The Situation of NORM in Non-Uranium Mining in China

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I Introduction

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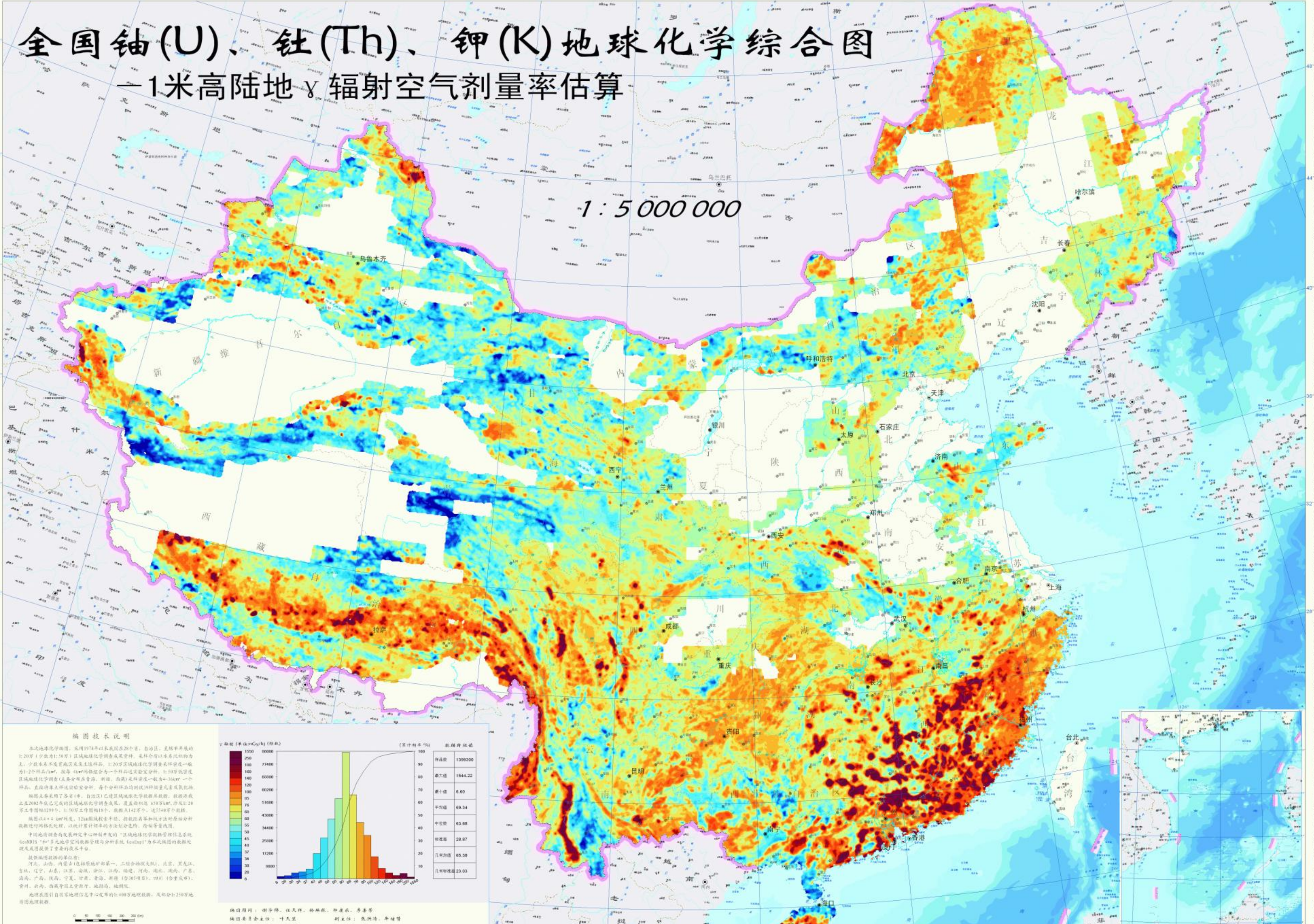
I Introduction

- According to Law on Prevention and Control of Radioactive Pollution, MEP(NNSA) in China is responsible for regulatory control on radiation protection to NORM.
- In China, the natural radiation exposure levels vary greatly in different areas.

全国铀(U)、钍(Th)、钾(K)地球化学综合图

—1米高陆地γ辐射空气剂量率估算

1∶5 000 000



数据特征值

样品数	1399300
最大值	1544.22
最小值	6.60
平均值	69.34
中位数	63.68
标准差	28.87
几何均值	65.38
几何标准差	23.03

编图技术说明

本次地球化学编图，采用1978年以来我国在28个省、自治区、直辖市开展的1:20万（少数为1:50万）区域地球化学调查成果资料。采样介质以水系沉积物为主，少数水系不发育地区采集土壤样品。1:20万区域地球化学调查采样密度一般为1-2个样品/km²，按每4km²网格组合为一个样品送实验室分析。1:50万低密度区域地球化学调查（主要分布在青海、新疆、西藏）采样密度一般为4-36km²一个样品，直接将单点样送实验室分析。每个分析样品均测试39种微量元素及氧化物。

编图主要采用了各省（市、自治区）已建区域地球化学数据库数据，数据源截止至2002年底已完成的区域地球化学调查成果，覆盖面积达658万km²，涉及1:20万工作图幅1299个，1:50万工作图幅18个，数据点142万个，近5540万个数据。

编图以4×4km²网度，12km圆域搜索半径，按距离幂加权方法对原始分析数据进行网格化处理，以统计累计频率的方法划分色阶，绘制等量线图。

中国地质调查局发展研究中心研制开发的"区域地球化学数据管理信息系统GeoMDIS"和"多元地学空间数据管理与分析系统GeoExpl"为本次编图的数据处理及成图提供了重要的技术平台。

