 2003 г.

Генеральный директор

А.Д. Корчагин
А.Д. Корчагин



РОССИЙСКАЯ ФЕДЕРАЦИЯ



ПАТЕНТ

НА ИЗОБРЕТЕНИЕ

№ 2230560

**СПОСОБ ПОЛУЧЕНИЯ ПРЕПАРАТА СПИРУЛИНЫ,
СОДЕРЖАЩЕЙ ХРОМ**

Патентообладатель(ли): *Объединенный институт ядерных исследований (RU)*

Автор(ы): *см. на обороте*

Заявка № 2002115679

Приоритет изобретения 11 июня 2002 г.

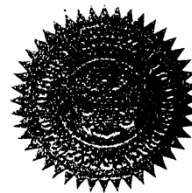
Зарегистрировано в Государственном реестре изобретений Российской Федерации 20 июня 2004 г.

Срок действия патента истекает 11 июня 2022 г.

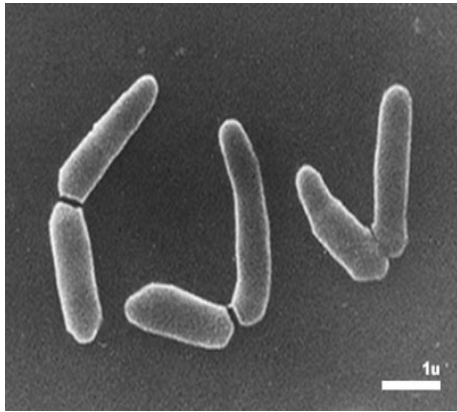
Руководитель Федеральной службы по интеллектуальной собственности, патентам и товарным знакам

Б.П. Симонов

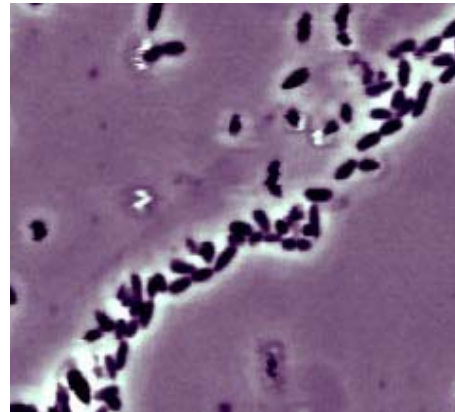
Б.П. Симонов



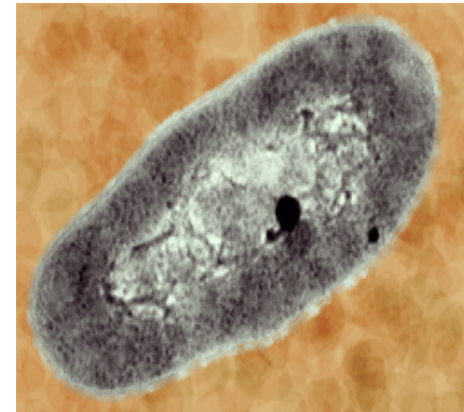
ARTHROBACTER GENERA



Arthrobacter globiformis



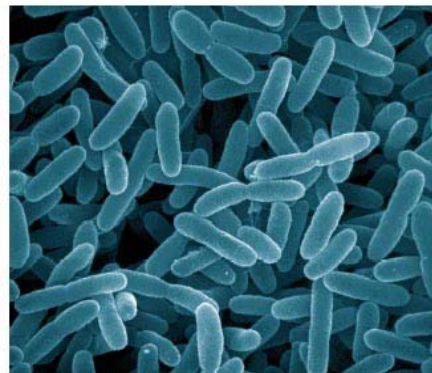
Arthrobacter oxydans



Arthrobacter sp.



Arthrobacter globiformis



Dechloromonas strain RCB bacteria can break down two toxins, both perchlorate and benzene, in anaerobic environments. (Image: John Bozzola and Steven Schmitt, SIUC IMAGE Facility)

Arthrobacter oxydans



Arthrobacter sp.

Anal. Chem. **2006**, 78, 6285–6290 (USA)

Impact factor 5.8

Articles

Epithermal Neutron Activation Analysis of Cr(VI)-Reducer Basalt-Inhabiting Bacteria

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Joint Institute for Nuclear Research, Dubna, Moscow Region, Russian Federation, Andronikashvili Institute of Physics and Chavchavadze State University, Tbilisi, Georgia, and Lawrence Berkeley National Laboratory, Berkeley, California 94720

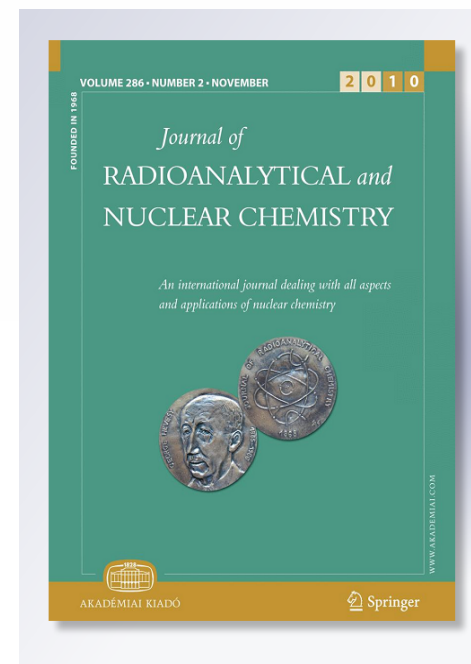
NAA for studying detoxification of Cr and Hg by *Arthrobacter globiformis* 151B

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Biotechnology of Cr(VI) transformation into Cr(III) complexes

