



Intergovernmental International Organization
Joint Institute for Nuclear Research
Dubna, Moscow Region, Russian Federation

Nuclear and Related Analytical Techniques Used to Study Atmospheric Deposition of Trace Elements and Radionuclides in Rural and Urban Areas Experiencing Environmental Stress

Marina Frontasyeva

Department of Neutron Activation Analysis & Applied Research
<http://fnp.jinr.ru/naa>

Объединенный институт ядерных исследований

Joint Institute for Nuclear Research

Международная межправительственная организация

International Intergovernmental Organization

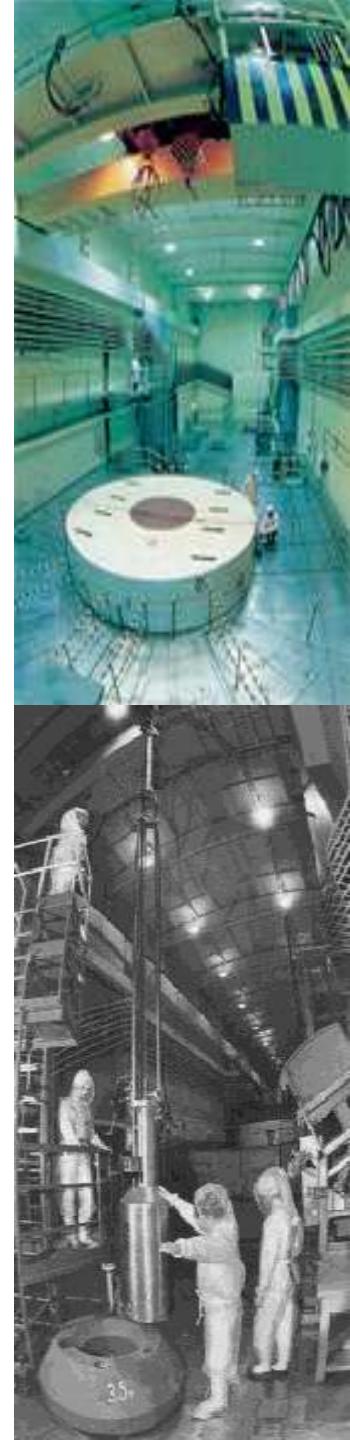
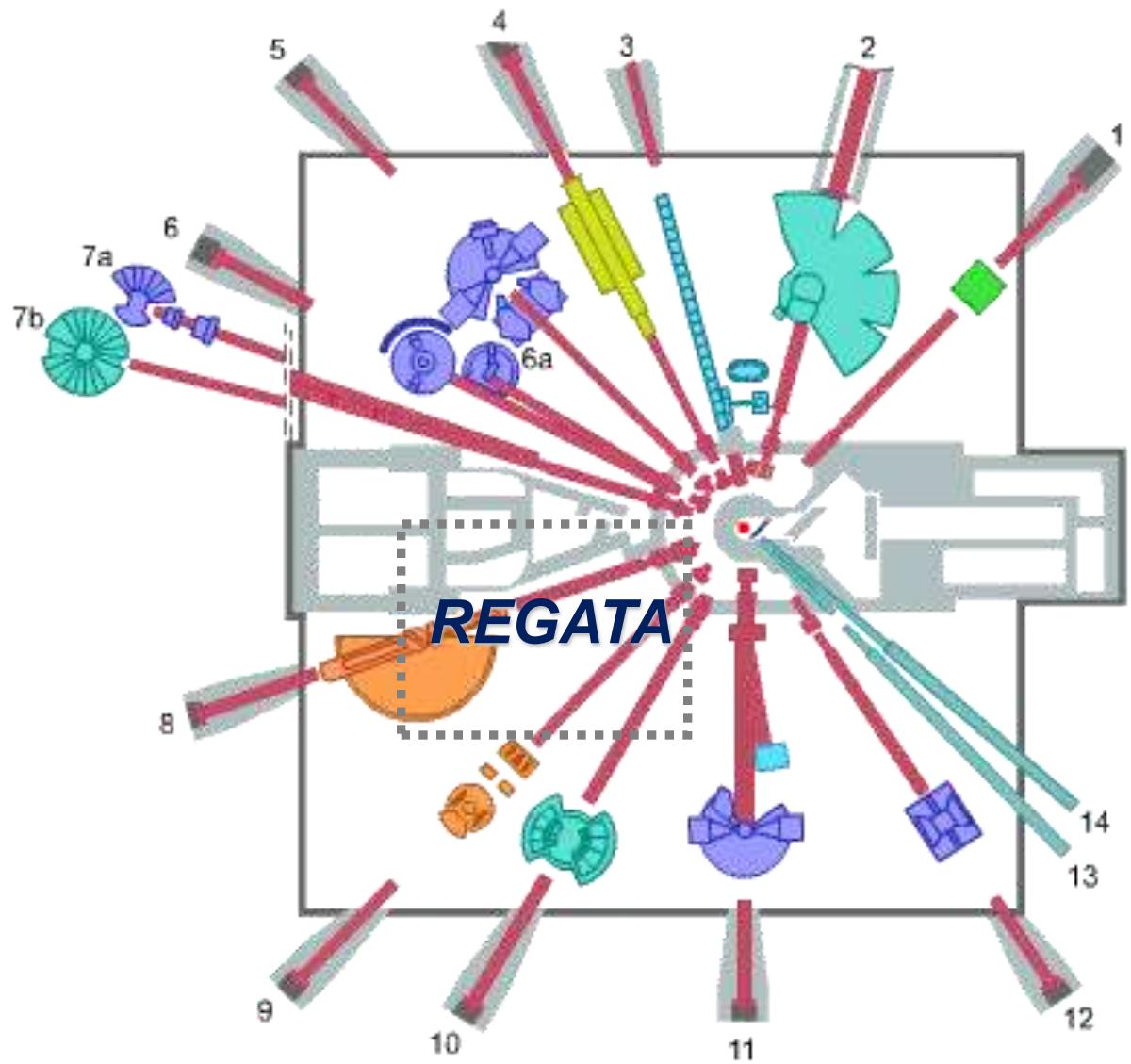


18 member states (former socialist countries) and 7 associated states
(Germany, Italy, Hungary, Japan, Serbia, South Africa and Egypt)
(Interest from India, China and Macedonia)

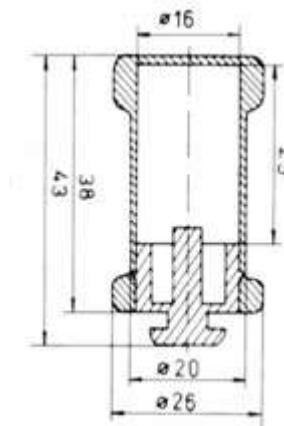
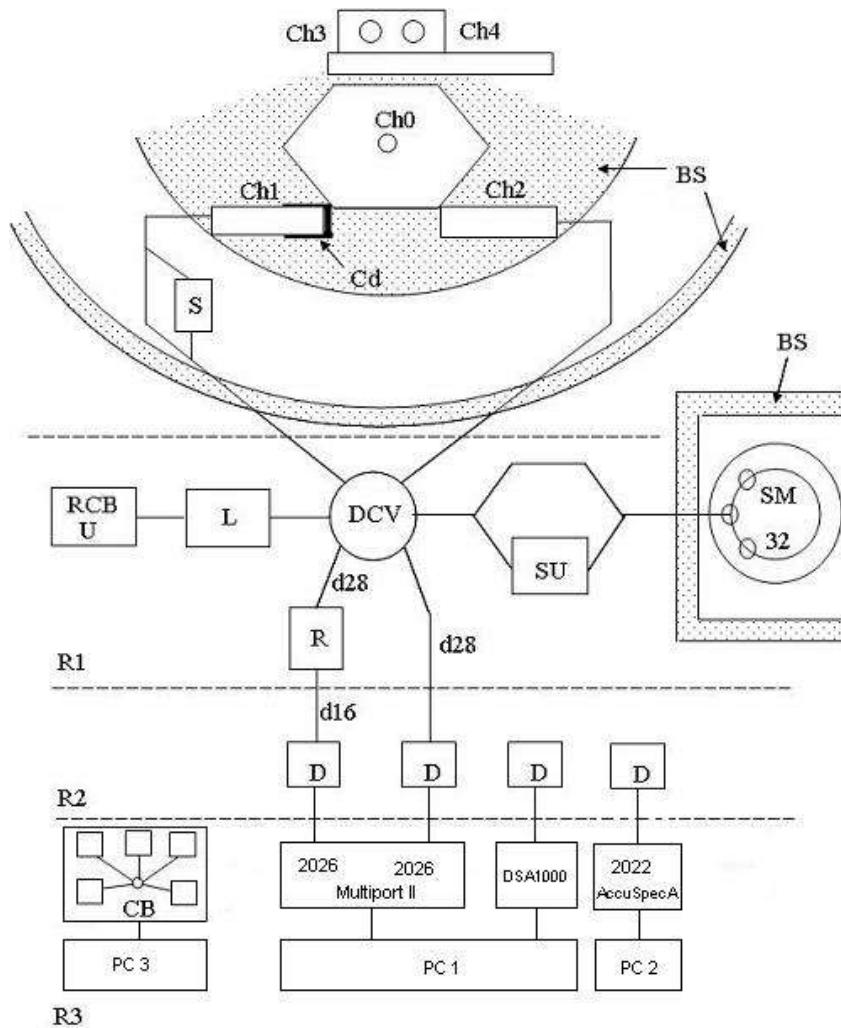
CONTENTS

- ▶ NAA at reactor IBR-2 in Dubna
- ▶ Moss biomonitoring of trace elements and radionuclides at JINR
- ▶ Examples:
 - ▶ Pb-Zn smelters: Baia Mare (RO), Kardzhali (BG)
 - ▶ Fe-Cr industry: Tikhvin (RF), Mo-i-Rana (NO)
 - ▶ Copper mines: Bor (SR)
 - ▶ Fe-V plant: Tula (RF)
 - ▶ Thermal power plant: Moscow (RF)
 - ▶ Long-lived radionuclides in the South Urals (RF)
 - ▶ Sequences of Fucushima disaster in the Far East of RF and South Korea

IBR-2 Pulsed Fast Reactor and Radioanalytical complex REGATA



Experimental facility REGATA at IBR-2 reactor

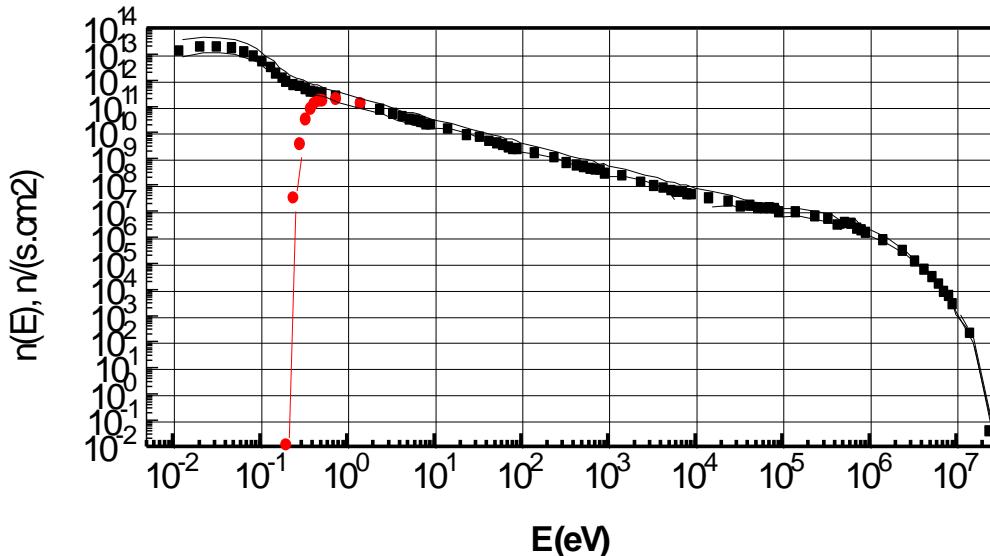


Transport capsules for irradiation



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- detector, CB- control board, 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)

Main characteristics of the irradiation channels at 1.5 MW

Irradiation site	Neutron flux density ($\text{n/cm}^2 \text{s}$) 10^{12}			$T^0\text{C}$	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