提供编图数据的单位有：

河北、山西、内蒙古（包括原地矿部第一、二综合物探大队）、北京、黑龙江、吉林、辽宁、山东、江苏、安徽、浙江、江西、福建、河南、湖北、湖南、广东、海南、广西、陕西、宁夏、甘肃、青海、新疆（含305项目）、四川（含重庆市）、贵州、云南、西藏等国土资源厅、地勘局、地调院。

地理底图引自国家地理信息中心发布的1:400万地理数据，及部分1:250万地形图地理数据。

0 50 100 150 200 250 km

等角割圆锥投影

（中央经线105°，双标准纬线25°、47°，1954北京坐标系）

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本系列图由中国地质调查局主持编制

中国地质调查局发展研究中心数据处理与制图

编图时间 2005年6月

- Natural radiation by human activities is the major contributors to the public and occupational exposure.
- High indoor radiation is caused by using waste or slag with higher radioactivity as building materials.

II Regulations framework

- Law on Prevention and Control of Radioactive Pollution
- Basic standards for protection against ionizing radiation and for the safety of radiation sources (GB18871-2002)
- Technical Requirements for radioactive waste management (GB14500 – 2002)

II Regulations framework related NORM

- **Administrative Rules on Prevention and Control of Pollution of Tailings.**
- **Requirement of Control on Radioactive Substance for Building Material Product and Industrial By-product used in Building Materials (GB 6763-2000)**

- The law and regulations in China requests that owner of non-uranium mine should conduct environmental impact assessment on radioactivity, if not exempted

- Currently, MEP is drafting a guideline for non-uranium mines.

III NORM situation in non-uranium mining

- NORM exposure to public from coal industry
  - normalized collective dose, from air effluent within 80 km, for coal power plant was 16.5 man-Sv/GWa, and for coal gangue power plant was 7000 man-Sv/GWa.
  - Total annual collective effective dose to public from buildings with coal-slag bricks in China was 3,300 man-Sv/a

The First China Pollution Sources Census

1 introduction

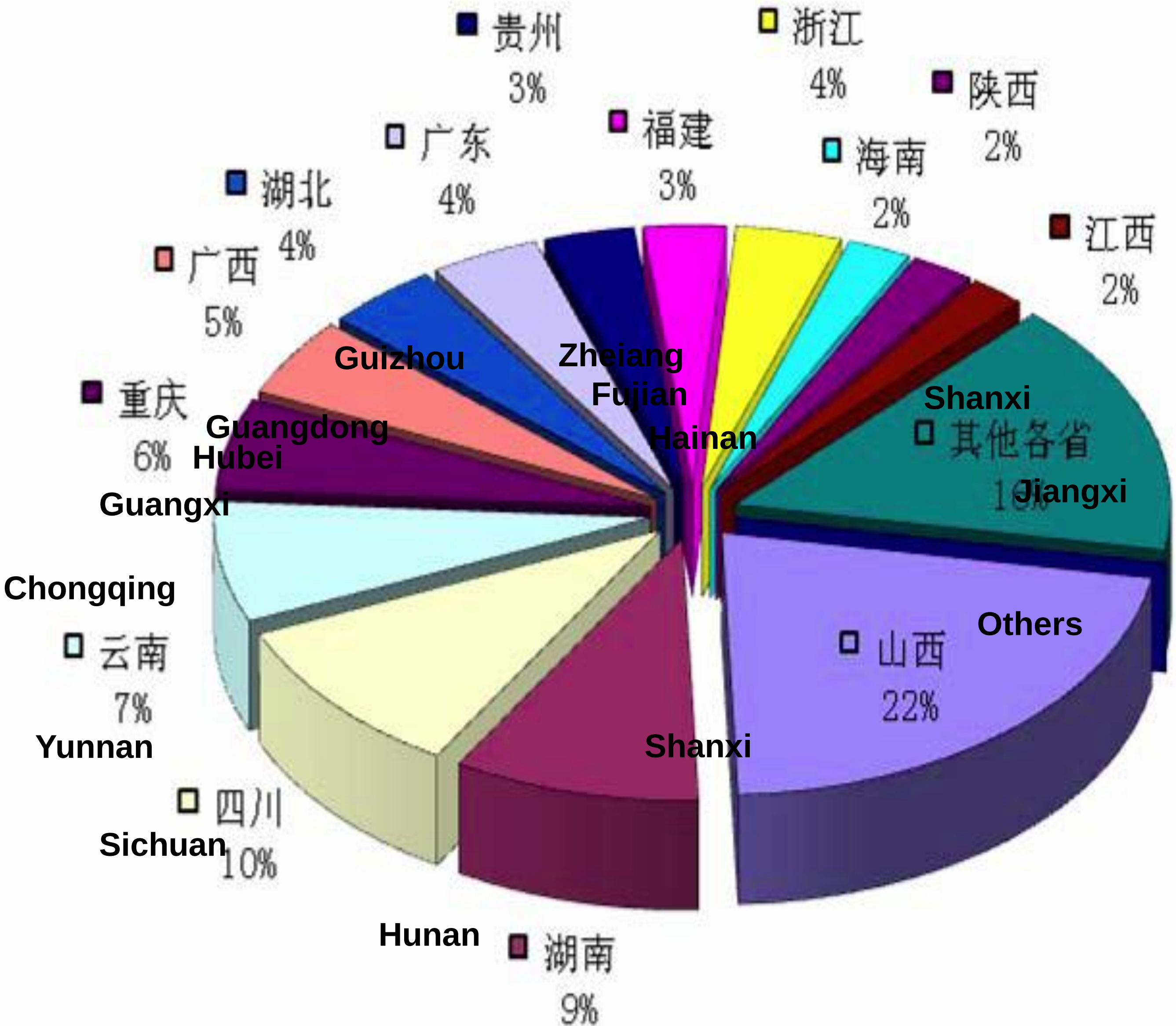
- FCPSC is national wide comprehensive investigation for target year 2007 on all kinds of pollution sources from industry, agriculture, daily life and pollution treatment centers.
- MEP organized from 2008 to 2009.