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Neutron activation analysis for development of mercury sorbent based on blue-green alga *Spirulina platensis*

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Characterization of Microbial Synthesis of Silver and Gold Nanoparticles with Electron Microscopy Techniques

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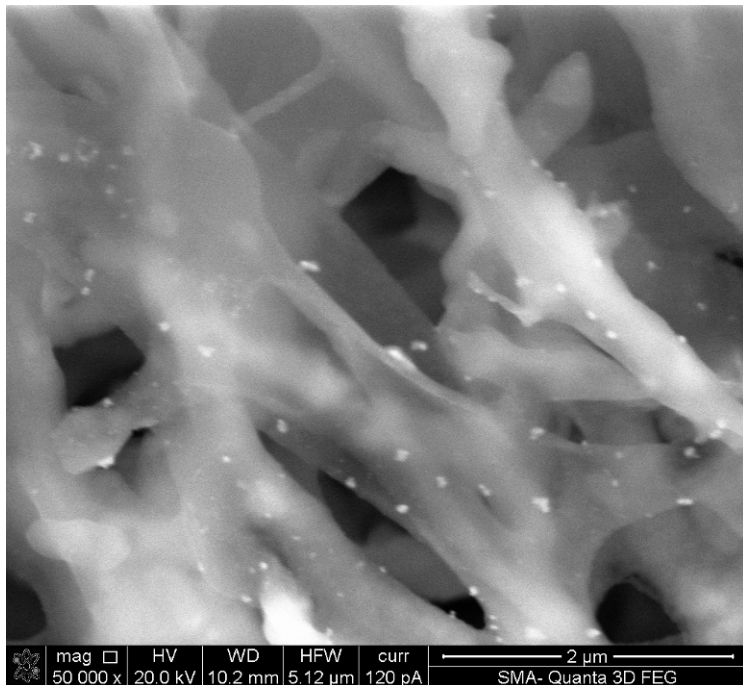
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77 Kostava Str., 0175 Tbilisi, Georgia

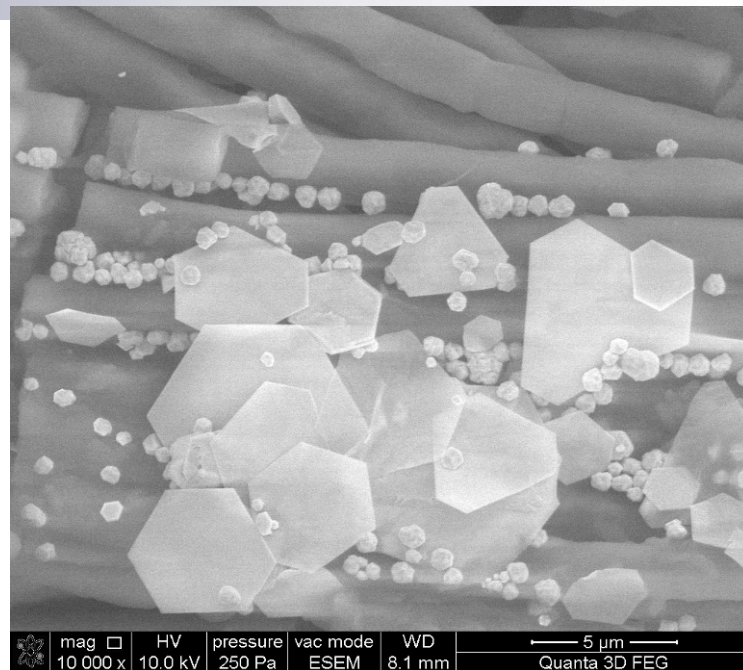
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Leninsky av., 59-2, 119333 Moscow, Russia



	mag		HV	WD	HFWD	curr	2 μm	
	50 000 x		20.0 kV	10.2 mm	5.12 μm	120 pA	SMA-Quanta 3D FEG	

