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Environmental remediation and radioactivity monitoring of uranium mining legacy in Portugal

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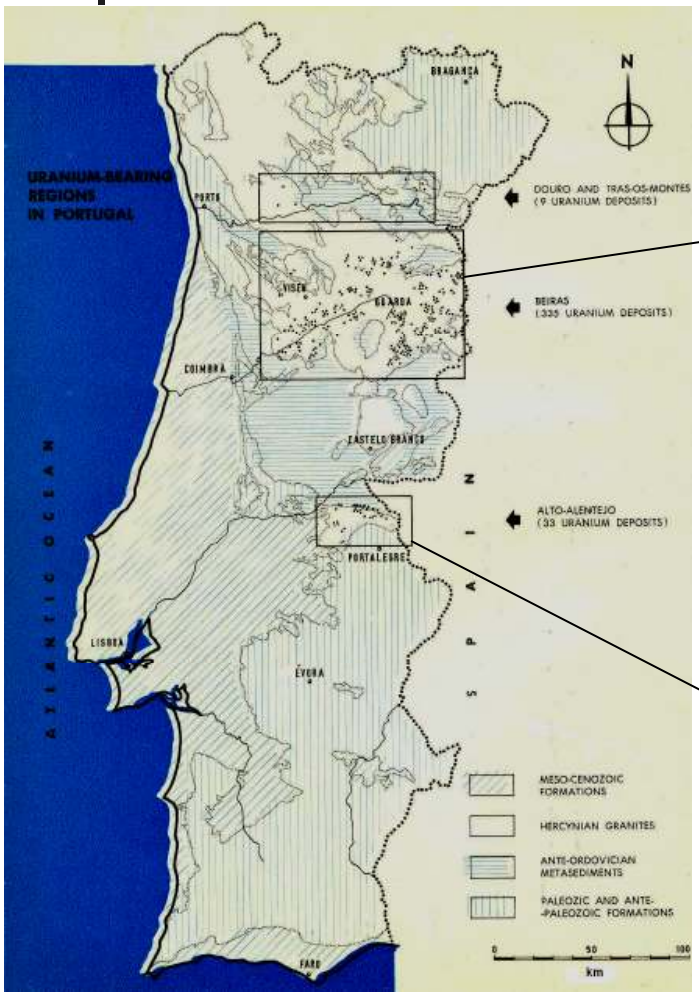
Outline

- Uranium-radium mining
- Waste produced and radiological impact
- Radiological monitoring and surveillance
- Remediation of legacy sites
- Future of uranium mining

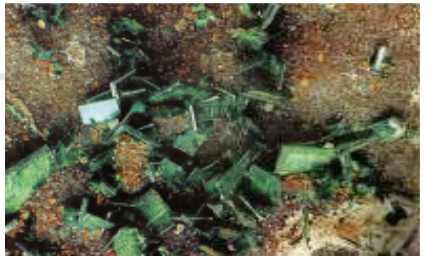
History of radium and uranium mining in Portugal

- 1907 Discovery of first uranium-radium deposit
- 1908 Construction of Radium Salts Factory
- 1944 Begining of uranium production
- 1954 Foundation of Junta de Energia Nuclear (JEN)
- 1977 Extinction of JEN and creation of ENU
- 2001 Close out of facilities. End of ENU
- 2003 Approval of remediation initiative.