FCPSC

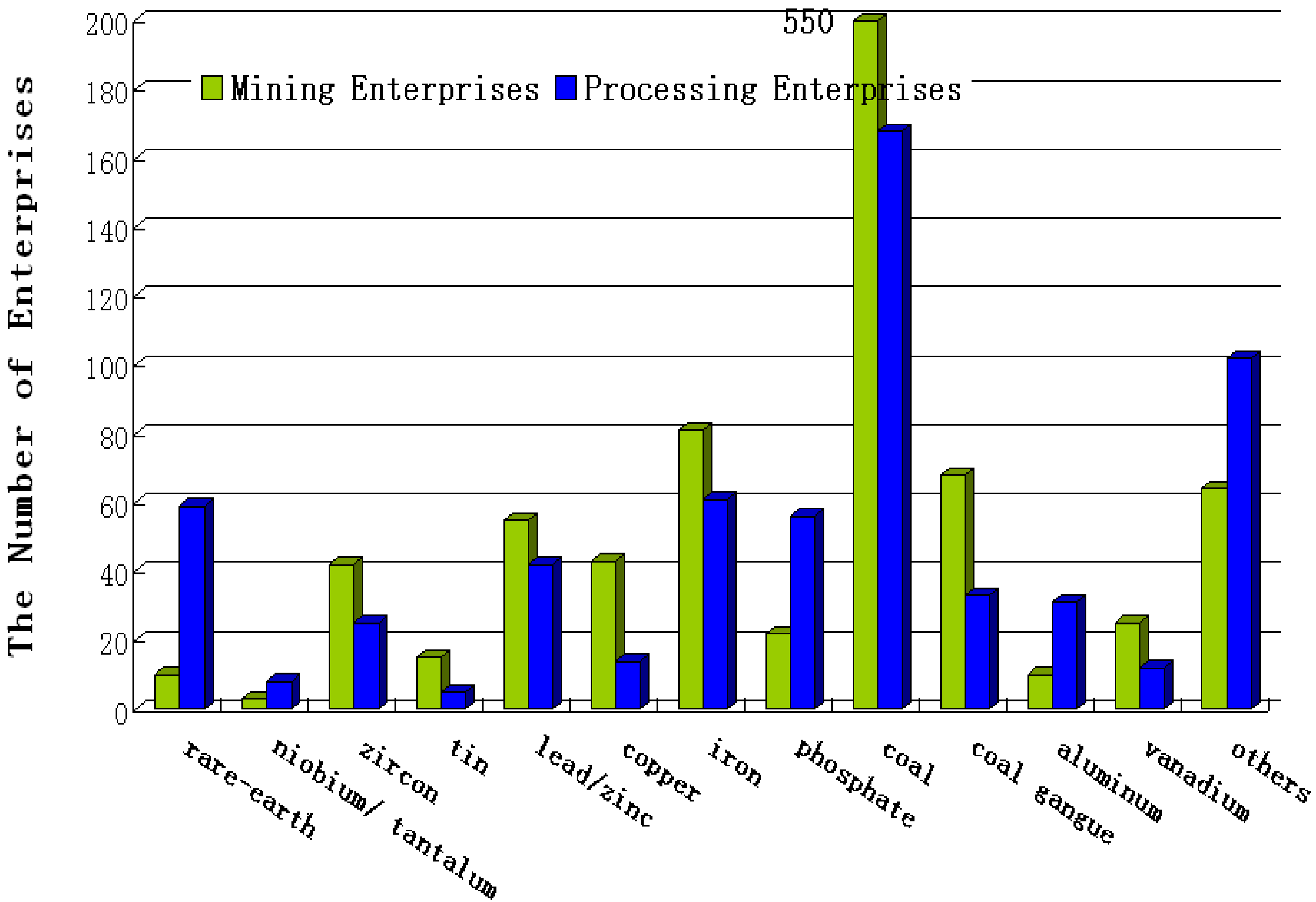
- For non-uranium mines, total 11 kinds mines
  - **rare earth**
  - **niobium/ tantalum**
  - **zircon and its oxides**
  - **tin**
  - **lead /zinc**
  - **copper**
  - **aluminum**
  - **vanadium**
  - **iron and steel**
  - **phosphate**
  - **coal including coal gangue.**

2 NORM industries in non-uranium mining

- Total 11,000 companies in NORM
- Among them, 1,433 companies were monitored in detail. They either produce ores, raw materials (concentrates), or wastes (slag, tailings) with that γdose rate on 1 meter distance is over 50 nGy/h of local background level.



Distributions of NORM Industries in China


The Number of Enterprises
200
180
160
140
120
100
80
60
40
20
0
550
Mining Enterprises
Processing Enterprises
rare-earth
niobium/ tantalum
zircon
tin
lead/zinc
copper
iron
phosphate
coal
coal gangue
aluminum
vanadium
others

3 Radioactivity in ores and raw materials

- Radioactivity in rare earths, niobium/ tantalum and zircon is high. Average external γ dose rates:
  - rare earths, 5,709 nGy/h,
  - niobium/ tantalum, 3,263 nGy/h
  - Zircon, 1,592 nGy/h.

