The Situation of NORM in Non-Uranium Mining in China

Liu Hua
Dept. of Nuclear Safety Management, Ministry of Environment Protection, China
(National Nuclear Safety Administration)

October, 2011
I Introduction

II Regulations framework

III NORM situation in non-uranium mining

IV A case study of Baiyun Obo mine

V Conclusions and discussion
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.
• 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.
• 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 γ dose rate on 1 meter distance is over 50 nGy/h of local background level.
Distributions of NORM Industries in China

- Hunan: 9%
- Shanxi: 22%
- Yunnan: 7%
- Sichuan: 10%
- Guangdong: 5%
- Guangxi: 4%
- Chongqing: 6%
- Hubei: 4%
- Hunan: 3%
- Zhejiang: 4%
- Fujian: 3%
- Hainan: 2%
- Jiangxi: 2%
- Others: 10%
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

## Concentrations of Natural Radionuclides

<table>
<thead>
<tr>
<th>Elements/mineral</th>
<th>Uranium, Bq/Kg</th>
<th>$^{226}$Ra (Bq/Kg)</th>
<th>Thorium (Bq/Kg)</th>
<th>External $\gamma$ dose rate (nGy/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rare earths</td>
<td>3972</td>
<td>78000</td>
<td>2529</td>
<td>30200</td>
</tr>
<tr>
<td>Nb/ Ta</td>
<td>4476</td>
<td>21500</td>
<td>18131</td>
<td>57486</td>
</tr>
<tr>
<td>Zircon</td>
<td>1289</td>
<td>6500</td>
<td>3510</td>
<td>13935</td>
</tr>
<tr>
<td>Tin</td>
<td>218</td>
<td>778</td>
<td>540</td>
<td>4276</td>
</tr>
<tr>
<td>lead/zinc</td>
<td>649</td>
<td>34749</td>
<td>465</td>
<td>16274</td>
</tr>
<tr>
<td>Copper</td>
<td>142</td>
<td>1065</td>
<td>163</td>
<td>874</td>
</tr>
<tr>
<td>Iron</td>
<td>270</td>
<td>6978</td>
<td>288</td>
<td>14265</td>
</tr>
<tr>
<td>Phosphate</td>
<td>396</td>
<td>2735</td>
<td>404</td>
<td>2072.5</td>
</tr>
<tr>
<td>Coal</td>
<td>383</td>
<td>167403</td>
<td>212</td>
<td>24021</td>
</tr>
<tr>
<td>Coal gangue</td>
<td>171</td>
<td>1321</td>
<td>118</td>
<td>682</td>
</tr>
<tr>
<td>Aluminum</td>
<td>482</td>
<td>1220</td>
<td>289</td>
<td>798</td>
</tr>
<tr>
<td>Vanadium</td>
<td>1036</td>
<td>12200</td>
<td>908</td>
<td>3980</td>
</tr>
<tr>
<td>Others</td>
<td>503</td>
<td>5029</td>
<td>744</td>
<td>8048</td>
</tr>
<tr>
<td>Elements/mineral</td>
<td>Concentrations of Natural Radionuclides</td>
<td>External γ dose rate (nGy/h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uranium (Bq/Kg)</td>
<td>²²⁶Ra (Bq/Kg)</td>
<td>Thorium (Bq/Kg)</td>
<td>Ave.</td>
</tr>
<tr>
<td>Rare earths</td>
<td>2081</td>
<td>1240</td>
<td>4876.3</td>
<td>3249</td>
</tr>
<tr>
<td>Nb/ Ta</td>
<td>7725</td>
<td>7212</td>
<td>4191</td>
<td>1624</td>
</tr>
<tr>
<td>Zircon</td>
<td>1026</td>
<td>945</td>
<td>327</td>
<td>358</td>
</tr>
<tr>
<td>Tungsten</td>
<td>922</td>
<td>1377</td>
<td>802</td>
<td>601</td>
</tr>
<tr>
<td>Lead/zinc</td>
<td>118</td>
<td>195</td>
<td>137</td>
<td>130</td>
</tr>
<tr>
<td>Copper</td>
<td>142</td>
<td>155</td>
<td>36</td>
<td>153</td>
</tr>
<tr>
<td>Iron</td>
<td>246</td>
<td>247</td>
<td>135</td>
<td>189</td>
</tr>
<tr>
<td>Phosphate</td>
<td>123</td>
<td>191</td>
<td>35.3</td>
<td>144</td>
</tr>
<tr>
<td>Coal</td>
<td>225</td>
<td>326</td>
<td>91</td>
<td>162</td>
</tr>
<tr>
<td>Coal gangue</td>
<td>191</td>
<td>79</td>
<td>92</td>
<td>115</td>
</tr>
<tr>
<td>Aluminum</td>
<td>402</td>
<td>282</td>
<td>349</td>
<td>300</td>
</tr>
<tr>
<td>Vanadium</td>
<td>813</td>
<td>675</td>
<td>73</td>
<td>264</td>
</tr>
<tr>
<td>Others</td>
<td>338</td>
<td>435</td>
<td>119</td>
<td>200</td>
</tr>
</tbody>
</table>
• 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.
• For 232Th

• There are 68 companies, 4.6% of 1433 companies.
  – radioactivity concentration $\geq 1,000$ Bq/Kg
  – annual production of ores and raw materials 0.61 mil-tons, and use raw materials 6.44 mil-ton.
• For $^{226}\text{Ra}$
• There are 123 companies, 8.4% of 1433 companies
  – radioactivity concentration $\geq 1,000$ 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

- $12 \times 10^6$ t/a of ores from Bayan Obo mine
- $9 \times 10^6$ t/a products of iron and steel
- more than $7 \times 10^3$ t/a products of oxide equivalent of REO (2006).
Baiyan Obo mine: about 18Km × 2 - 3Km.
The BTISP and Baotou City

Tailing pond
RE industry
Ferrous slag dump
River Huanghe
BTISP

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
About 2060km² 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.
Follow up ground work

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

In Situ HPGe Gamma Spectrometer
Follow up ground work

Dose meter

$^{222}\text{Rn}/^{220}\text{Rn}$ and $^{220}\text{Rn}$ 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 55Km², 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 - 2.38 mSv/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 7Km², 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 Km²)
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!