Geology and mine areas

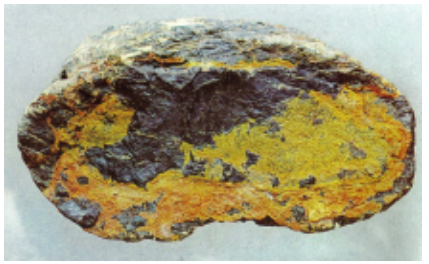


Impregnated schist



Torbernite

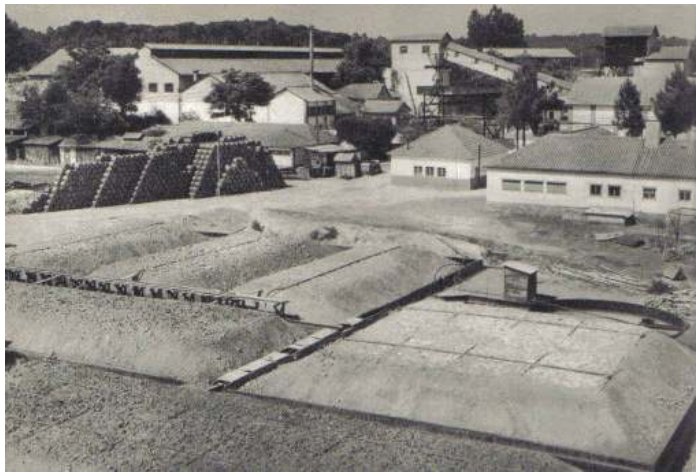
Sabugalite

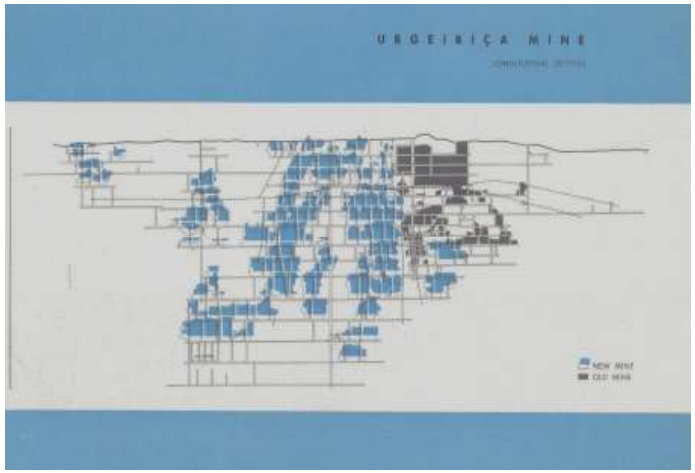


Gummite

Uranium extraction

- The main ore chemical treatment plant near the mine of Urgeiriça. There has been also milling in 4 other sites.
- Uranium ore from small mines was transported to Urgeiriça.
- Heap leaching with H_2SO_4 and *in situ* leaching in mines





Urgeiriça: ore processing

- Mine of Urgeiriça:
  extraction 1913 -1992
- Uranium ore processing facilities closed in 2001
  - Residues containing radioactivity ~ 13 Mton

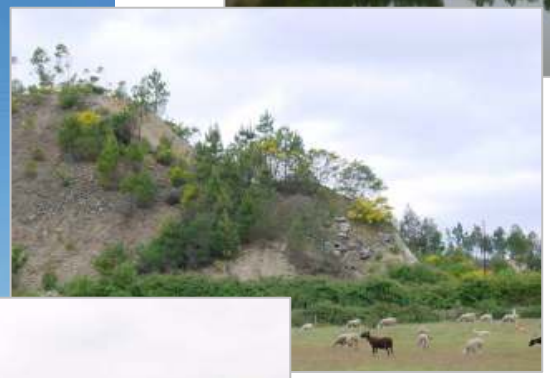
WASTE WATERS:
Acid mine waters and Process waters

- Large volumes
- Low pH (1-3), high sulphate ion conc
- Often treated: neutralized with hydroxide, and ^{226}Ra and U co-precipitated with $BaSO_4$
- Decantation in ponds:
  - overlaying water released into streams or pumped back into the mine
  - Decanted sludge pumped as a slurry into dewatering ponds (evaporation); mud contains high U, Ra, Po, etc.