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			

ATLAS: Al As Al Cd Cr Cu Fe Hg Ni Pb S Sb V Zn



UNECE



United Nations Economic Commission for Europe

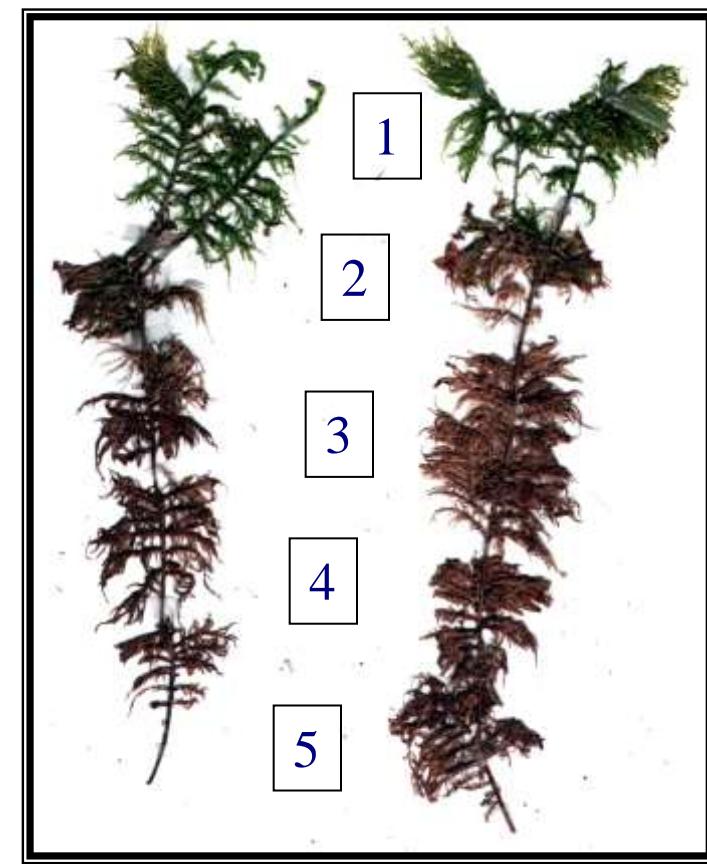
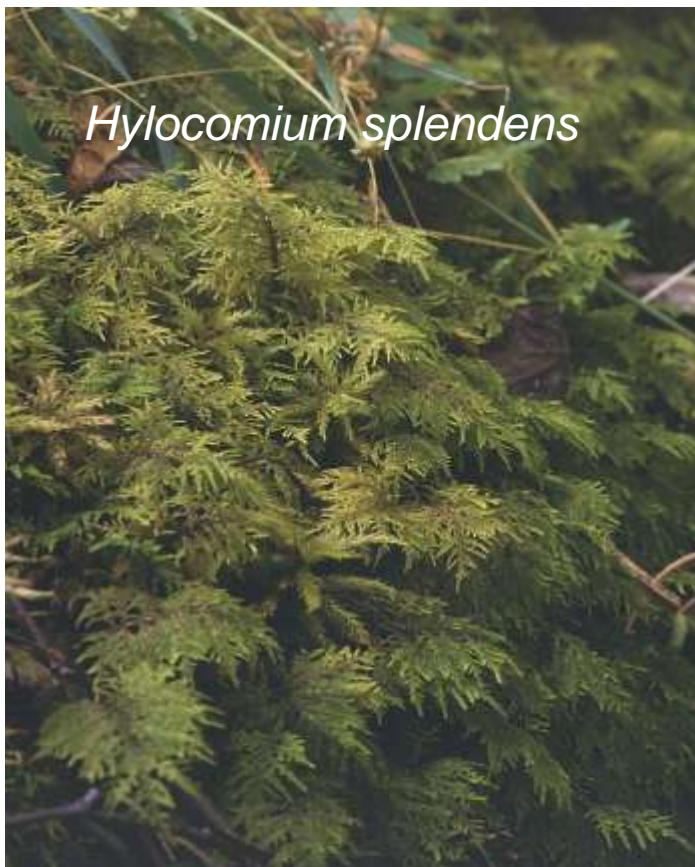
International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

Working Group on Effects - 1981



1993: Biomonitoring...

M.V. Frontasyeva, V.M. Nazarov and E. Steinnes. **Mosses as monitors of heavy metal deposition: Comparison of different multi-element analytical techniques.** In R.J. Allan and J.O. Nriagu, eds., *Heavy Metals in the Environment*, Vol.2, pp. 17-20. CEP Consultants, Edinburgh **1993**.





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

OUR EXPERIENCE IN AIR POLLUTION STUDIES



JINR Project REGATA

(1995-2000-2005-2010-2015)

Trace element atmospheric deposition study in selected European and Asian countries – assessment based on moss analysis

Participating countries:

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

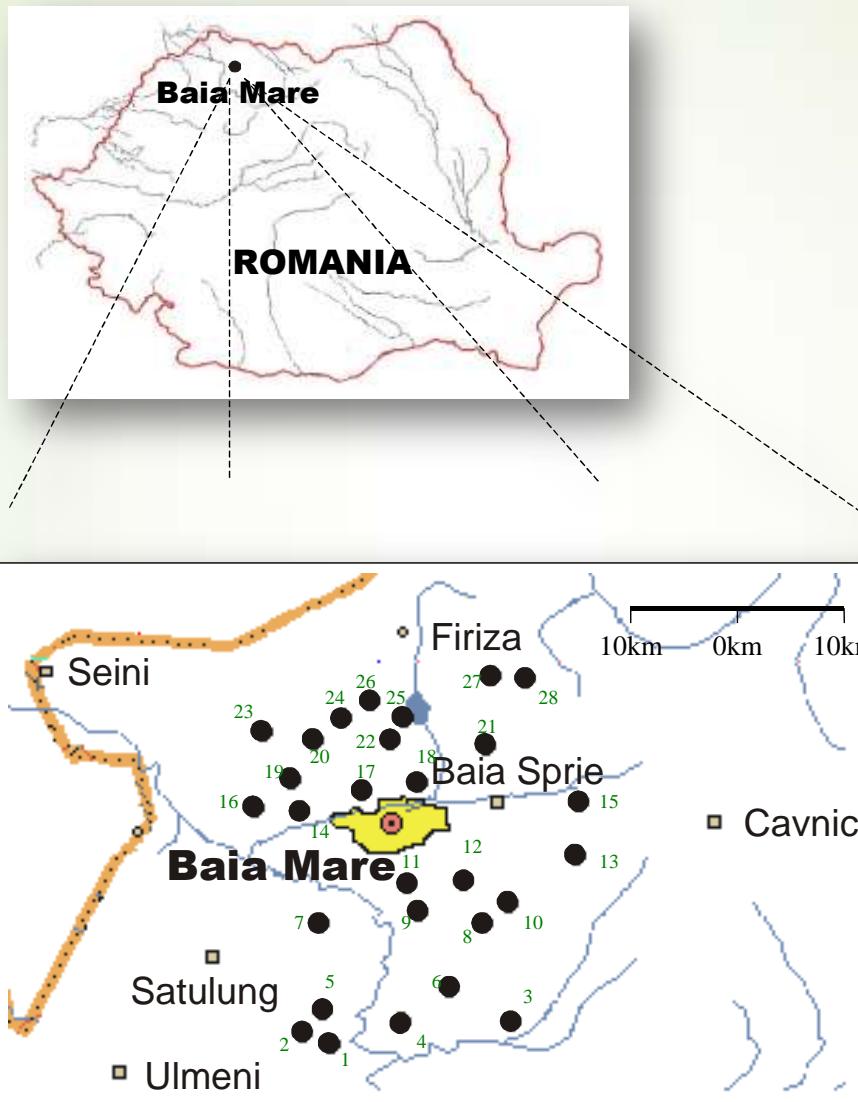
Transfer of the coordination of the European moss survey to the Joint Institute for Nuclear Research, Dubna, RF

- ▶ Secretariat of the UN LRTAP Convention in October 2013 – approval of Russia, JINR, Dubna
- ▶ The 27th Task Force Meeting, January 27-30, 2014, Paris, France – official procedure of transfer of coordination

Priority LRTAP Convention (see Decision 2010/18 and 2011/14)

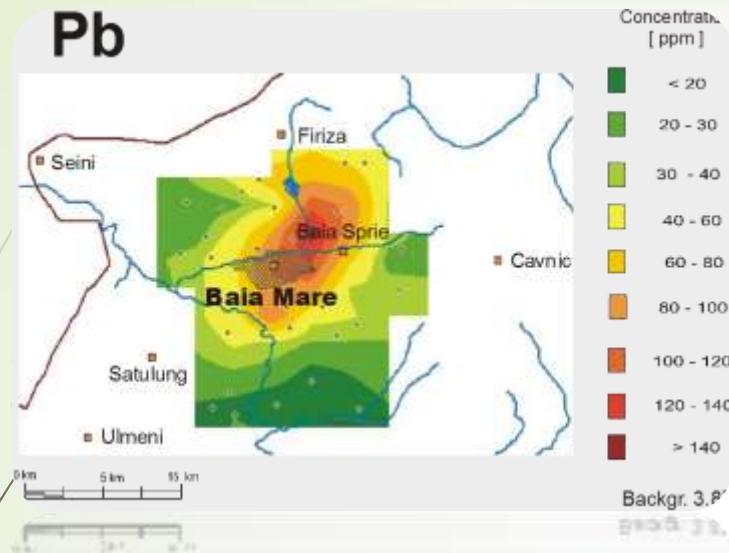
- ▶ Improve ratification and compliance of Protocols by countries in Eastern Europe, the Caucasus and Central Asia and South-Eastern Europe to improve air quality
- ▶ Increase participation and activities of all Convention Bodies (including ICP Vegetation) in those countries
- ▶ Hence, decision to transfer coordination European moss survey to the Russian Federation to enhance network activities as supported by JINR
- ▶ Results will be reported to ICP Vegetation Task Force

Pb-Zn smelters: Baia Mare (RO)

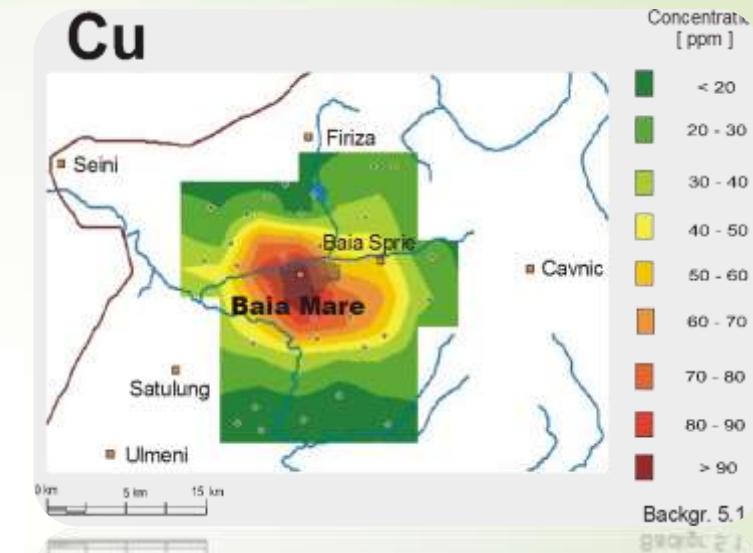


Zn-Pb smelter: Baia Mare (RO)