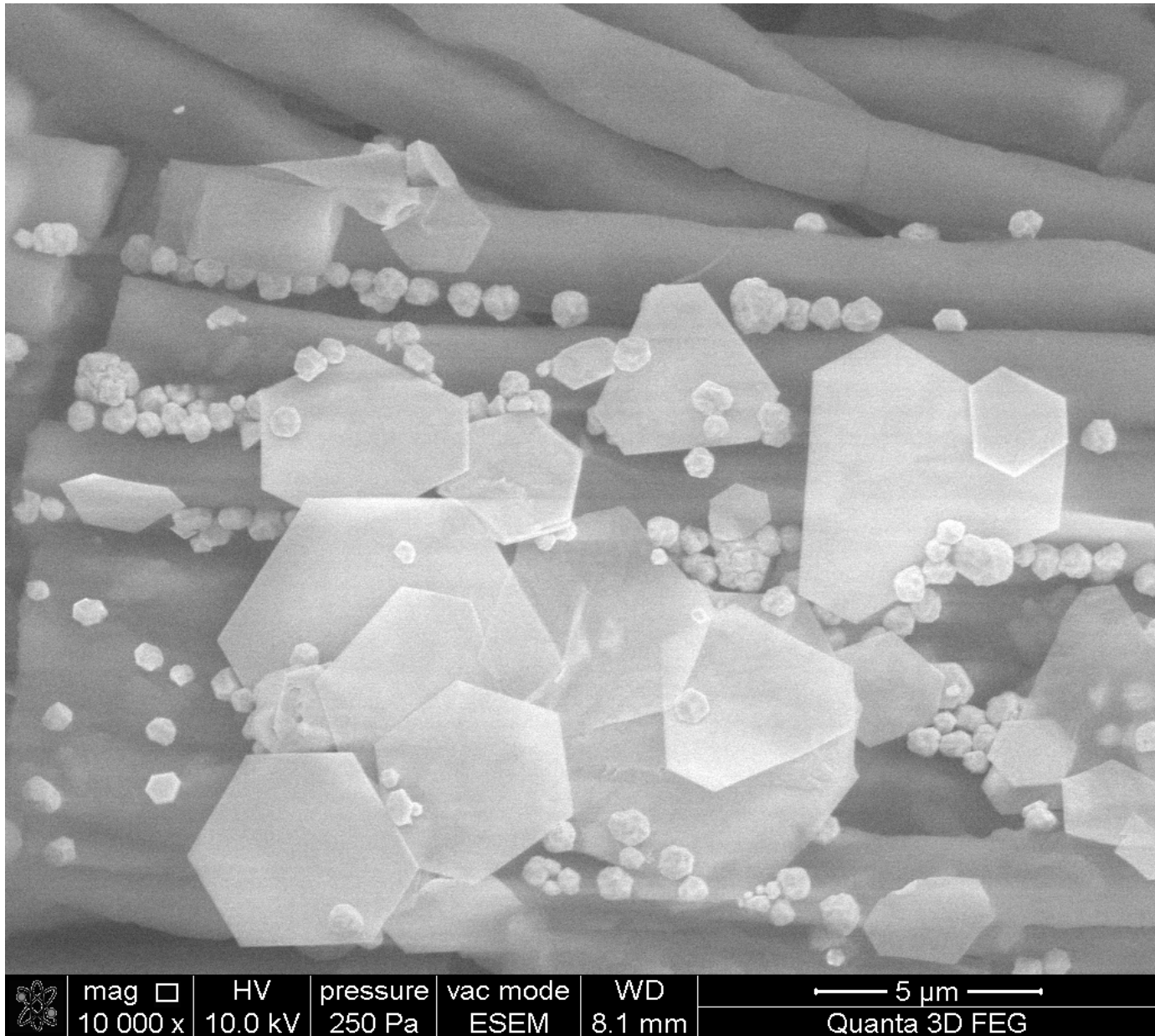


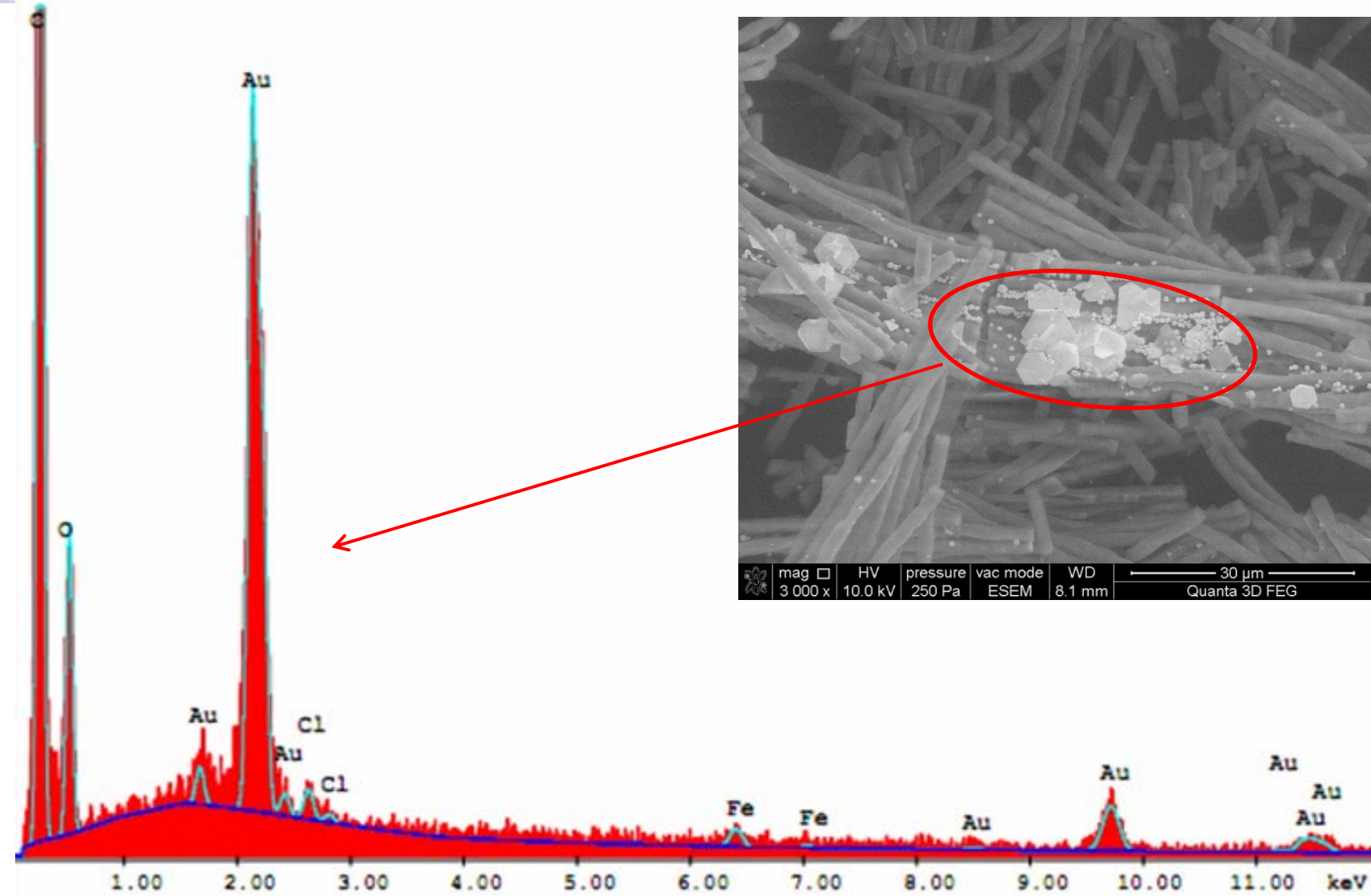
	mag		HV	pressure	vac mode	WD	5 μm	
	10 000 x		10.0 kV	250 Pa	ESEM	8.1 mm	Quanta 3D FEG	