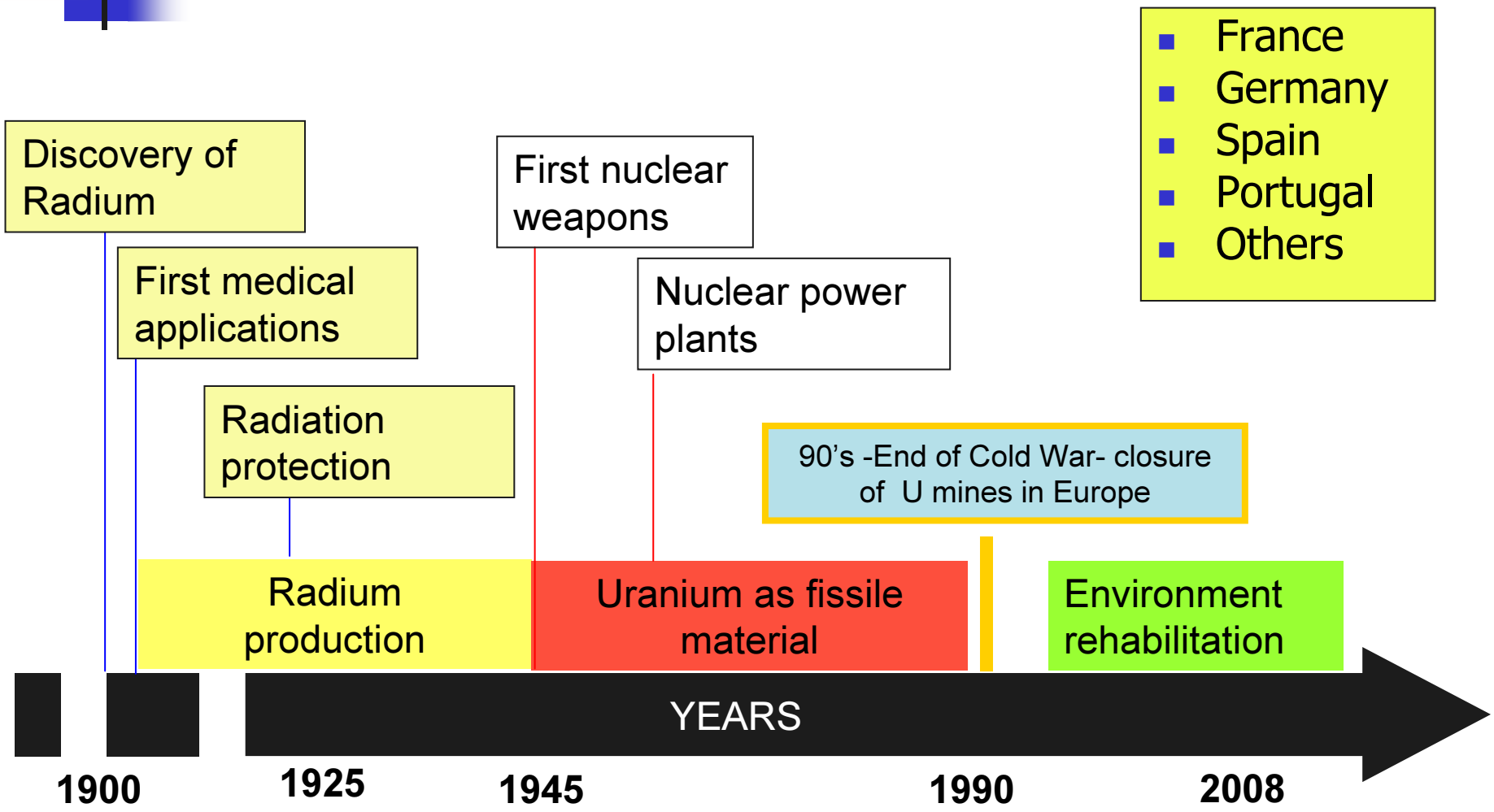
SOLID WASTE: Mill tailings

- Fine sands, high specific activity of ^{226}Ra, ^{230}Th, ^{210}Pb, ^{210}Po,…
- Low concentrations of uranium
- May contain stable metals, eg., As, Y, Bi, Fe, Cu, etc
- and sludge (mud) from water treatment