Their average concentration of 238U, 226Ra or 232Th is more than 1,000 Bq/kg.

Radioactivity in Mineral Resources

Elements/ mineral	Concentrations of Natural Radionuclides						External γ dose rate（nGy/h）	
	Uranium, Bq/Kg		^{226}Ra（Bq/Kg）		Thorium（Bq/Kg）			
	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
Rare earths	3972	78000	2529	30200	5782	137000	5709	32671
Nb/ Ta	4476	21500	18131	57486	2015	9242	3263	8023
Zircon	1289	6500	3510	13935	1733	10200	1592	5830
Tin	218	778	540	4276	133	872	272	838
lead /zinc	649	34749	465	16274	69	2729	173	1029
Copper	142	1065	163	874	34	183	170	493
Iron	270	6978	288	14265	68	2597	162	1234
Phosphate	396	2735	404	2072.5	26	346	273	1241
Coal	383	167403	212	24021	51	910	153	2552
Coal gangue	171	1321	118	682	82	241	135	242
Aluminum	482	1220	289	798	240	638	323	910
Vanadium	1036	12200	908	3980	1501	27000	280	968
Others	503	5029	744	8048	508	16535	422	5940

Radioactivity in solid waste

Elements/ mineral	Concentrations of Natural Radionuclides						External γ dose rate （nGy/h）	
	Uranium（Bq/Kg）		^{226}Ra（Bq/Kg）		Thorium（Bq/Kg）			
	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
Rare earths	2081	83044	1240	53700	4876.3	85600	3249	48344
Nb/ Ta	7725	36310	7212	34751	4191	21775	1624	7634
Zircon	1026	9908	945	7202	327	2120	358	1500
Tin,	922	2850	1377	4350	802	3160	601	1482
lead /zinc	118	715	195	2049	38.4	137	130	303
Copper	142	1630	155	2380	36	145	153	385
Iron	246	6028	247	9908	135	2289	189	1177
Phosphate	123	724	191	1042	35.3	202.4	144	331
Coal	225	7600	326	92178	91	910	162	987
Coal gangue	191	763	79	415	92	212	115	328
Aluminum	402	1398	282	581	349	694	300	615
Vanadium	813	2096	675	1692	73	771	264	760
Others	338	2968	435	4720	119	1390	200	1180

FCPSC

- For Uranium
- There are 117 companies, 8% of 1433 companies
  - radioactivity concentration ≥ 1,000 Bq/Kg
  - annual production of ores and raw materials 5.9 mil-tons, and use raw materials 2.5 mil-ton.

FCPSC

- For 232Th
- There are 68 companies, 4.6% of 1433 companies.
  - radioactivity concentration ≥ 1,000 Bq/Kg
  - annual production of ores and raw materials 0.61 mil-tons, and use raw materials 6.44 mil-ton.

FCPSC

- For ^{226}Ra
- There are 123 companies, 8.4% of 1433 companies
  - radioactivity concentration ≥ 1,000 Bq/Kg
  - Annual production of ores and raw materials 2.01 mil-ton, and use of raw materials 1.35 mil-ton.