Microbial Synthesis of Silver Nanoparticles by *Streptomyces glaucus* and *Spirulina platensis*

Nelly Yason Tsibakhashvili^{1,2}, Elena Ivanovna Kirkesali¹, Dodo Trofim Pataraya³,
Manana Amir Gurielidze³, Tamaz Levan Kalabegishvili^{1,2}, David Nugzar Gvarjaladze²,
Giorgi Ilia Tsertsvadze⁴, Marina Vladimirovna Frontasyeva^{5,*}, Inga Ivanovna Zinicovscaia⁵,
Maxim Sergeevich Wakstein⁶, Sergey Nikolaevich Khakhanov⁷,
Natalya Vladimirovna Shvindina⁷, and Vladimir Yakovlevich Shklover⁷

Spirulina platensis with gold nanoparticles





EDAX spectrum of *Sp. platensis* cells after exposure to hydrated gold chloride solution

Published in *Advanced SCIENCE LETTERS*

MICROBIAL SYNTHESIS OF SILVER NANOPARTICLES *Streptomyces glaucus* AND *Spirulina platensis*

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G. Tsertsvadze⁴, M.V. Frontasyeva⁵, I. Zinicovscaia⁵,
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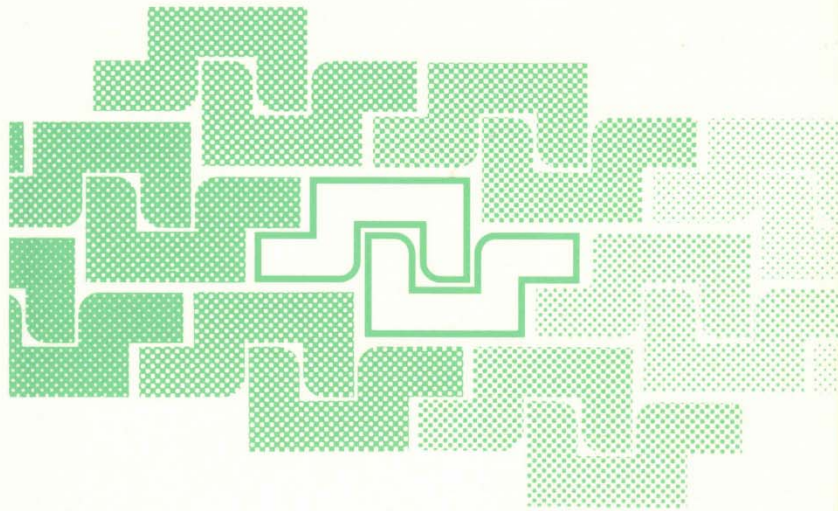
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Leninsky av., 59-2, 119333 Moscow, Russia*





Radionuclides and Heavy Metals in Environment

Edited by

Marina V. Frontasyeva, Vladimir P. Perelygin
and Peter Vater


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Environmental Sciences – Vol. 5, 2001,
p. 245-257

**Development of the method of
bacterial leaching of metals from
lean ores, rocks and industrial
wastes using neutron activation
analysis.**

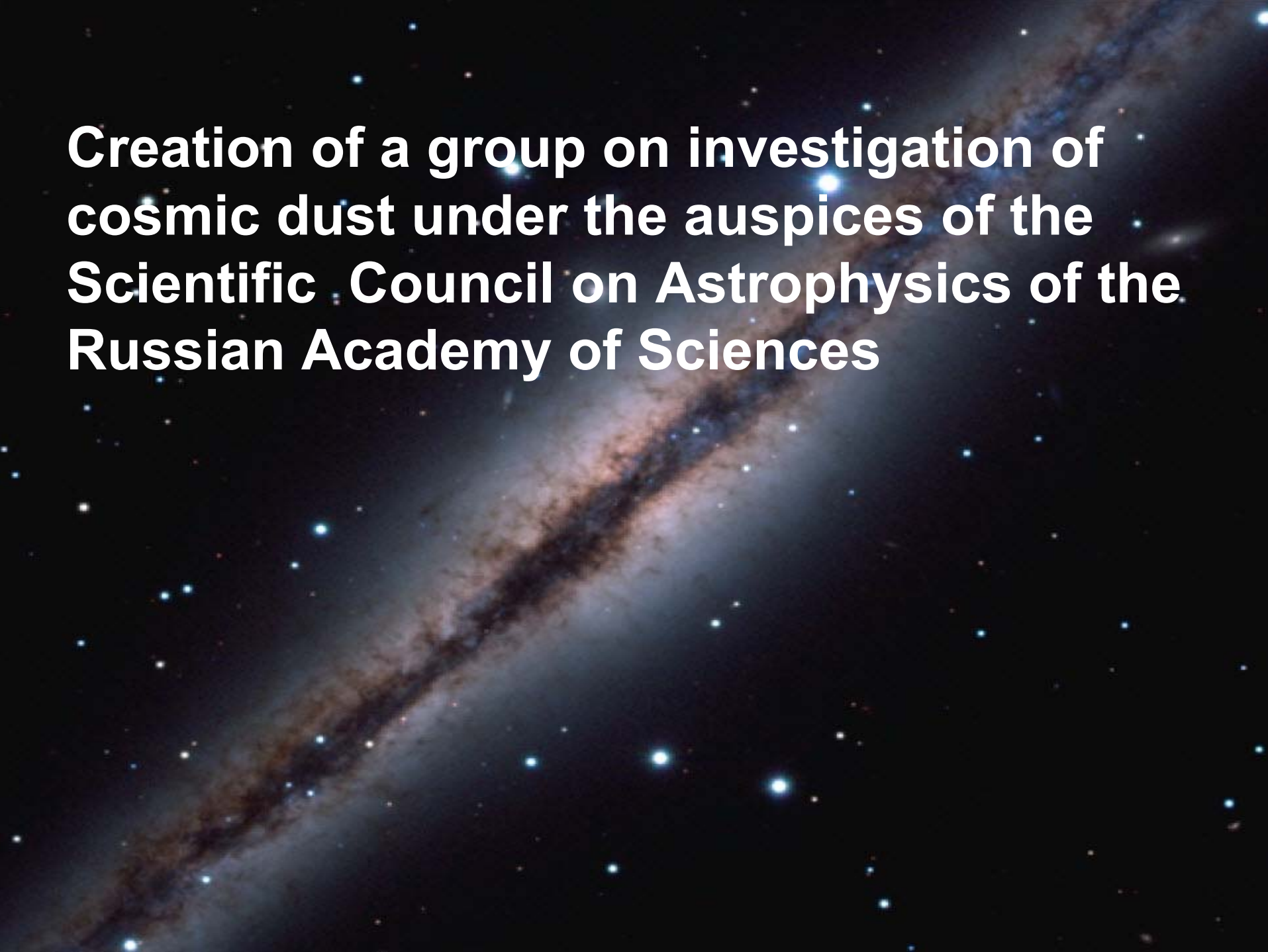
**L.A. Tsertsvadze, T.D. Dzadzamia,
Sh.G. Petreashvili, G.G. Shutkerashvili,
E.I. Kirkesali, M.V. Frontasyeva,
S.S. Pavlov, S.F. Gundorina**