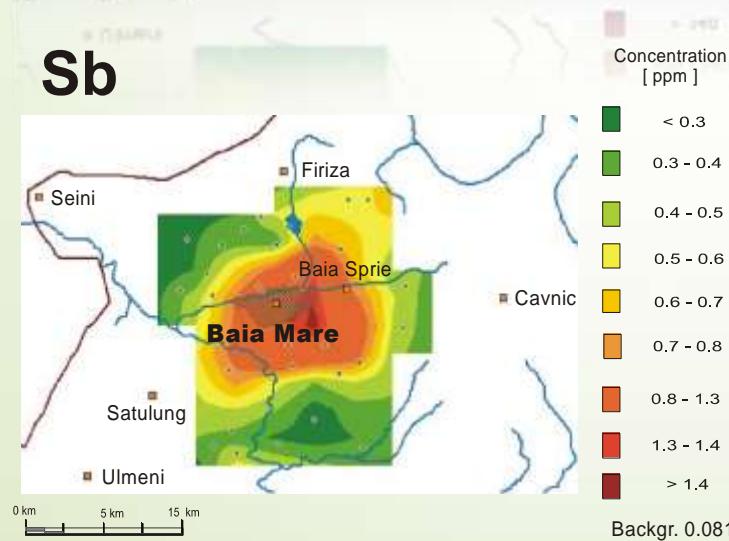
Pb



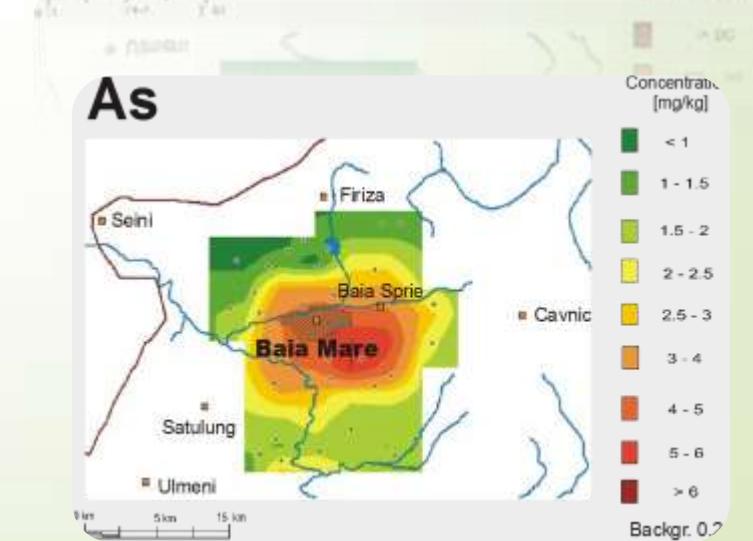
Cu



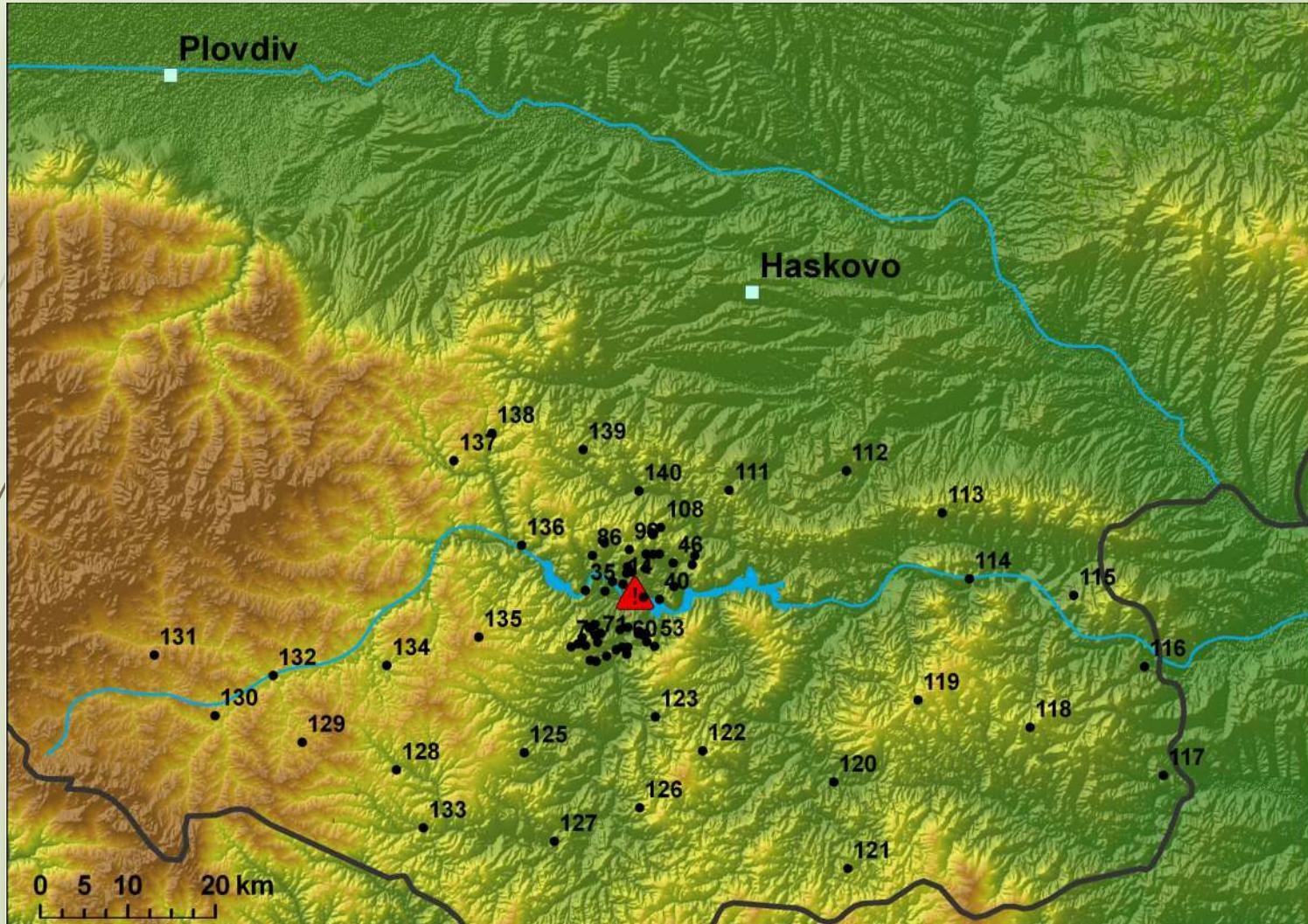
Sb

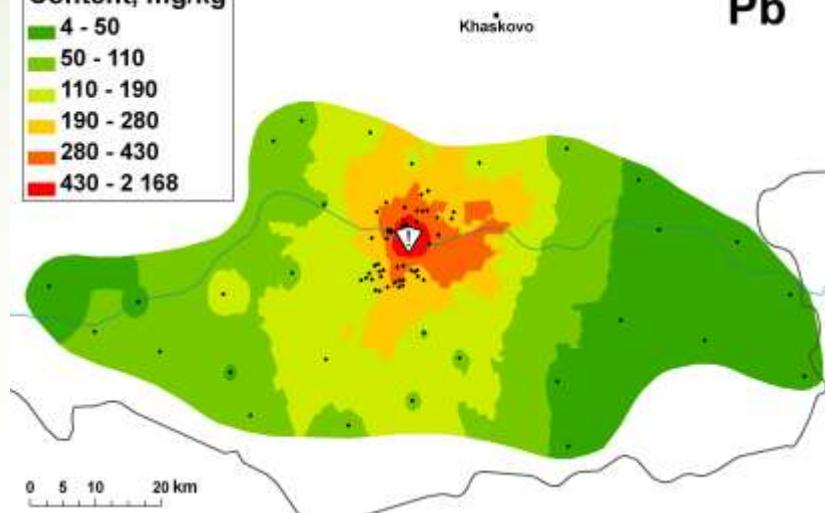
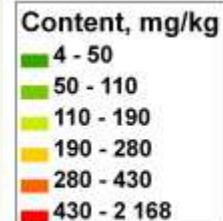
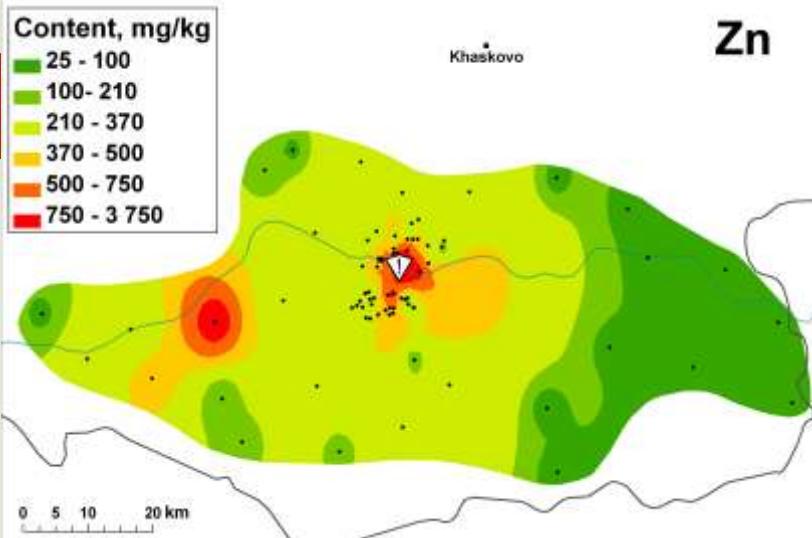
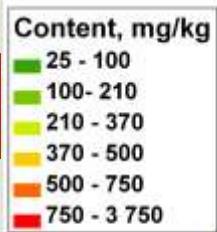


As

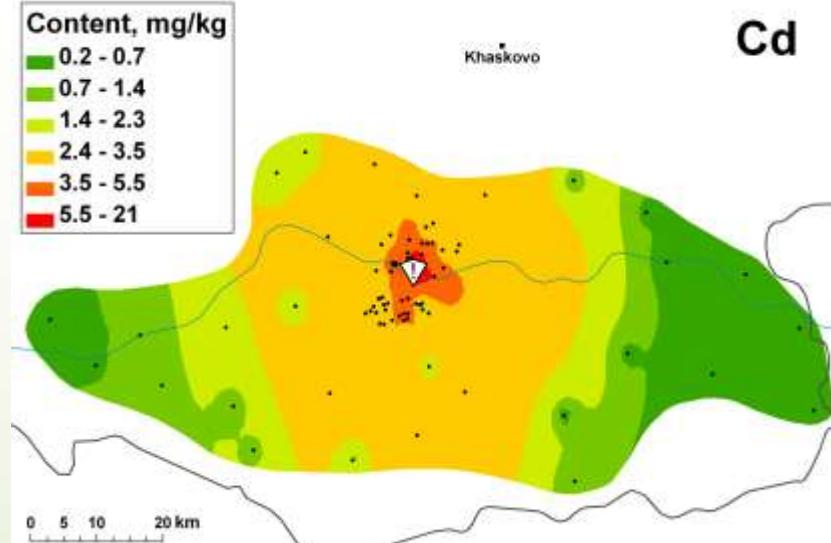
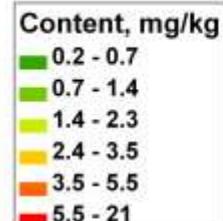
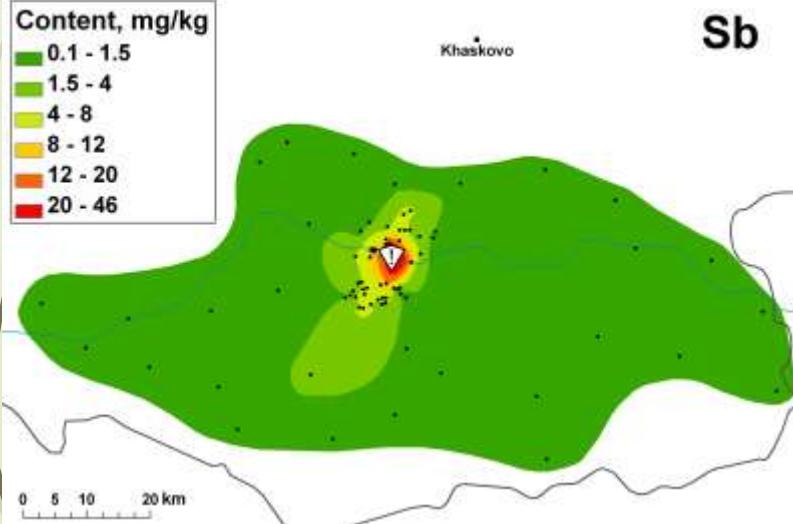
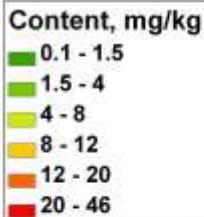


Pb-Zn smelter: Kardzhali (BG)