IV A case study of China Baiyun Obo mine

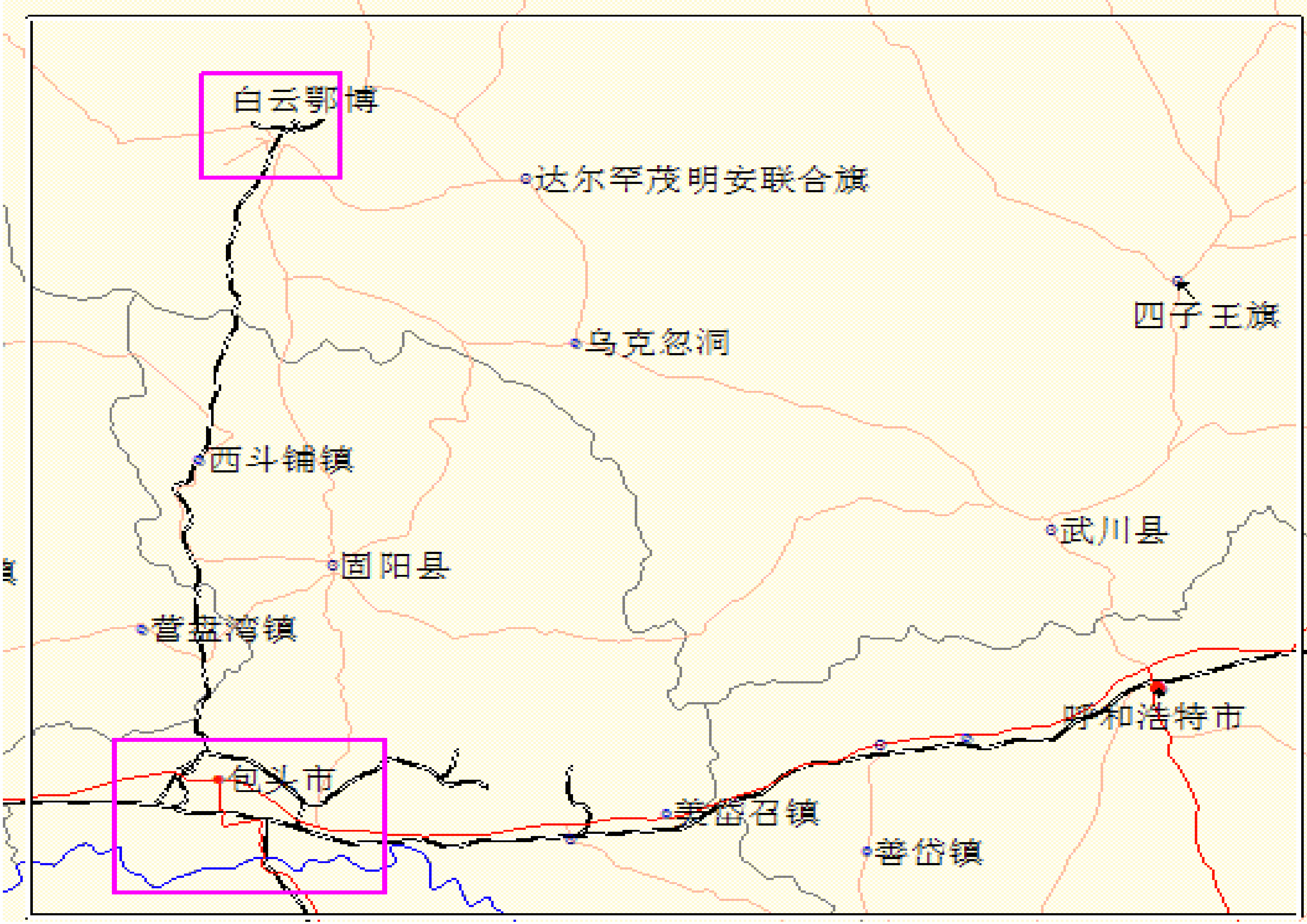
1 Basic situation of Baiyun Obo mine

- **Bayan Obo mine founded in 1954**
  - **Mining and crashing**
  - Bao Tou **Iron and Steel Plant (BTISP)**
  - **Rare earth plants (1974)**

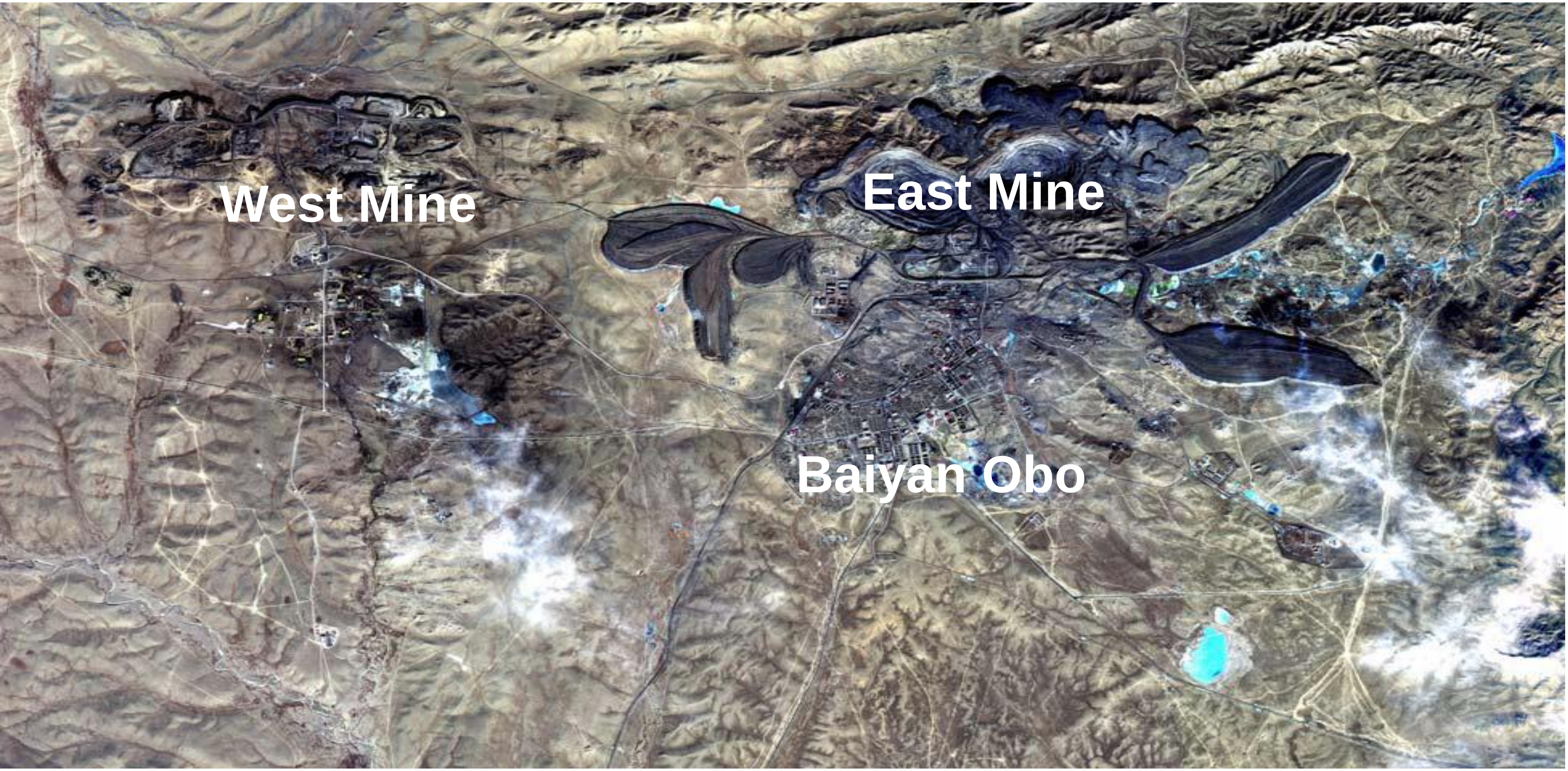
IV A case study of Baiyun Obo mine

1 Basic situation of Baiyun Obo mine

- 12×10^6 t/a of ores from Bayan Obo mine
- 9×10^6 t/a products of iron and steel
- more than 7×10^3 t/a products of oxide equivalent of REO (2006).