For quantitative analysis of samples the epithermal neutron activation analysis (ENAA) in the radioanalytical complex REGATA at the reactor IBR-2M will be carried out by the end of 2011

Elemental concentration in biomass of *Streptomyces glaucus* (irradiation time 8 s)

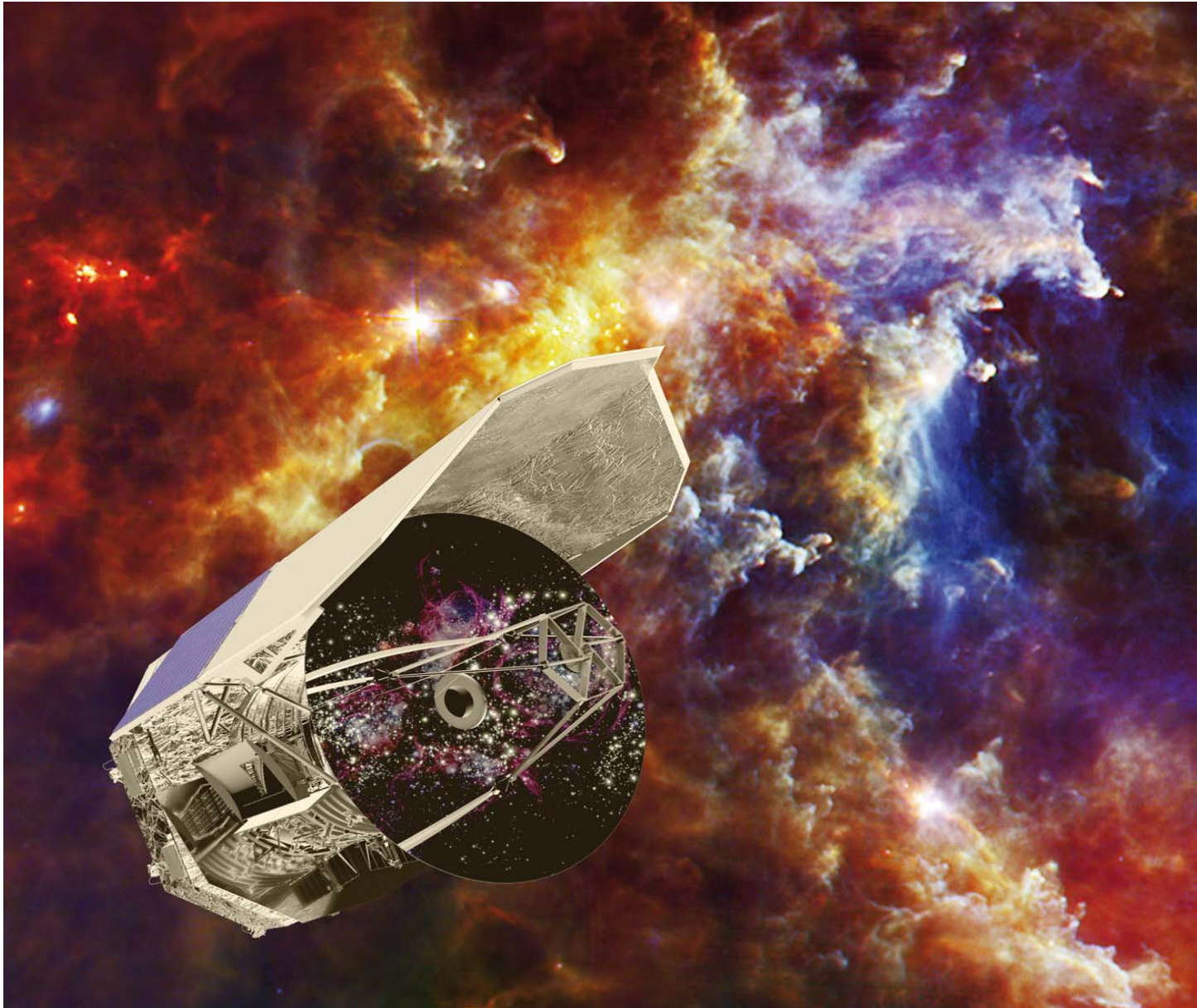
Element	Energy, keV	Concentration, µg/g	Error, %
Ag	657.76	37	5
K	1524.58	3290	8
La	1596.21	15	14
Mn	846.75	25.0	6
Na	1368.55	381	5
Sb	564.24	1.3	15