Uranium mining legacy



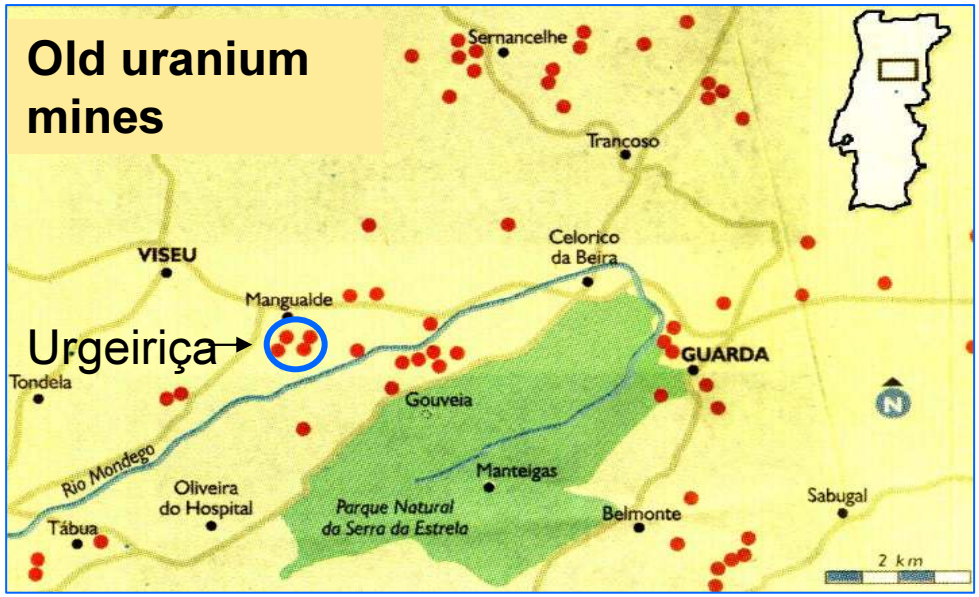
Uranium mining in Europe



Legacy of radium and uranium mining in Portugal

Mineralizations of Uranium in the centre-North of Portugal (province/region of Beiras)

- **400 uranium deposits identified**
- **60 deposits exploited (open pits or underground)**
- **Exploitation of radioactive ores 1908-2001**



Legacy of industry

- About 60 old mining sites
  - -conventional safety issues
    (acid water, subsidence, ventilation wells, stability of tailings,…)
  - - radiological protection issues
  - - toxicological issues (metals in water, risk to public health)
- Solid waste
  - ~ 60 Mtons total
  - ~ 15 Mtons in Urgeiriça (milling tailings)

- Waste piles: uncovered, leaching, dust
- Acid water drainage
- Sludge from acid water neutralization

“MinUrar” Project

- **Assessment of environmental contamination and effects on population health**

Requested by the Government following protests by populations

Recommendations

- To undertake environmental remedial action (site dependent)
- Environmental radiological surveillance of old uranium mining and milling sites

RADIOACTIVITY in soils and mine waste

Bq/kg (dry weight)

	238U	235U	234U	230Th	226Ra	210Po	232Th
Mill Tailings, Mina da Urgeiriça Barragem Velha	2530	118	2880	10340	24720	20350	410
Ore M. Ureiriça. Descarga do minério-	38320	1720	38250	30115	15570	30820	425
Mill Tailings Mina da Cunha Baixa (Mangualde)	2030	90	2280	3600	6700	4700	460
Mill Tailings Mina da Bica (Sabugal)	10700	480	11400	30000	50000	29000	180
SOIL Espinho (Mangualde)	**230**	**10**	**236**	**301**	**619**	**287**	**226**