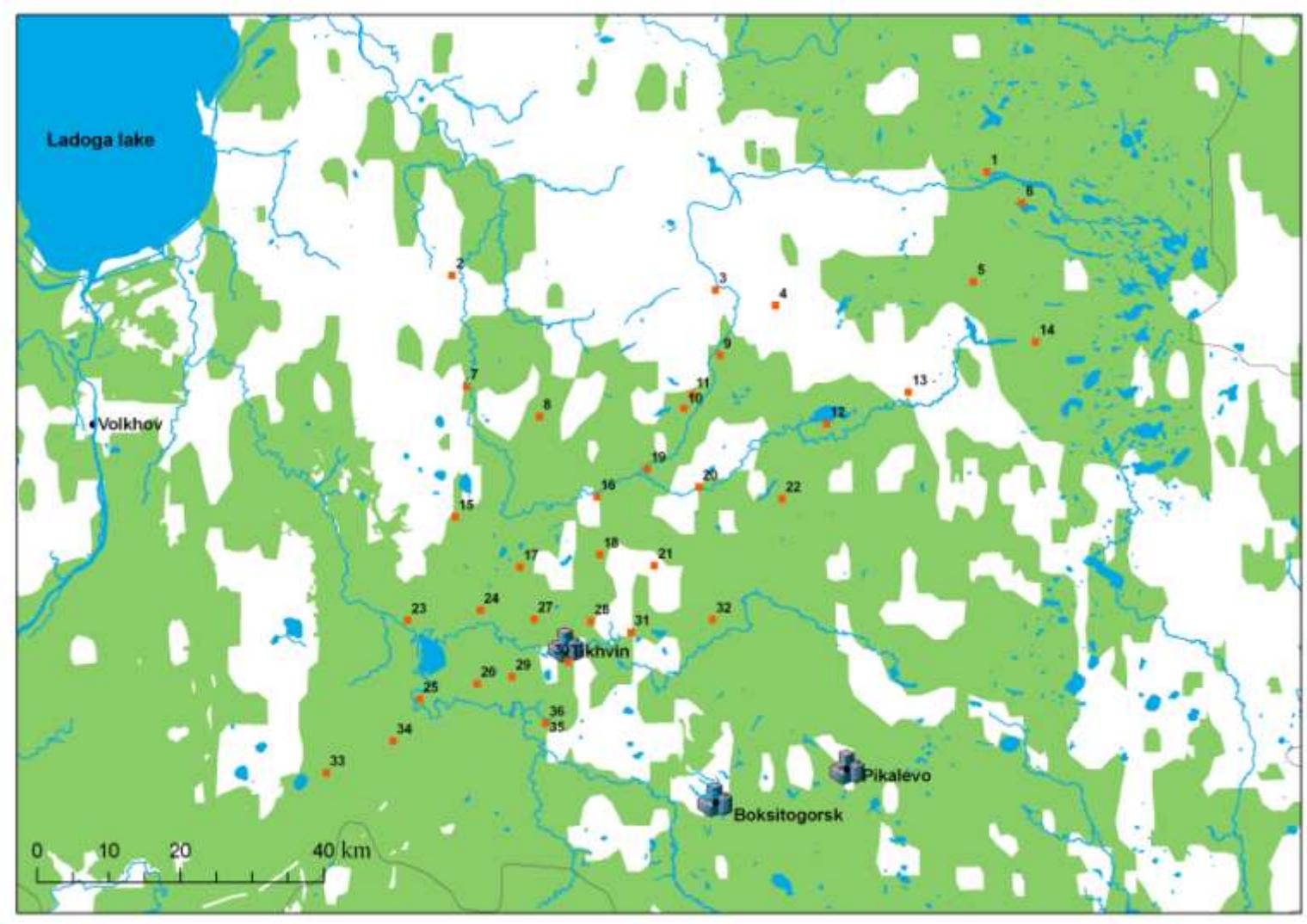


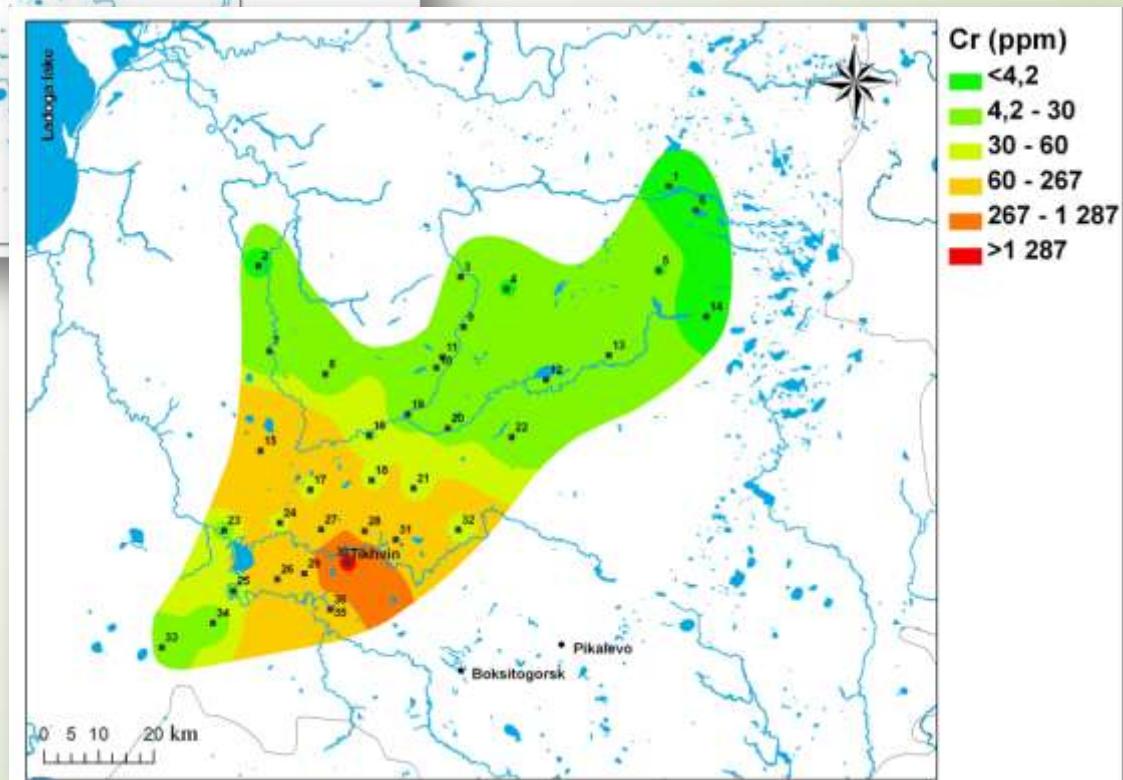
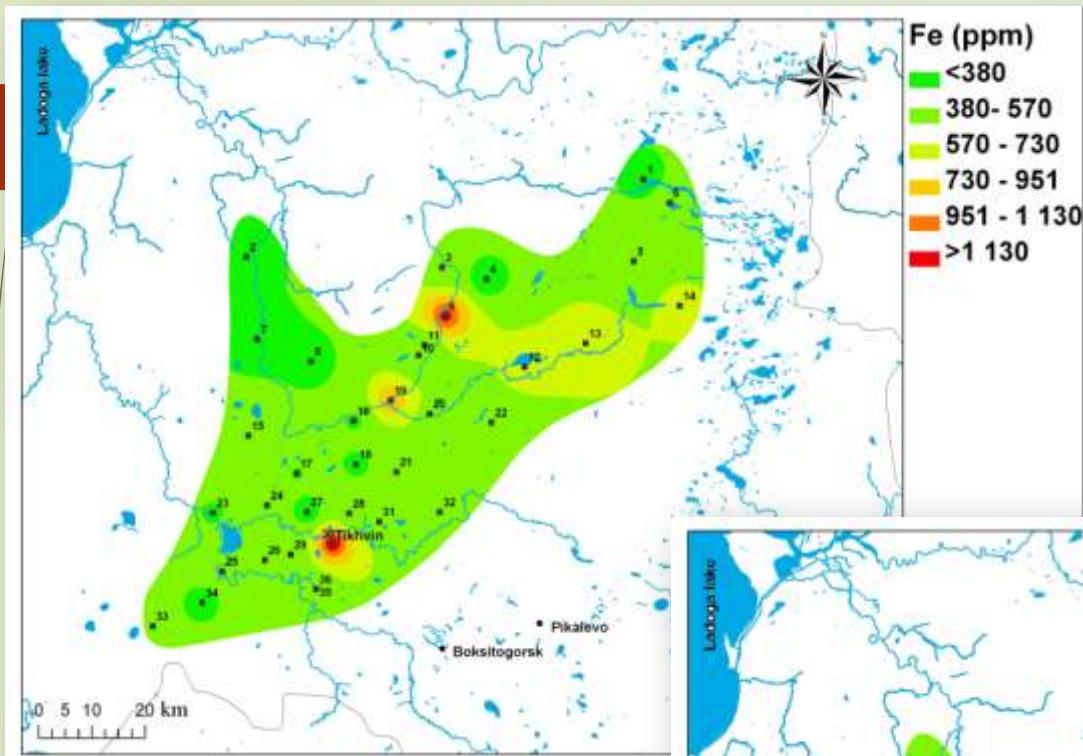


Pb-Zn smelter: Kardzhali (BG)

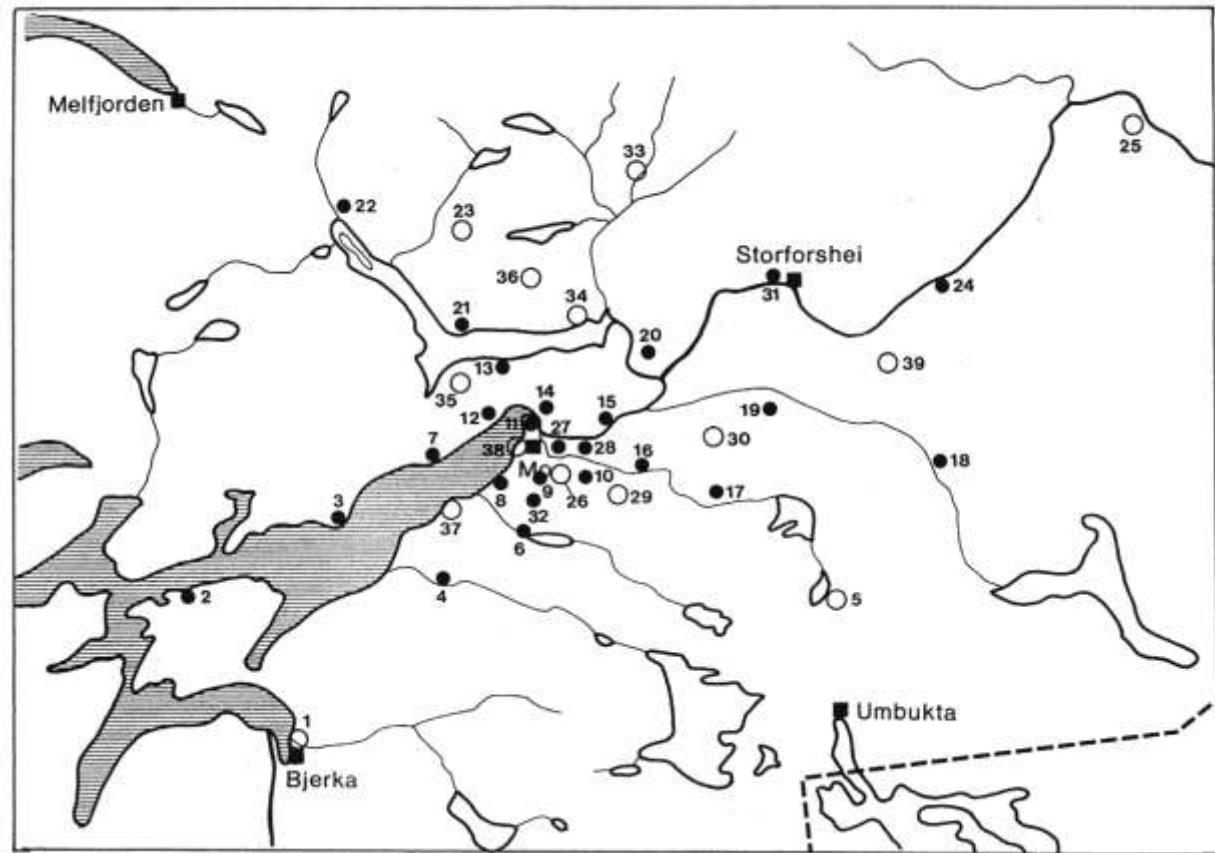
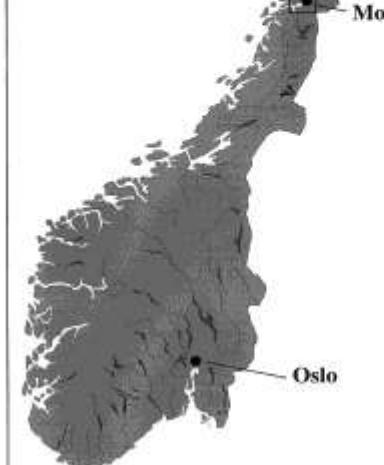