**Creation of a group on investigation of
cosmic dust under the auspices of the
Scientific Council on Astrophysics of the
Russian Academy of Sciences**

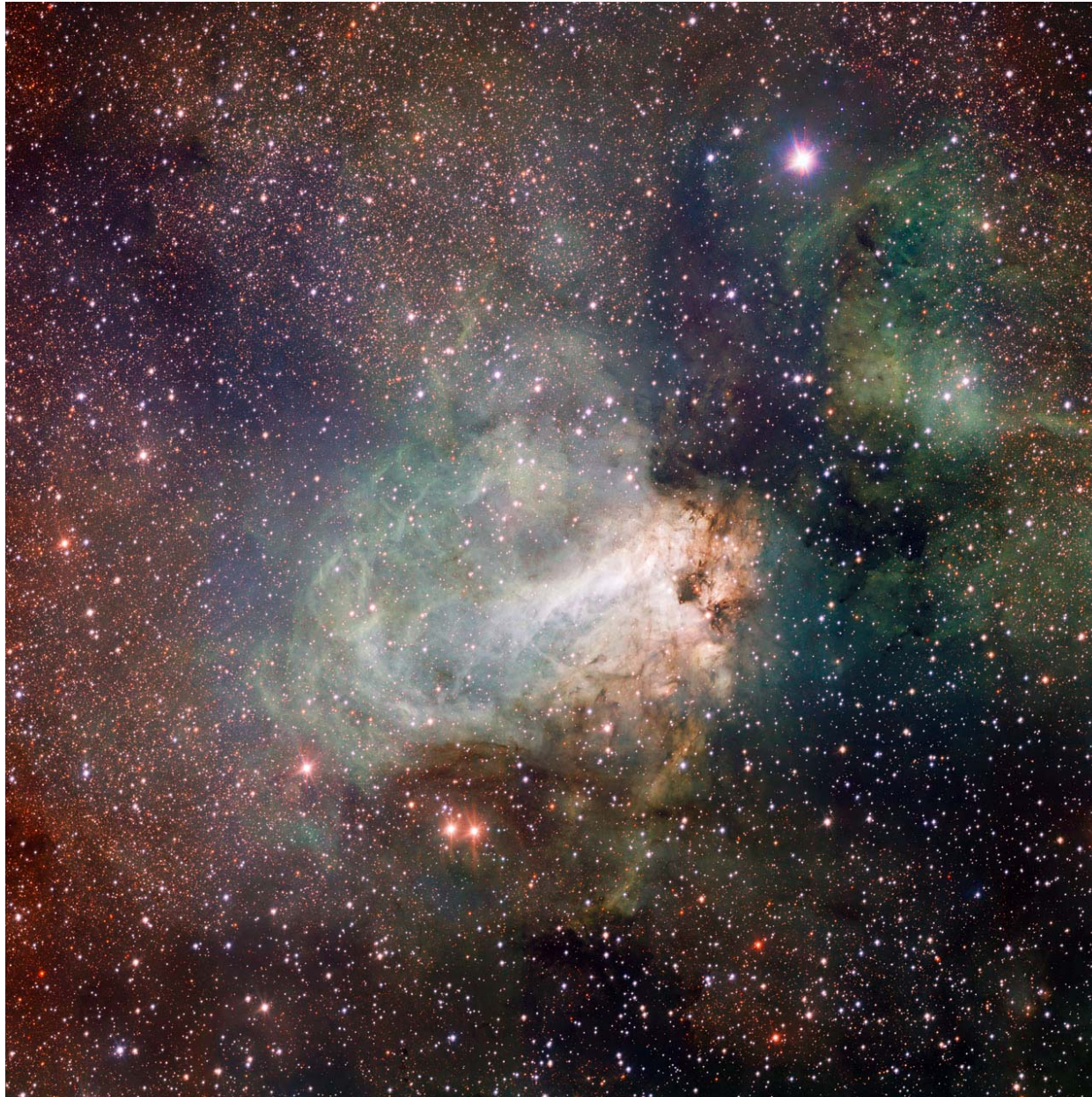
Herschel Detects Cosmic Dust From Supernova