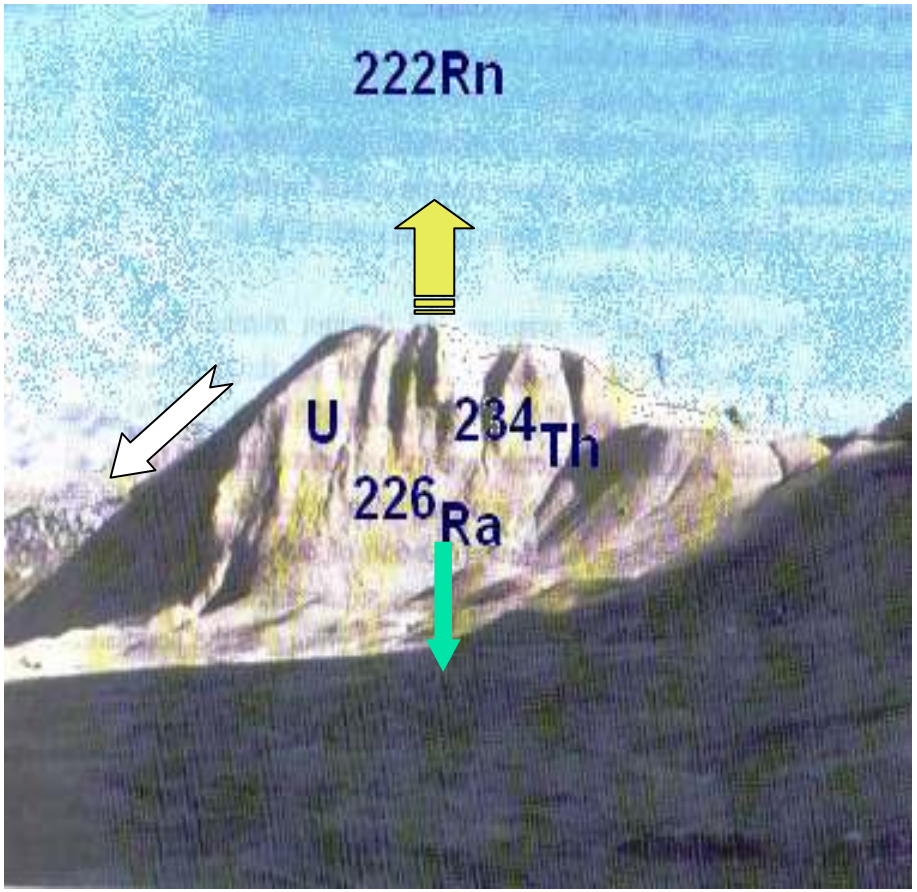
Ambient dose rate

Dose equivalent, mSv per year

	Counties	Dose
GE	**Canas Senhorim** county (outside mining area)	**2.4**
	Mill tailings Barragem Velha	**8.8**
	Sludge Barragem Nova	**3.2**
	Low grade ore Escomb Sta Barbara	**16.2**
	Low grade ore Descarga minério	**32.0**
	Shaft area Zona do Poço nº 5	**4.5**
GN 1	Old mine area Moreira de Rei	**2.2**
	Old mine area Rio de Mel	**2.3**
GN 2	Reference Sátão	**1.2**

REMEDIATION: cover the tailings

- Prevent radon exhalation
- Prevent erosion and environmental dispersion of dust materials
- Prevent removal and use of materials (in building construction, roads, etc.)
- Reduction of external radiation dose



Tailings shall be confined and materials isolated from biosphere

Aims of radiological monitoring

- To demonstrate compliance with regulations, i.e., that environmental, radiological, or chemical contamination is not exceeding limits/standards
- To ensure that the critical groups of population are not exposed to enhanced radiation dose from this practice (1mSv/y)
- To provide information on safety to the authorities and to the public

Terrestrial ecosystems monitoring

- ✓Ambient gamma dose rate
- ✓*In situ* gamma spectrometry
- ✓Sampling soils, vegetables (cabbage, potatoes, milk,…) for analysis

Aquatic ecosystems monitoring

✓Water parameters Measurement

✓In situ filtration of water samples for radiochemical analyses

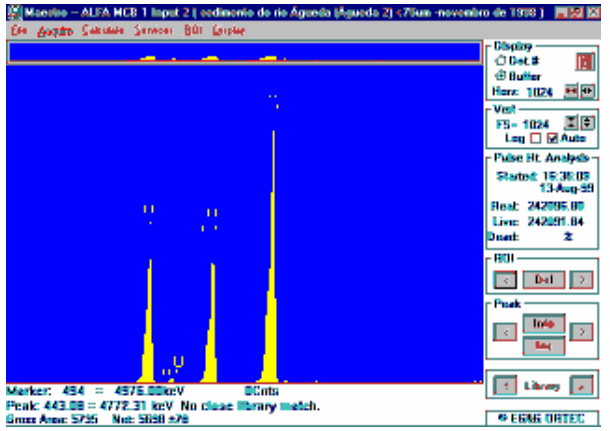
✓Collection of biota samples for analysis