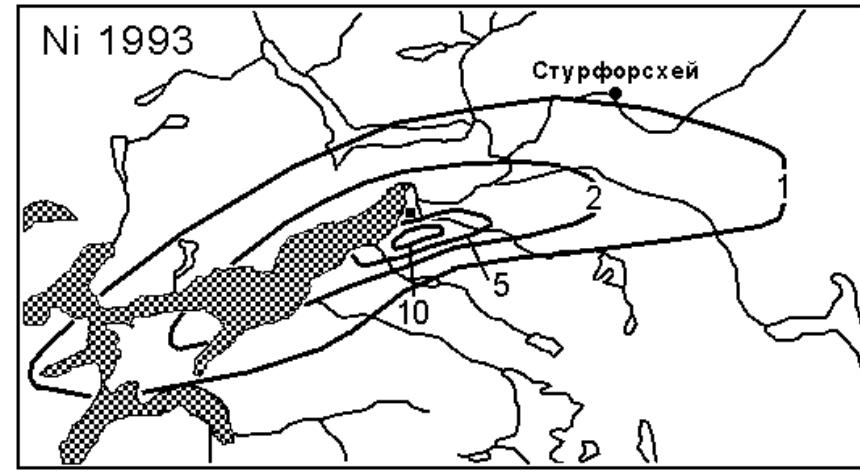
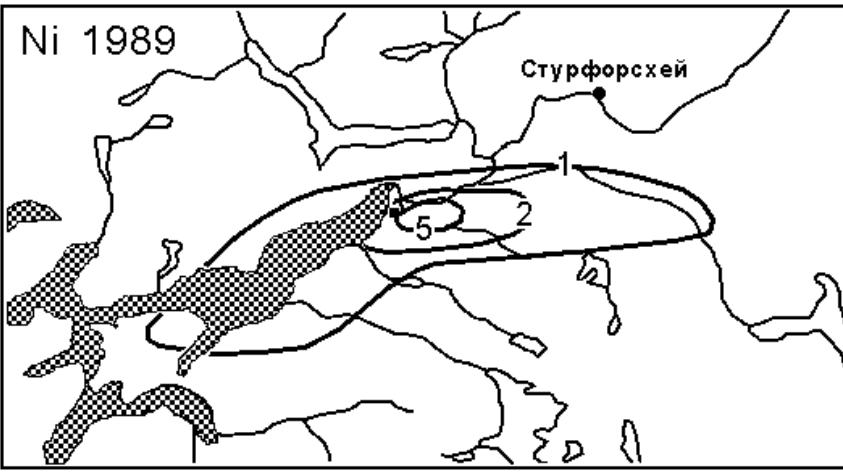
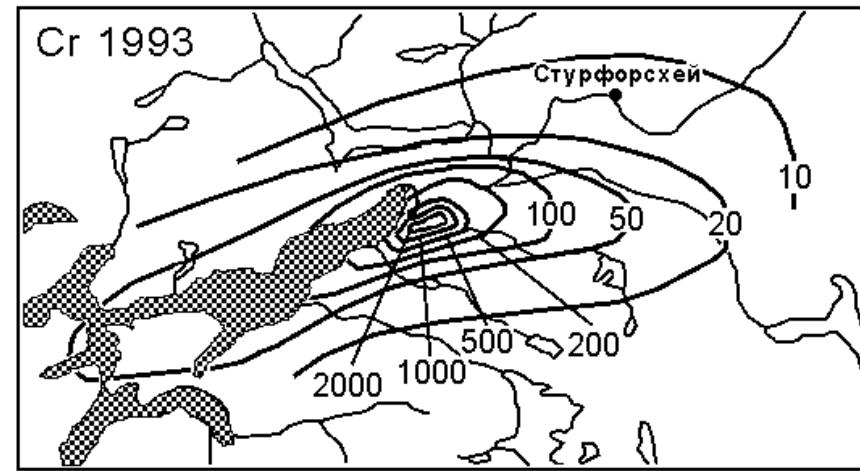
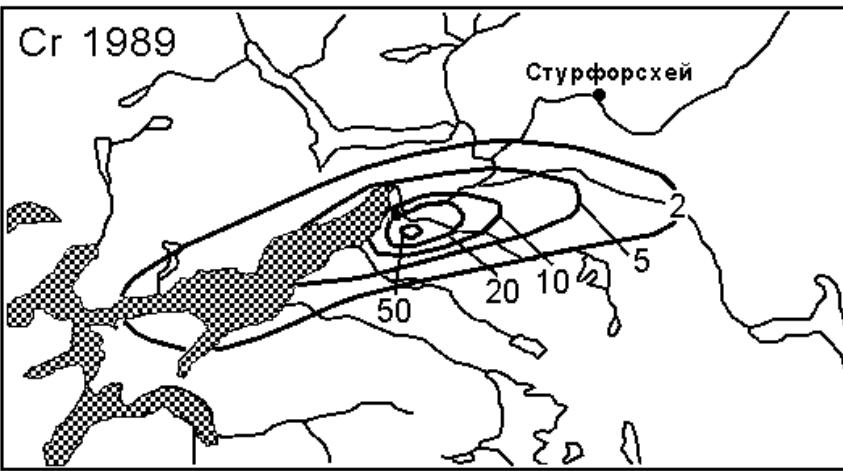
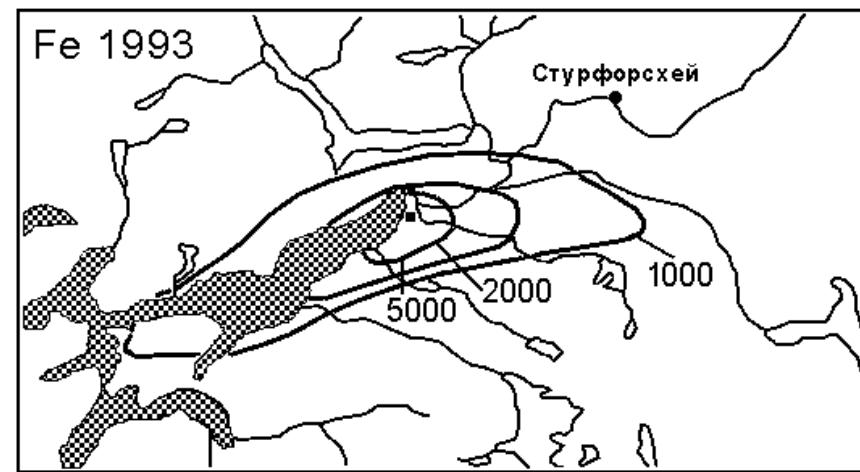
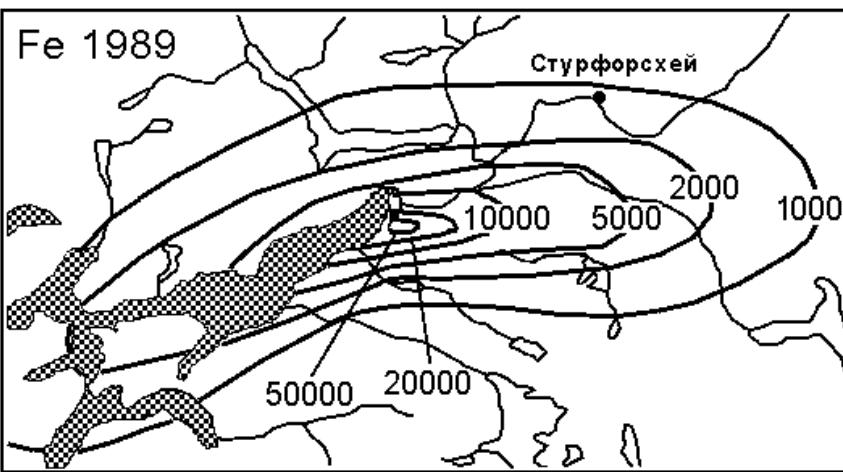
Fe-Cr industry: Tikhvin (RF)



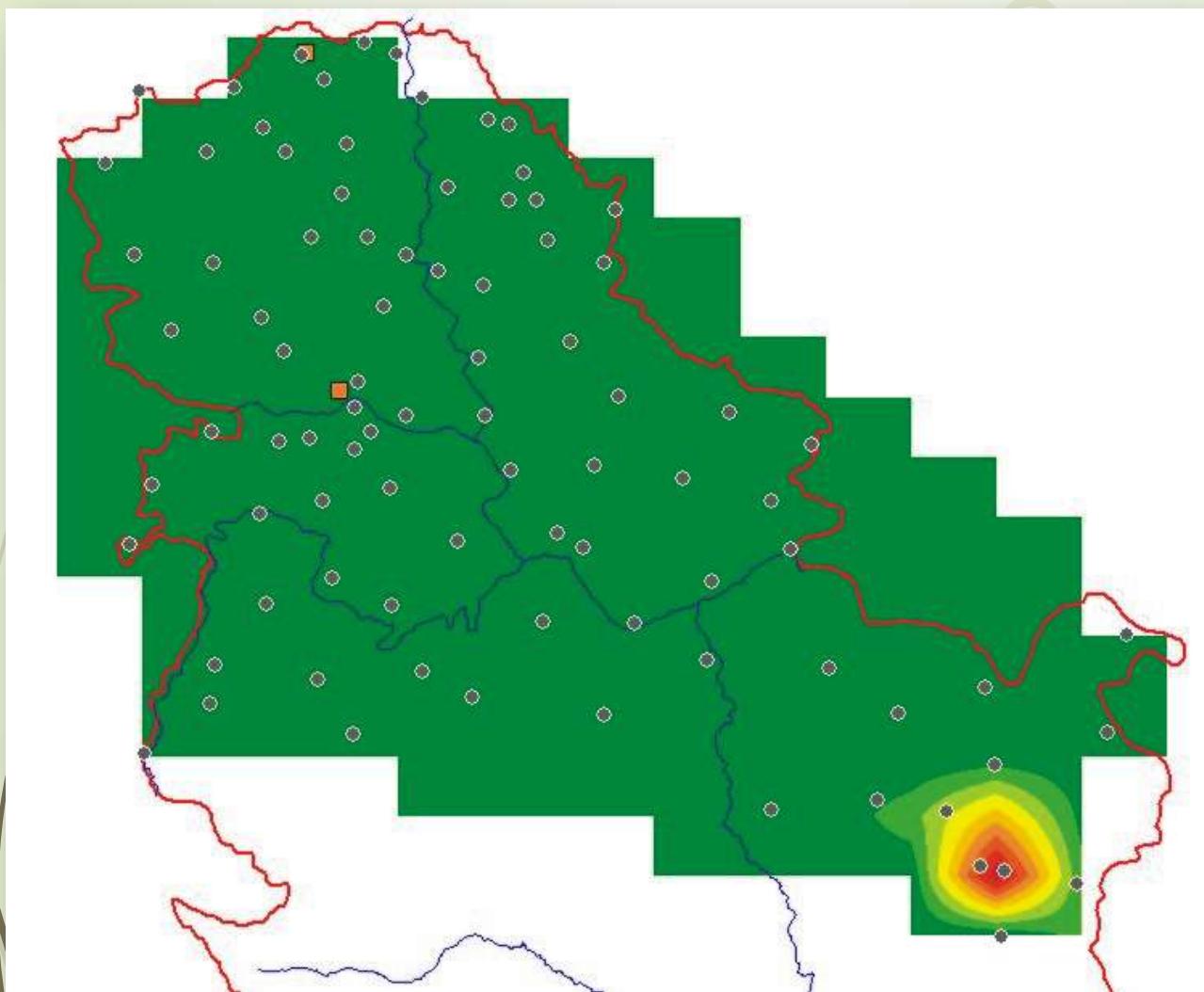


Fe-Cr industry: Mo-i-Rana (NO)