白云鄂博
达尔罕茂明安联合旗
四子王旗
乌克忽洞
西斗铺镇
固阳县
武川县
营盘湾镇
呼和浩特市
包头市
美岱召镇
善岱镇

Baiyan Obo mine: about 18Km × 2 - 3Km.



The BTISP and Baotou City

The Baiyan Obo ores are rich in thorium, so it causes a certain radiological impact on both work places and the environment during mining and processing.

2 The Monitoring Program

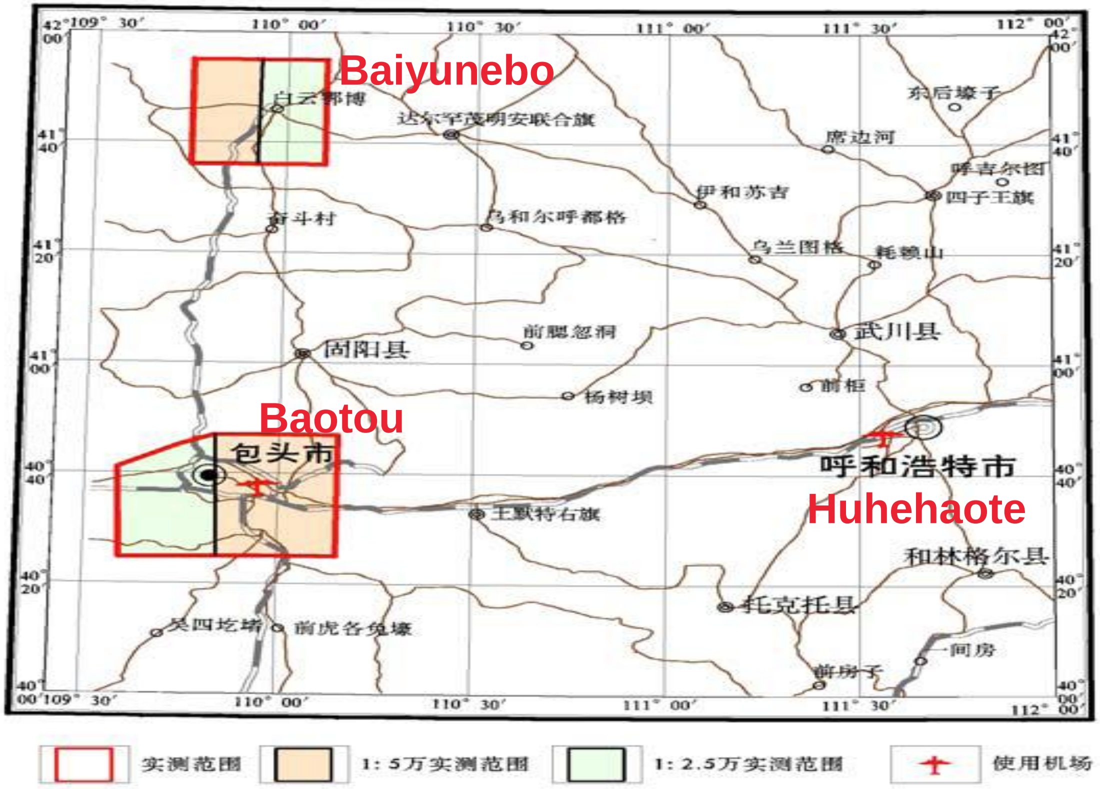
- **Aero survey and ground measurements**
  - ✓ **Work was done during 2006-2009**

- **Other data**
  - ✓ **The Monitoring Data of Baotou Radioactive Environmental Quality in 2006**
  - ✓ **A Study of Radiological Impact on Baotou Area resulting from Exploitation of Baiyan Obo Ores in 1998**

Airborne gamma spectrometry

✓ About 2060km^2 has been flown in 2006.

✓ The follow-up ground measurements to verify the sites with elevated levels of radioactivity



Baiyun:23Km×28Km
Baotou:42.5Km×30 Km

Airborne gamma spectrometry

The AGS system was installed in fixing wings aircraft, with large volume(32L) sodium iodide (NaI(Tl))detector.

GR-820

NaI (Tl) detector

Follow up ground work

In Situ HPGe Gamma Spectrometer

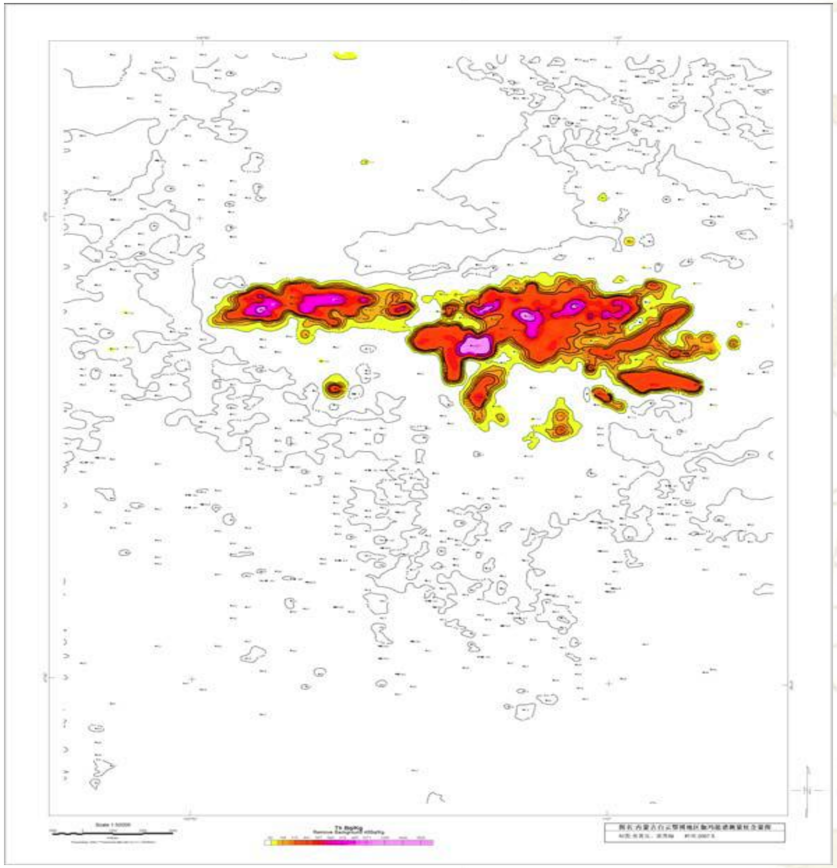
The CGS system was installed in jeep, with large volume(4L) , GR460 , NaI(Tl) detector.