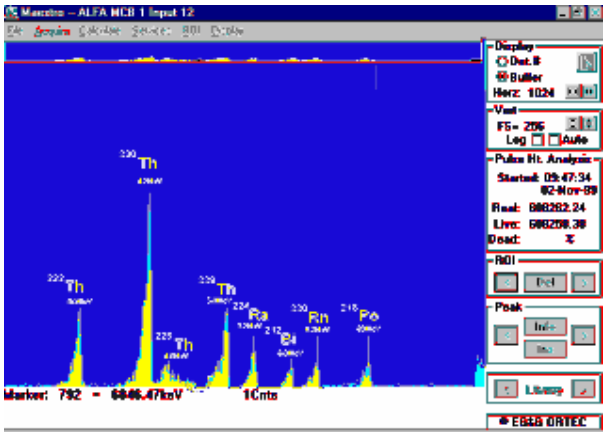
Atmospheric monitoring

- Measurement of atmospheric radon (outdoors and indoors)
- Sampling aerosol particulates for radioelement analysis

Radionuclide analysis

- Alpha spectrometry
- Gamma spectrometry
- Liquid scintillation
- Alpha-Beta counting
- Analytical Quality Assurance





Dose calculation

- Taking into account
  - External radiation
  - Inhalation
  - Ingestion
- Effective Dose Limit for members of the Public: 1mSv/y