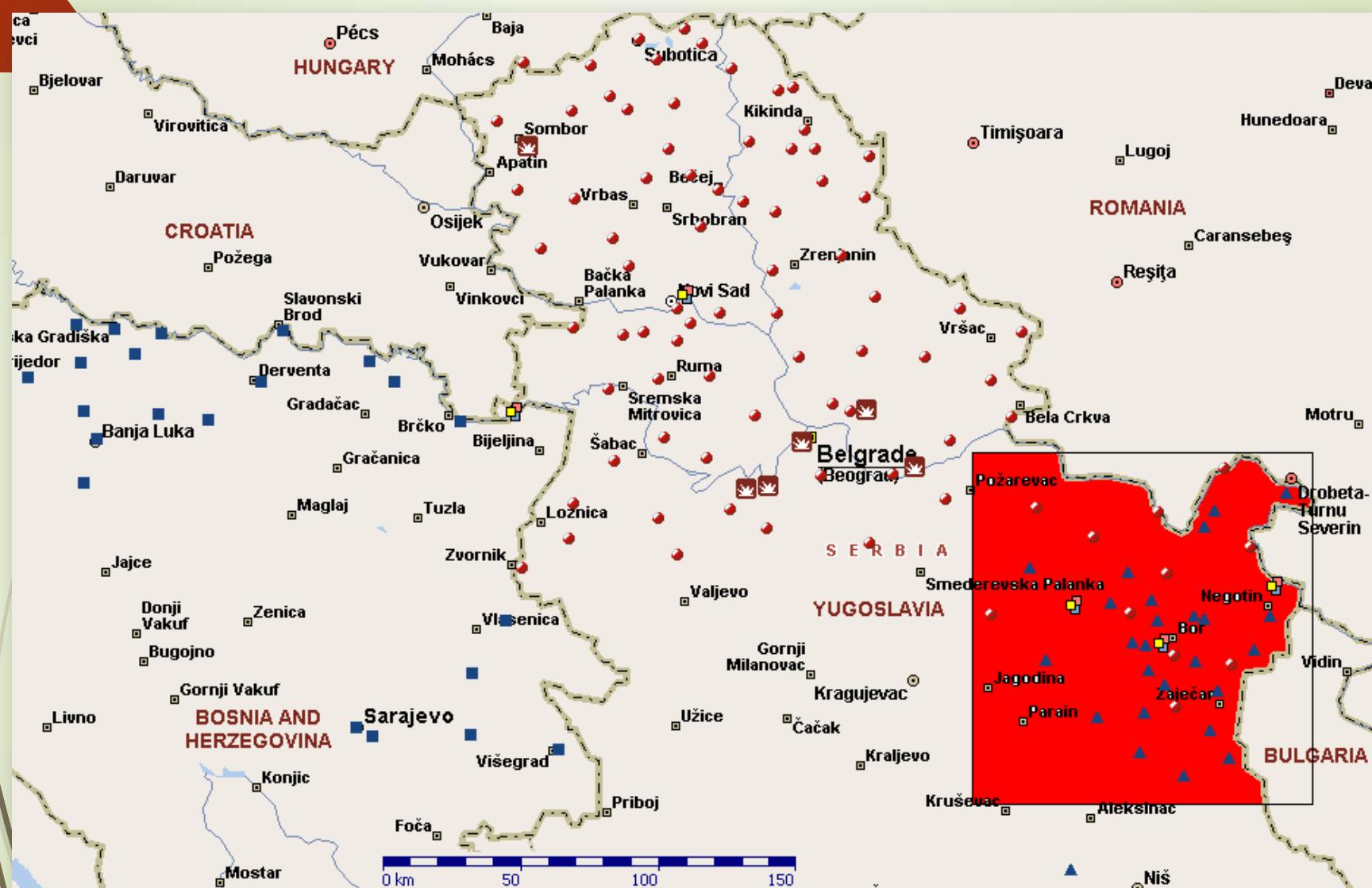




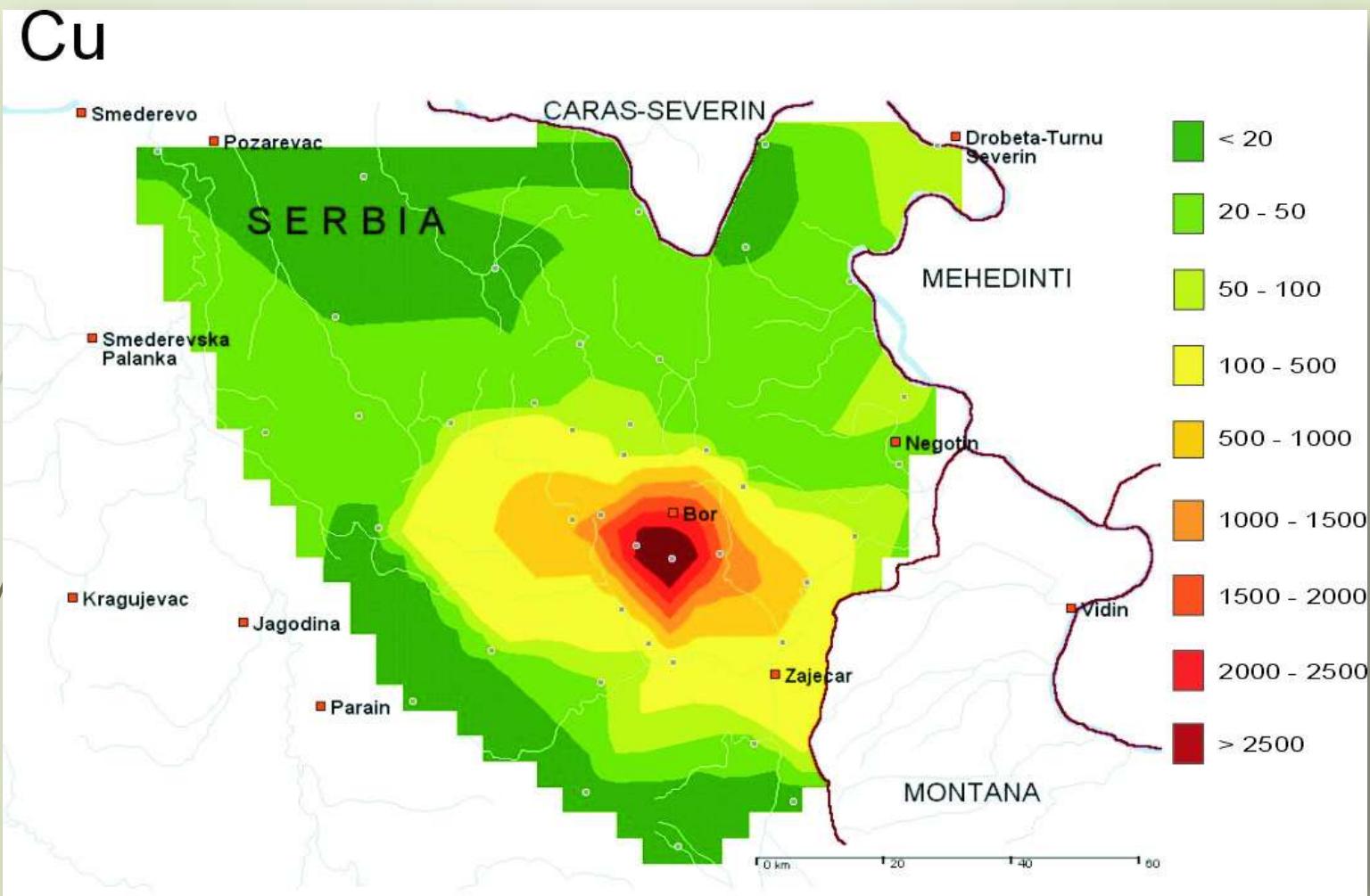
Copper mine: Bor (SR)



Copper mine: Bor (SR)

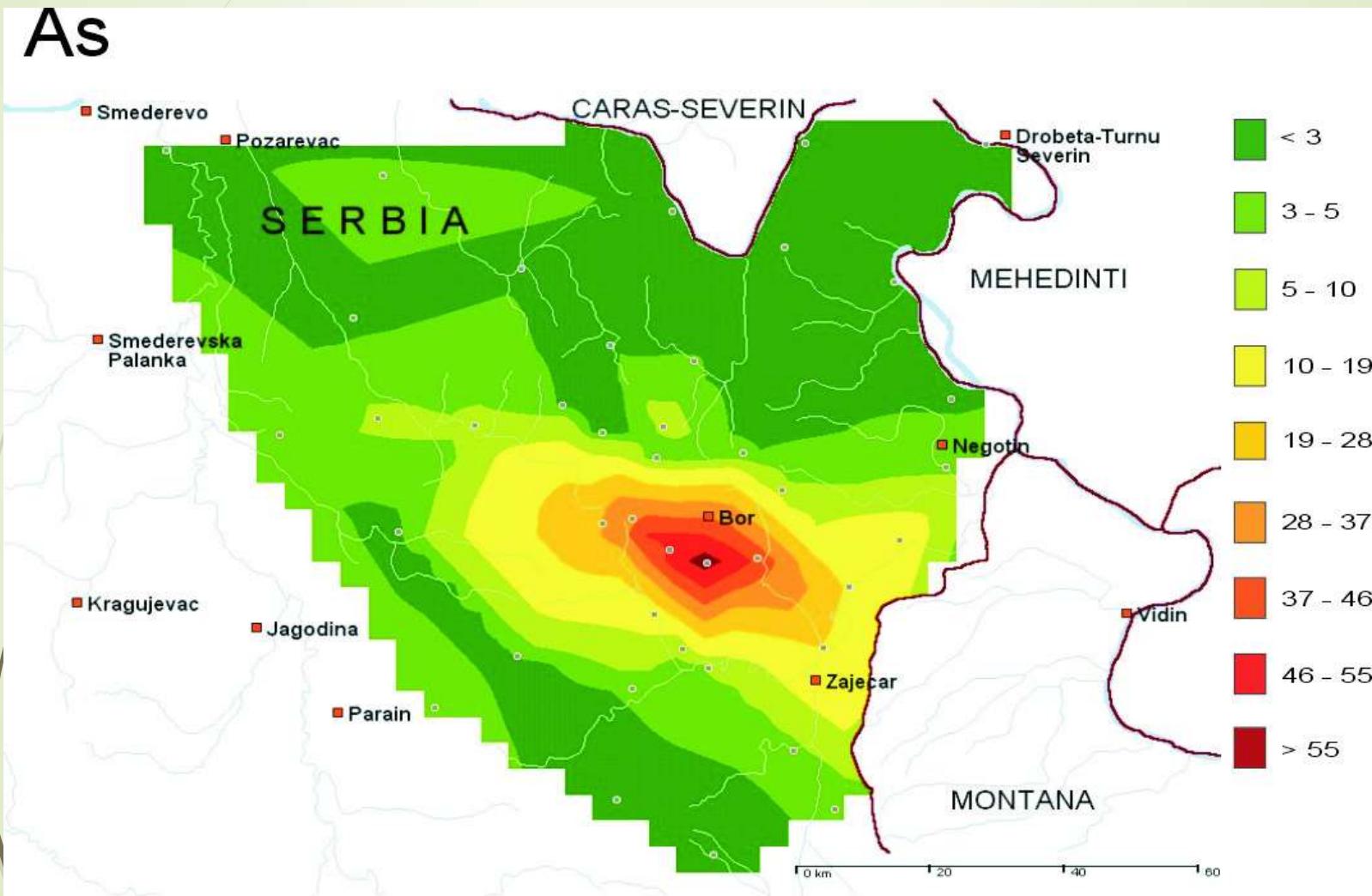


Copper mine: Bor (SR)

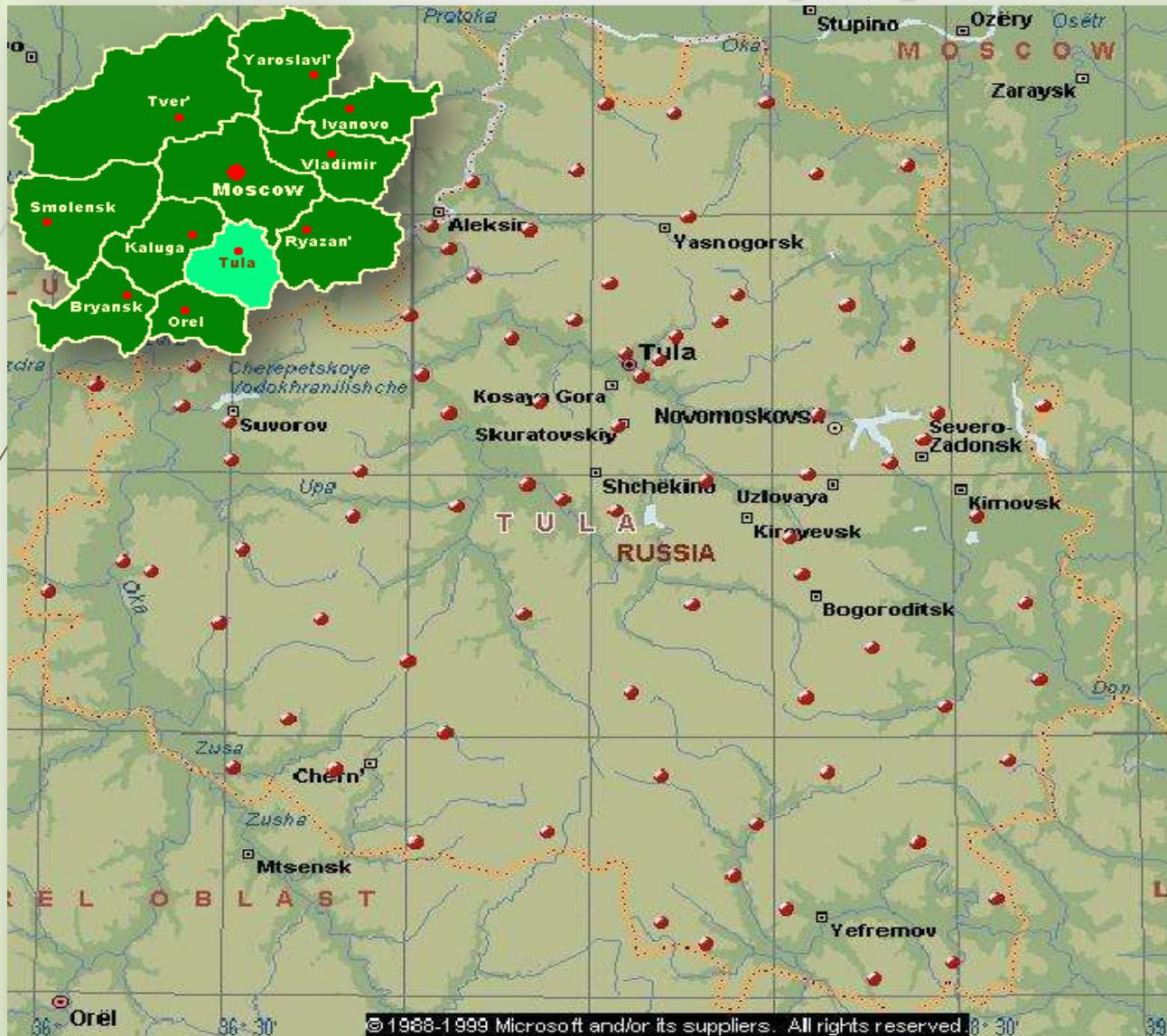


Program GRINVIEW, GIS software package GIS-INTEGRO

Copper mine: Bor (SR)



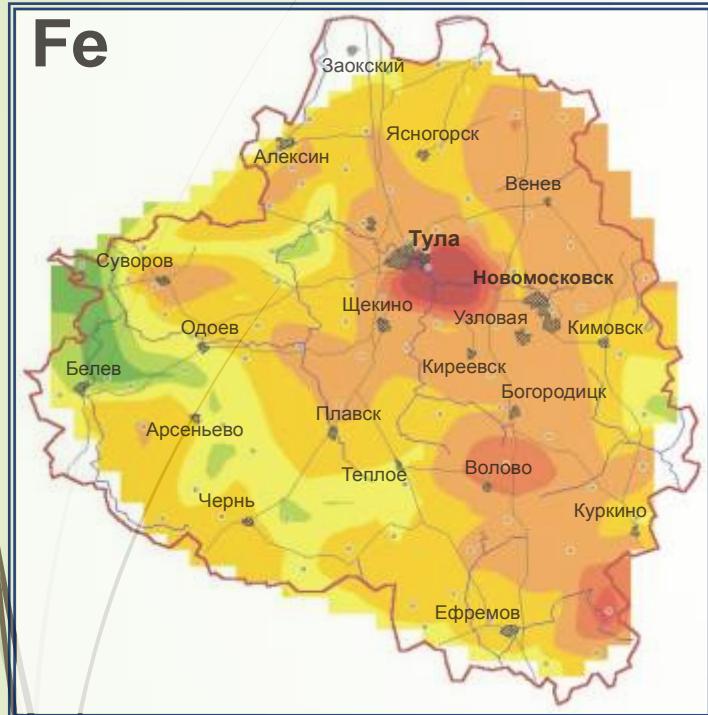
Fe-V plant in Tula (RF)