Follow up ground work

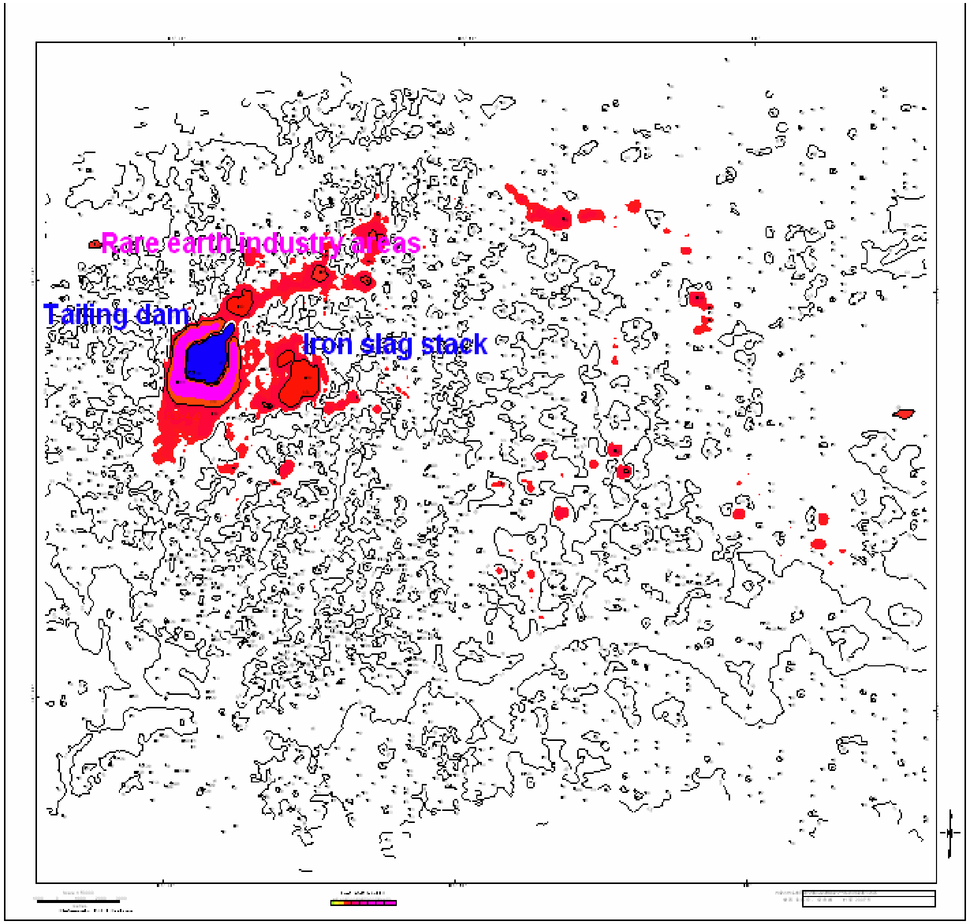
Dose meter

^{222}Rn/ ^{220}Rn and ^{220}Rn progeny
CR-39 detector

Regional Radiological data



Gamma radiation levels in Baiyunebo



Gamma radiation levels in Baotou

3 Exposures and environmental impacts

(1) Baiyun Obo mine

- Background radiation: 85nGy/h
- Higher radiation area: mining areas, about $55Km^2$, typical 200—800nGy/h
  - mining sites, 600 - 2,000nGy/h
- Contaminated soil is in upper layer of 10 cm, activity concentration of Th is 80-120 Bq/kg.