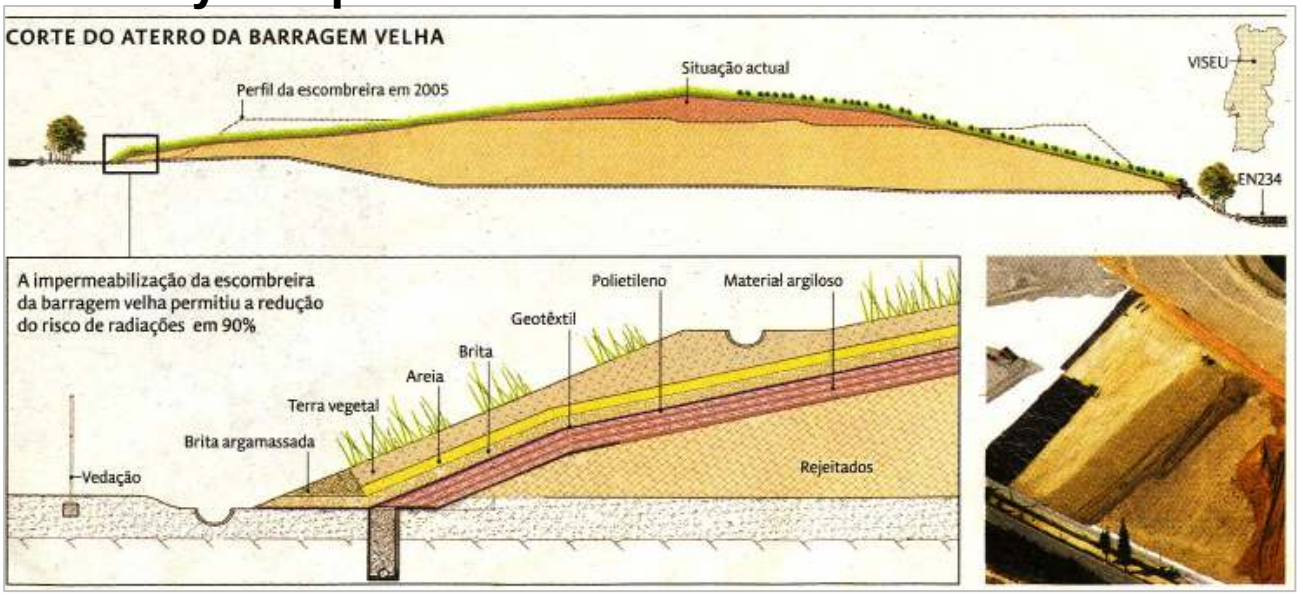
Environmental Remediation

- Approved by the Government
- Implemented by Mining Company Holding - started in 2006
- Goals:
  - Confine the milling tailings
  - Concentrate mining waste in 4 disposal sites
  - treat the acid mine waters

Tailings cover

Aerial view of Urgeiriça (early 2008)

Multi layer cap



Post-remediation maintenance and stewardship

- Continuous water treatment
- Sludge-radioactive material
- Long term stewardship

Lessons from past U mining

- Post mining restoration not planned in advance
- Provision of funds not made
- Finally, environmental remediation is needed and to be performed nearly everywhere
- “Reactive” rehabilitation has been costly.

Life-cycle of an uranium mine

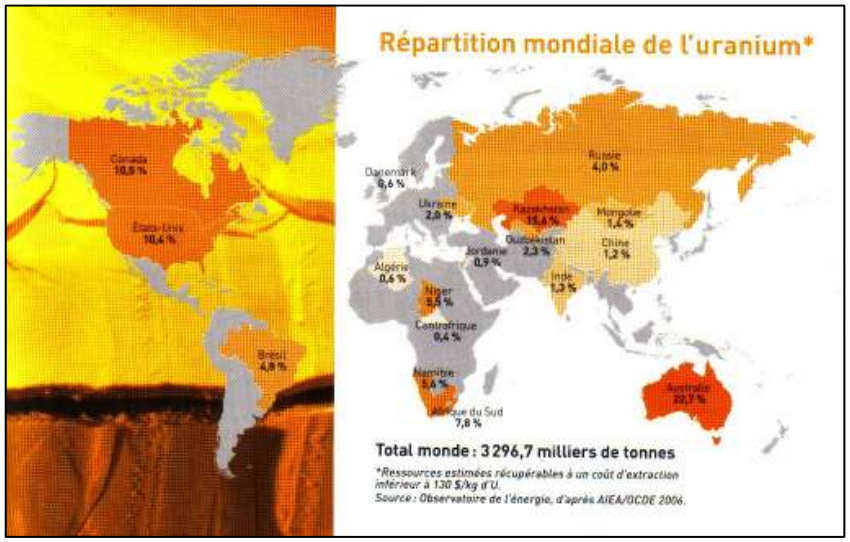
- **Prospection**:
  - identification of ore deposits
  - assessment of deposit value and extraction costs
- **Mining: extraction of the ore**
  - mine operation: underground/open pit
  - transport of the ore
  - ore processing
- **Close out of the mine**
  - safety requirements
  - environmental remediation

Radiological monitoring for radiation protection in uranium mining

- **Baseline survey**:
  - before the mining of radioactive ore
  - reference for post mining remediation
- **Radiological survey during mine operation**:
  - occupational exposure of miners
  - Control of external radiation (radon, etc) and environmental contamination of waters, soils, forest, etc.
- **Post mine closure**:
  - During remediation works
  - Post remediation surveillance

Future of uranium mining

- *Production may increase* in the future; regain of interest in nuclear energy
- Some *small producers may want to come back into U production*
- No future for uranium mining with traditional methods: *a new paradigm is required*



Environmental restoration as part of uranium production

- Public *perception of risks*: past and present
- Regulators: *Mining licenses* and permits
  - Protection of man, non-human biota, natural resources (EIA)
  - Conformity with new ICRP recommendations and dose limits
- «*Social license*» !
  - Trust, acceptable impact, post-extraction rehabilitation
- *Additional costs* that must be incorporated in uranium production costs
  - Environment protection
  - Radiological protection of workers and public (1 mSv/y dose limit)
  - Rehabilitation of sites

Thank you for your attention !

THE END