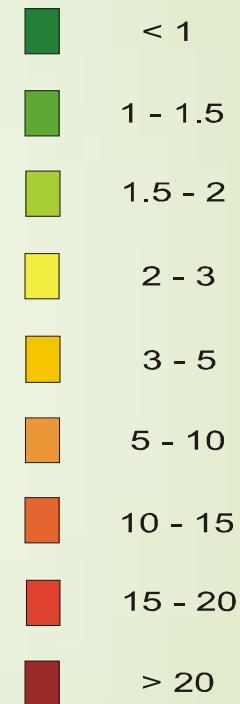
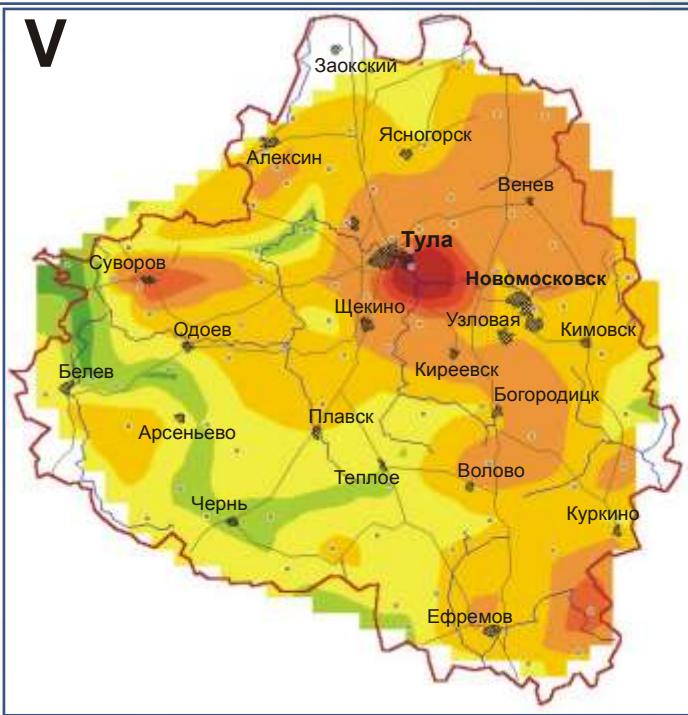
Fe-V plant in Tula (RF)

Relative units
to local background

Fe



V



Thermal power plant in Moscow



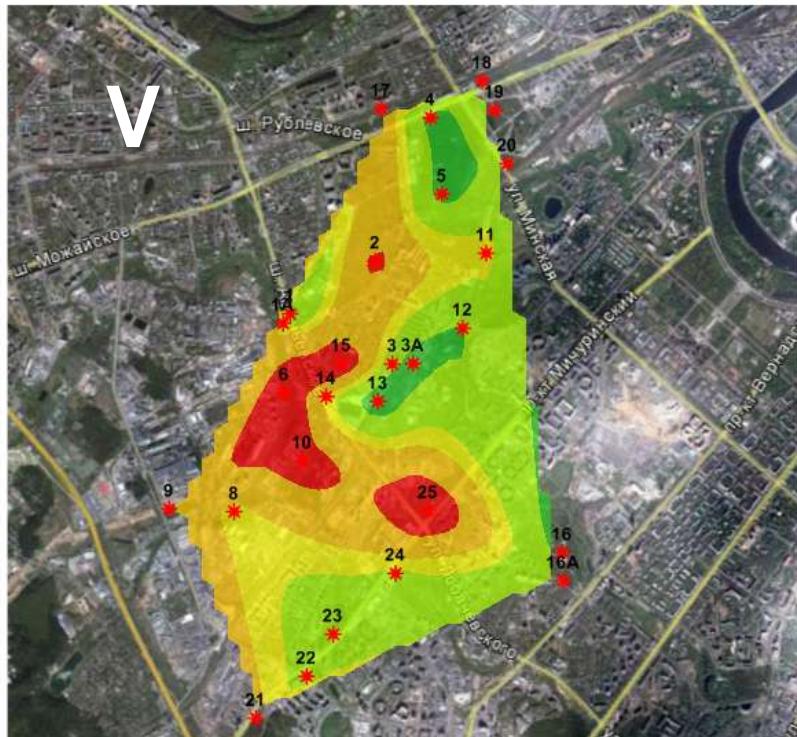




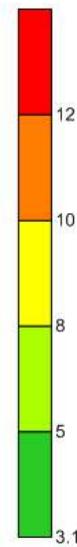
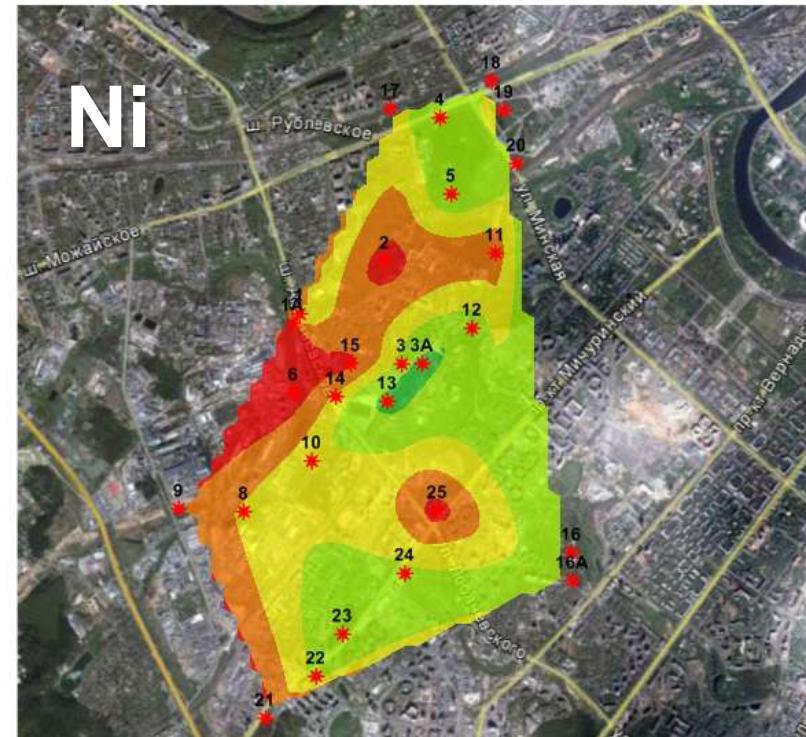
Olga Kapturova and Alexandra Volokhova, school No. 814, Moscow

Thermal power plant in Moscow

V



Ni

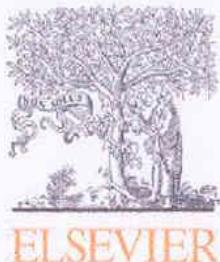




The moss technique was successfully used in our studies for mapping radionuclide distribution in Belarus and Slovakia since 23 years after Chernobyl accident and it can be used for assessing sequences of the Fukushima disaster in the Far East of Russia (mapping of radionuclide distributions around the city of Vladivostok).

Most important publication

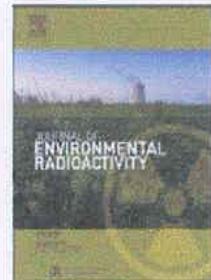
Journal of Environmental Radioactivity xxx (2012) 1–6



Contents lists available at SciVerse ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad



Distributions of ^{137}Cs and ^{210}Pb in moss collected from Belarus and Slovakia

Yu.V. Aleksiayenak^{a,*}, M.V. Frontasyeva^a, M. Florek^b, I. Sykora^b, K. Holy^b, J. Masarik^b, L. Brestakova^b, M. Jeskovsky^b, E. Steinnes^c, A. Faanhof^d, K.I. Ramatlhape^e

^aFrank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow Region, Russia

^bDept. of Nuclear Physics and Biophysics, Comenius University, Bratislava, Slovakia

^cNorwegian University of Science and Technology, NO-7491 Trondheim, Norway

^dSouth African Nuclear Energy Corporation, Pretoria, South Africa

^eCentre of Applied Radiation Science and Technology, North-West University, (Mafikeng Campus), Mmabatho, South Africa



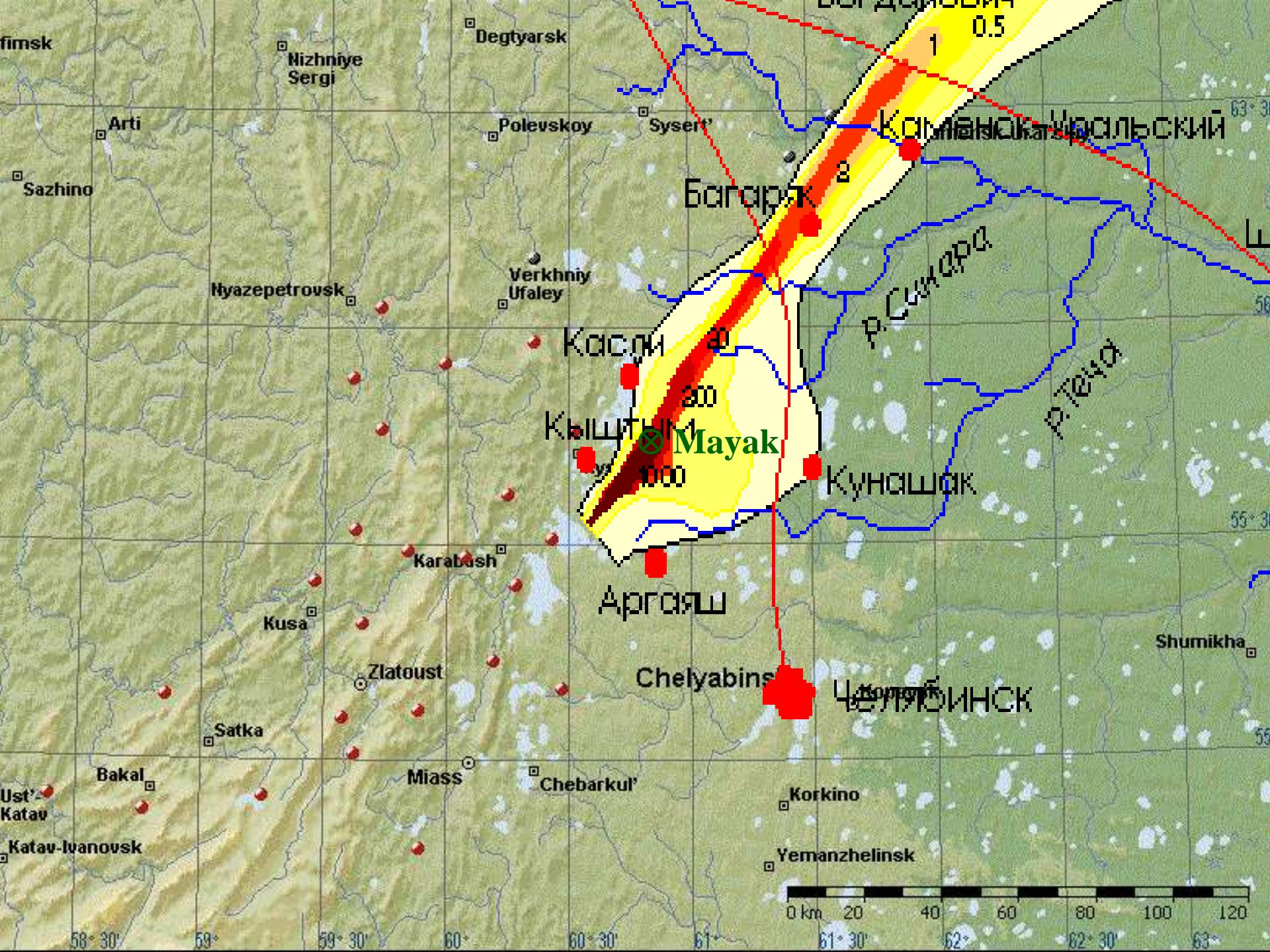
Long-lived radionuclides in the South Urals (RF)