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



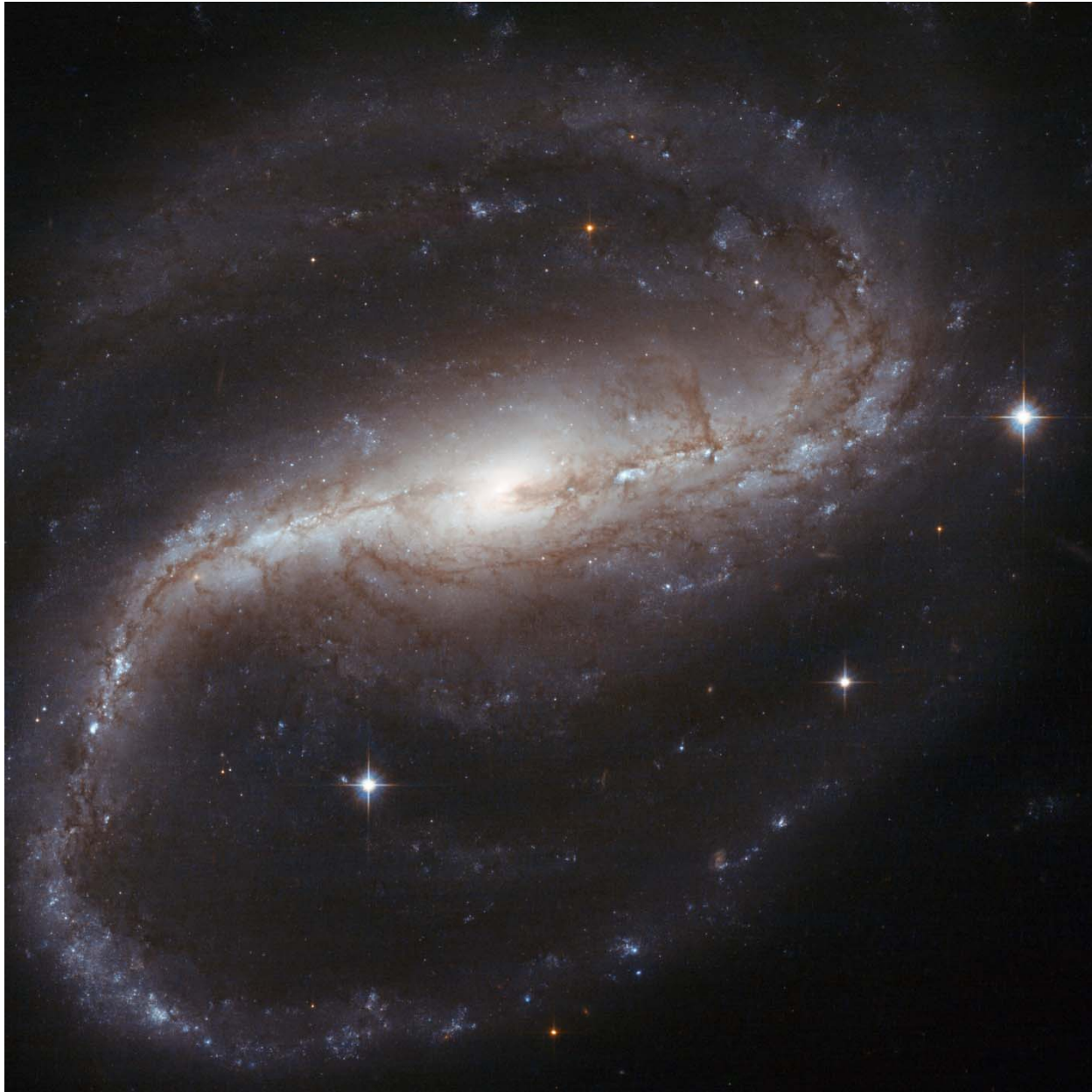
ESO Releases First Images From The VLT Survey Telescope

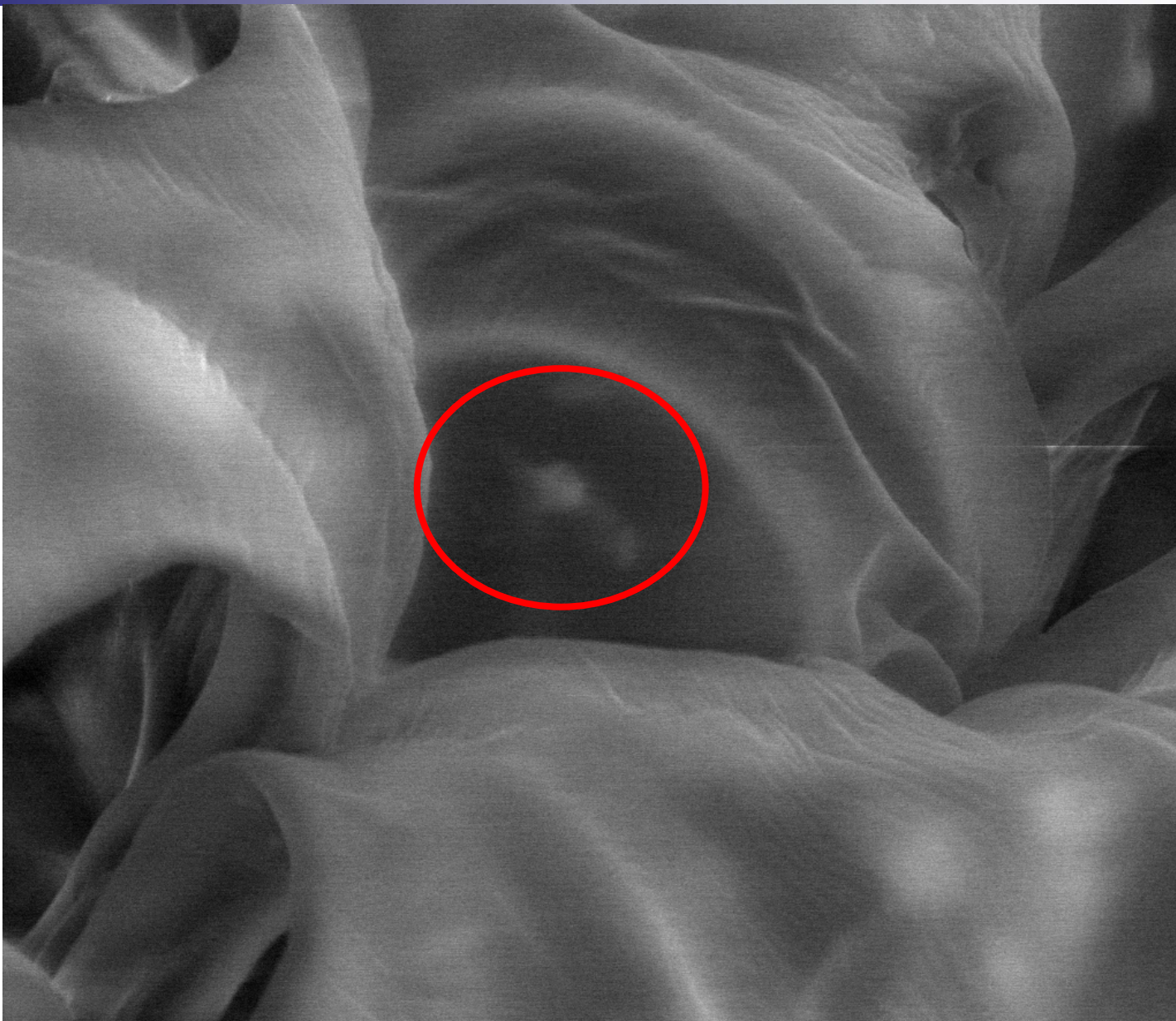
Posted on: Wednesday, 8 June 2011, 10:50 CDT | [Related Video](#)