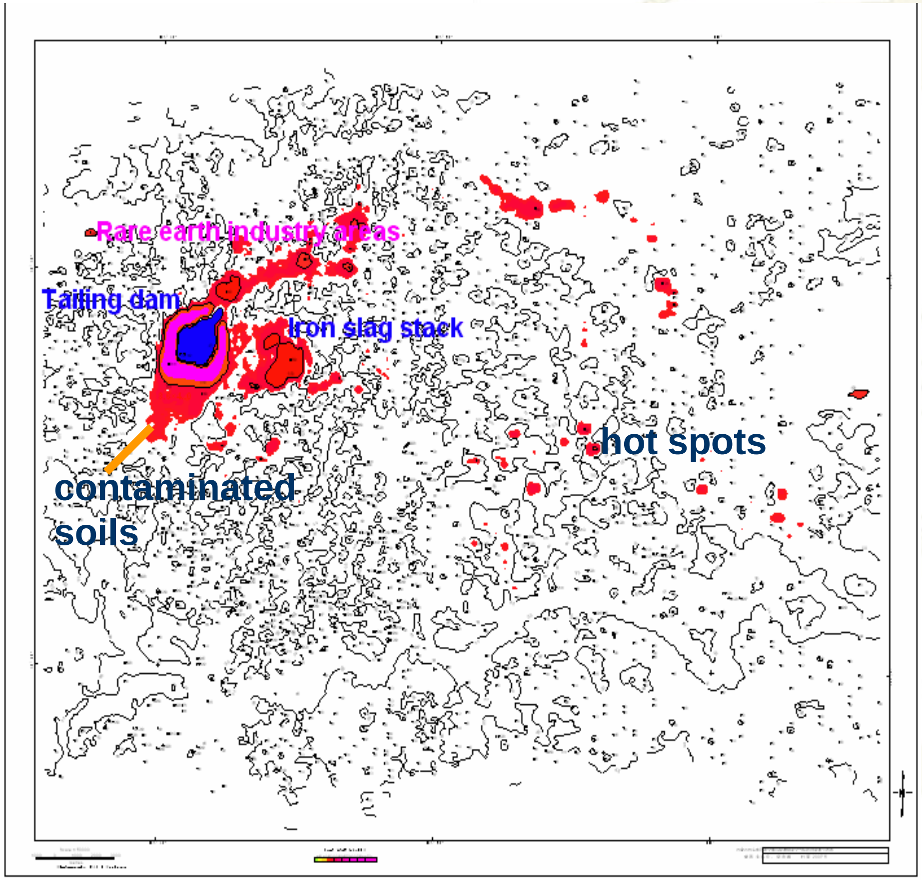
Preliminary dose assessment

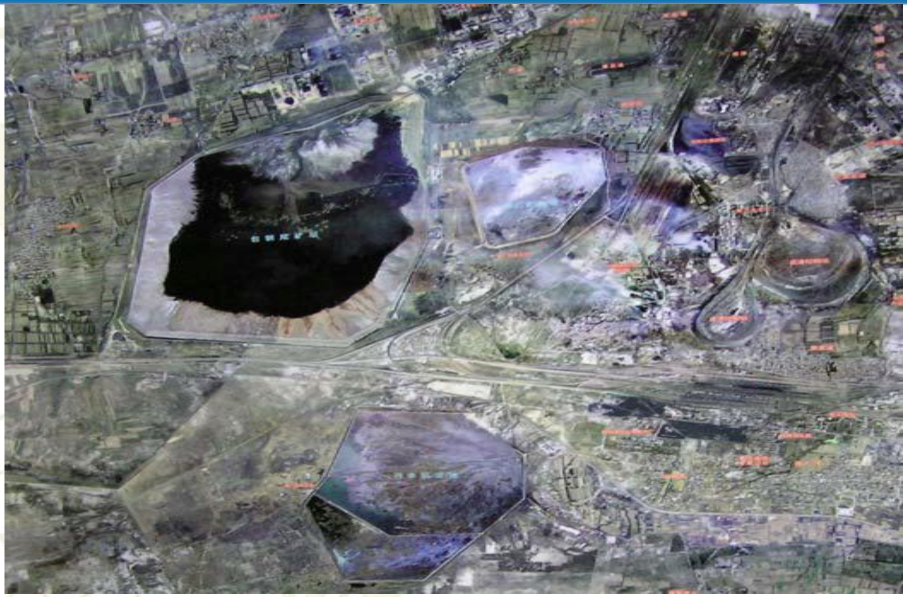
- occupational exposures:
  - external exposures: 0.24 - 1.0 mSv/a
  - internal exposures of ^{220}Rn: 1.84 - 2.38mSv/a
- public exposures:
  - external exposure in local area is 0.044 mSv/a,
  - internal exposure of ^{220}Rn is 1.84 mSv/a

(2) Baotou city area and BTISP plant

- Background radiation: 65nGy/h.
- Higher radiation: BTISP, RE plant, about 7Km^2, typical 500-1,000nGy/h
  - RE plants, 200 - 600nGy/h, with hot spots
  - BTISP slag stock, 600-2000 nGy/h
  - BTISP tailing pond, 650-1,200nGy/h, if no cover by water
  - Contaminated soil is in upper layer of 20cm, activity concentration of Th is 50-350 Bq/kg.

sites with elevated levels of radioactivity





BG: 65nGy/h (50Bq/Kg for Th)
Tailing pond: 650-1200 nGy/ h (11 Km^2)
Ferrous slag dump: 500-1200nGy/ h
The contaminated soil area: 85-150nGy/h
80-200Bq/kg for Th in the upper layer of 10 -20cm.
32 hot spots : 120-1200nGy/h

Preliminary dose assessment

- Occupational exposures:
  - external exposures 0.29 - 0.61 mSv/a
  - internal exposure by ^{220}Rn progeny : 1.05-5.27 mSv/a
- Public exposures
  - external exposure: 0.043mSv/a,
  - internal exposure by ^{220}Rn progeny: 0.02 mSv/a.
  - indoor dose: 1.86 – 2 mSv/a by construction material

Ⅴ Conclusions and discussion

1 NORM radiation is the major additional dose exposure both to the public and occupational workers. NORM radiation has become an urgent problem

2 The regulatory body should draft a list of non-uranium mine for regulatory control, and make related regulations and rules as soon as possible.

3 To adopt grade approach of exemption, notification, authorization, 1 Bq/g as exemption level.

4 To improve management system for NORM waste and to develop NORM waste management rules.

5 The regulatory body should strengthen supervision NORM.

6 Radiation safety training courses should be conducted regularly.

Thank You !