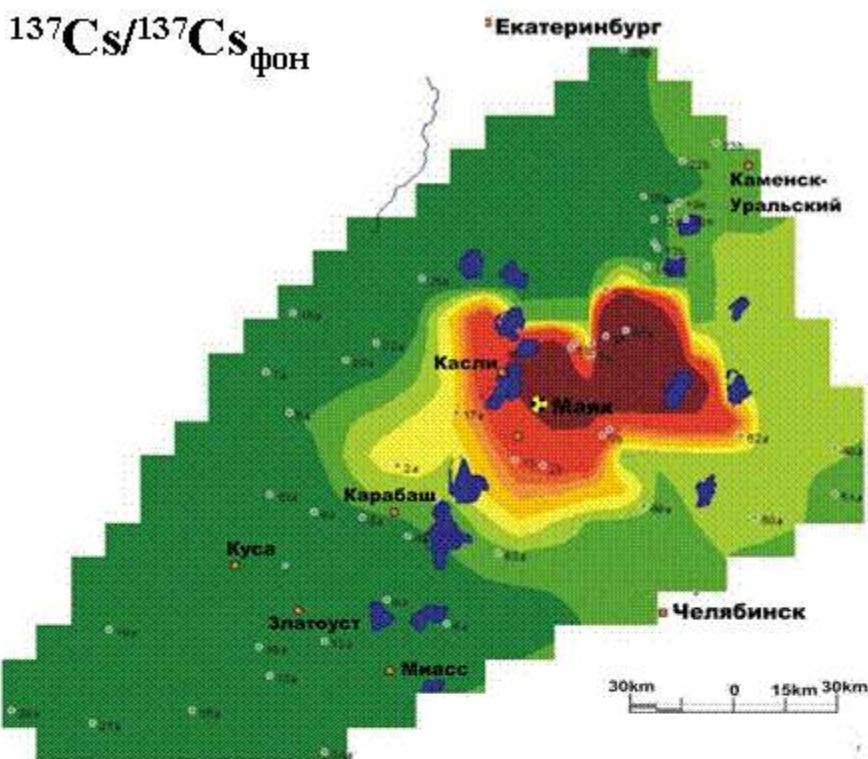
IAEA coordination research project

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





$^{137}\text{Cs}/^{137}\text{Cs}$ фон



^{137}Cs local baseline value

2.56 kBq /m²

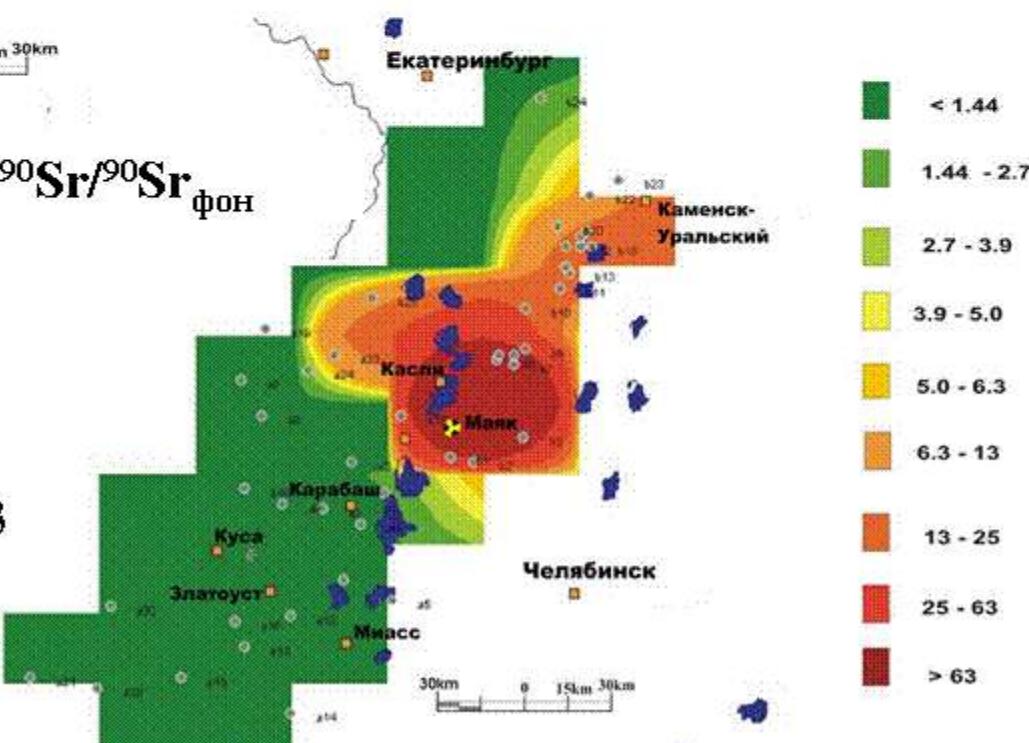
1957: Kyshtym accident: Sr/Cs = 70

1967: Karachai emissions: Sr/Cs = 0.3

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

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

$^{90}\text{Sr}/^{90}\text{Sr}$ фон

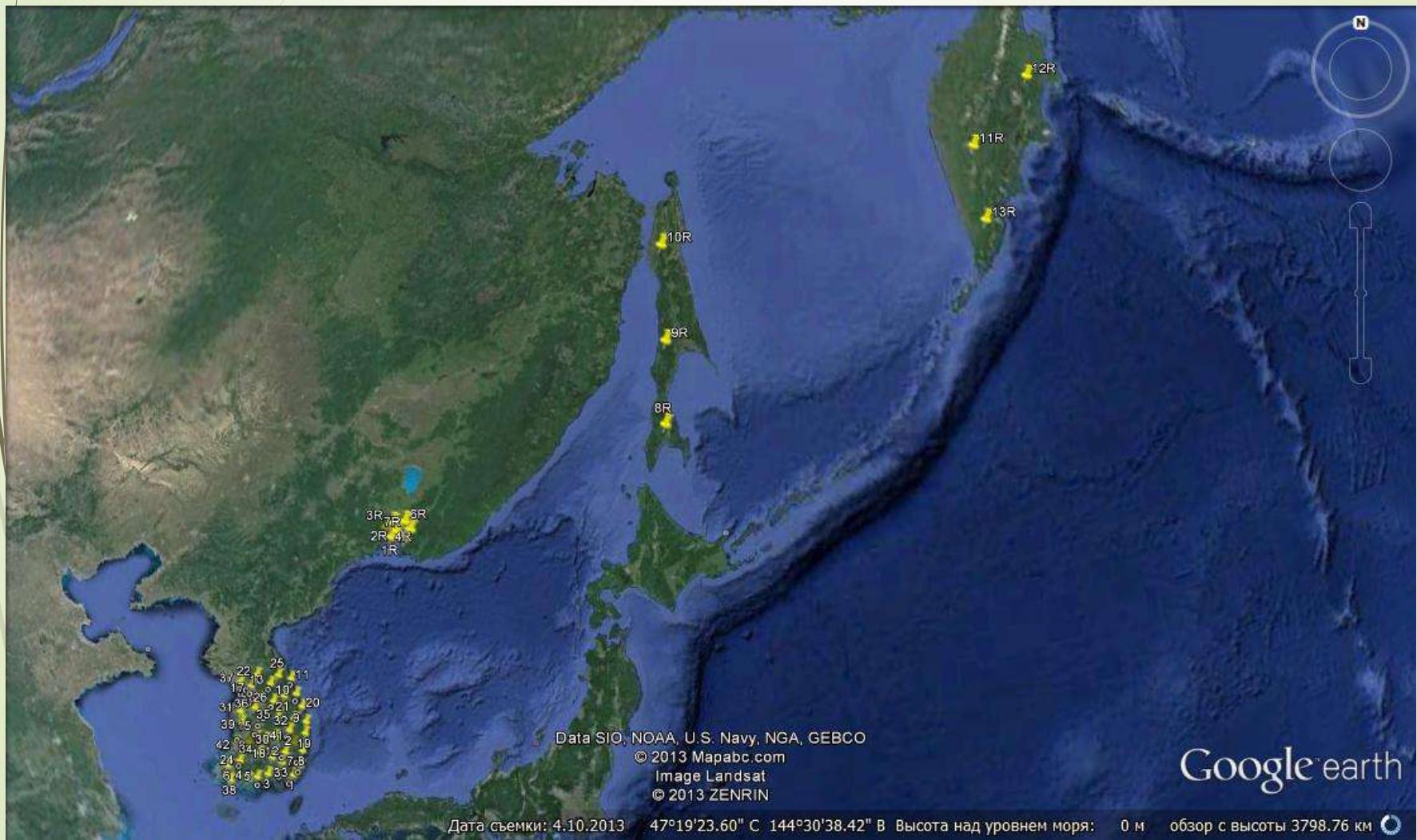




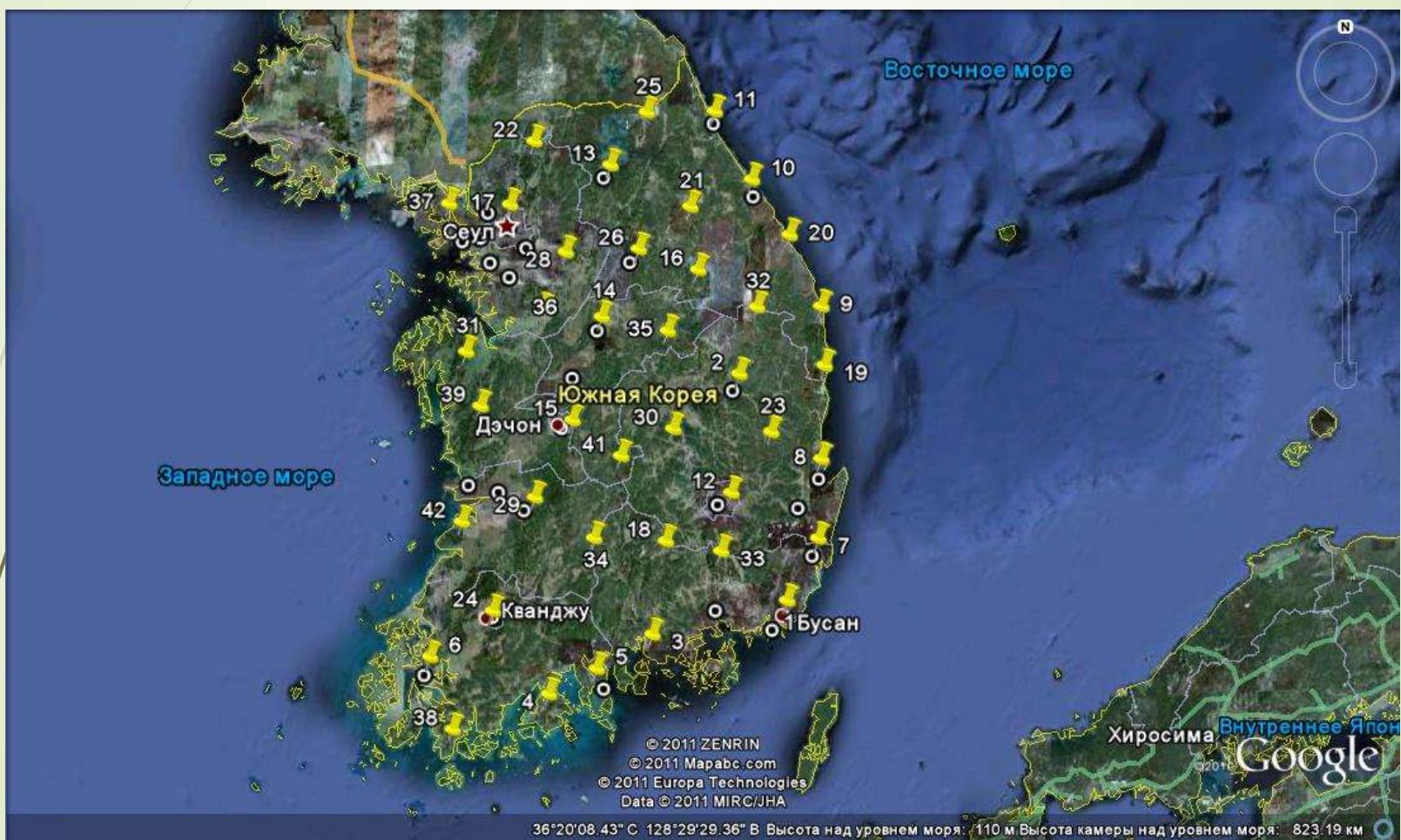
Long-lived radionuclides in the Far East of RF and South Korea

**The moss technique is supposed to be
used for assessing sequences of the
Fukushima disaster in the Far East of the
Russian Federation and entire territory of
South Korea**

Long-lived radionuclides in the Far East of RF and South Korea



Long-lived radionuclides in the Far East of RF and South Korea



CONTACT DETAIL

Dr. Marina Frontasyeva

**Department of NAA and Applied Research
Division of Nuclear Physics
Frank Laboratory of Neutron Physics
Joint Institute for Nuclear Research
141980 Dubna, Moscow Region
Russian Federation**

**Tel: +7 (49621) 65609
E-mail: mfrontasyeva@jinr.ru
(<http://flnp.jinr.naa/>**

THANK YOU FOR ATTENTION!