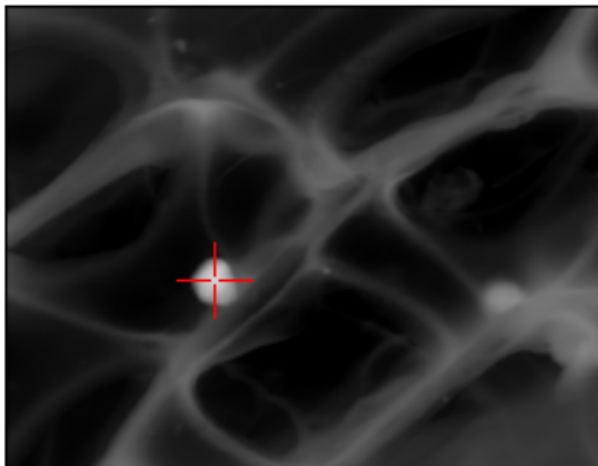
Spiral Spins Both Ways

Credit: ESA/Hubble & NASA, Posted on: Monday, 20 June 2011, 06:29 CDT



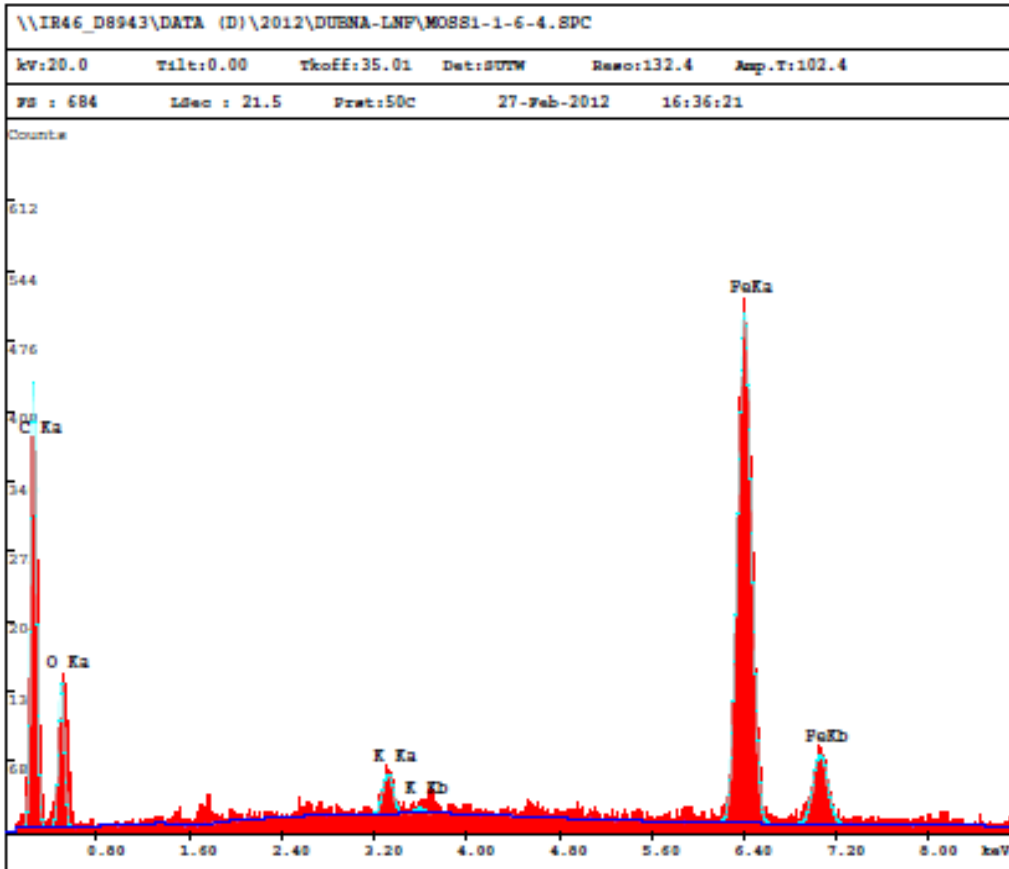


	HV 10.0 kV	mag □ 12 000 x	WD 10.0 mm	tilt 0 °	pressure 150 Pa	mode SE	5 μm
							SMA QUANTA 3D FEG



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

SE1 ← 2µm



Dream Team





Thank you for attention!

**You are welcome to join
our collaboration!**