

The role of EDM in the environmental remediation of old mining areas



Catarina Diamantino
catarina.diamantino@edm.pt

Frederico Martins
frederico.martins@edm.pt



Prometia

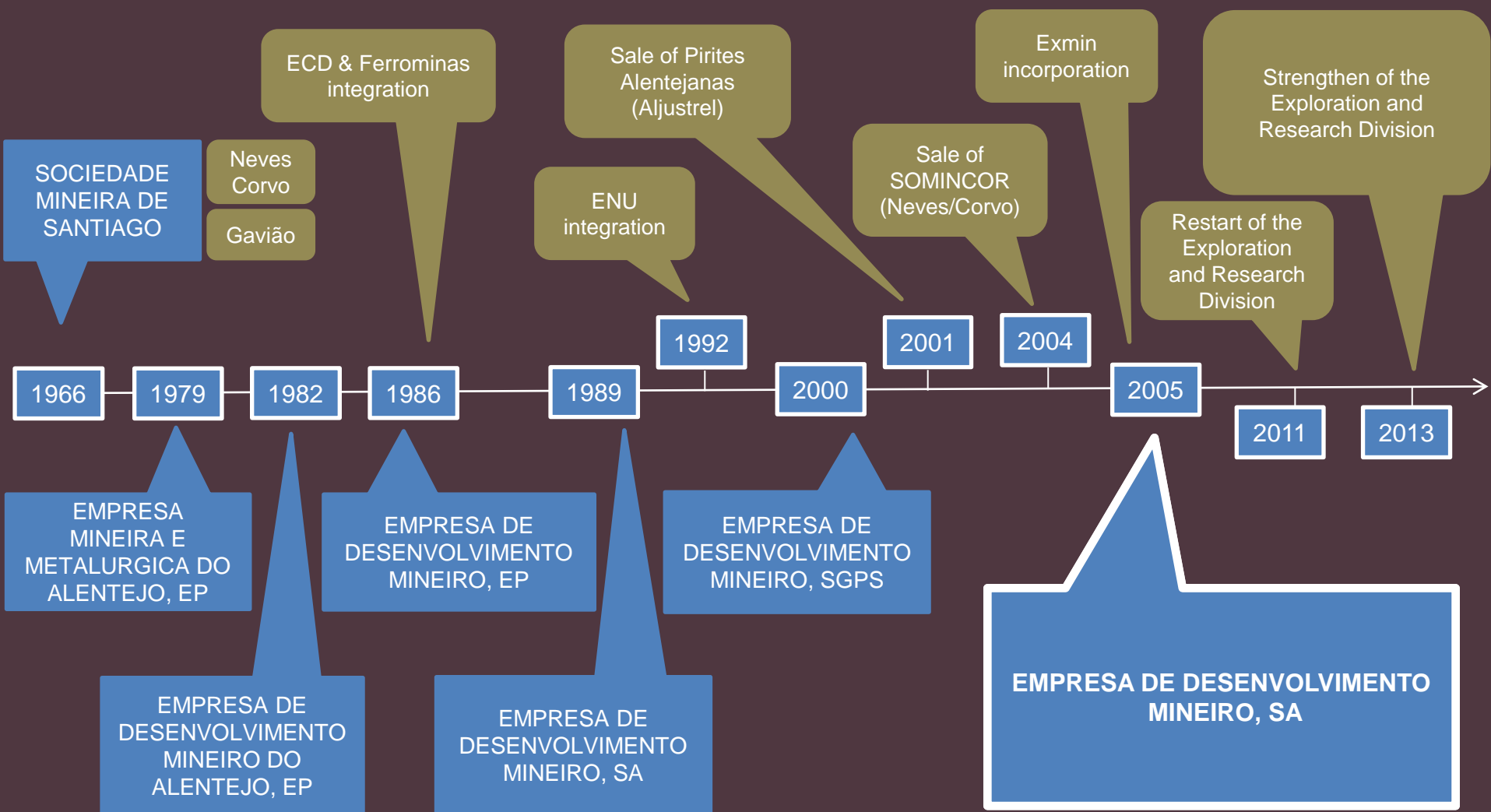
Scientific seminar nov 28-30, 2023



Summary

1. EDM Presentation
2. Mineral resources exploration
3. Environmental remediation of old mines
 - Developed approach, examples of the interventions
4. Challenges in mining remediation
5. R&I Projects
6. Final considerations

EDM - Empresa de Desenvolvimento Mineiro

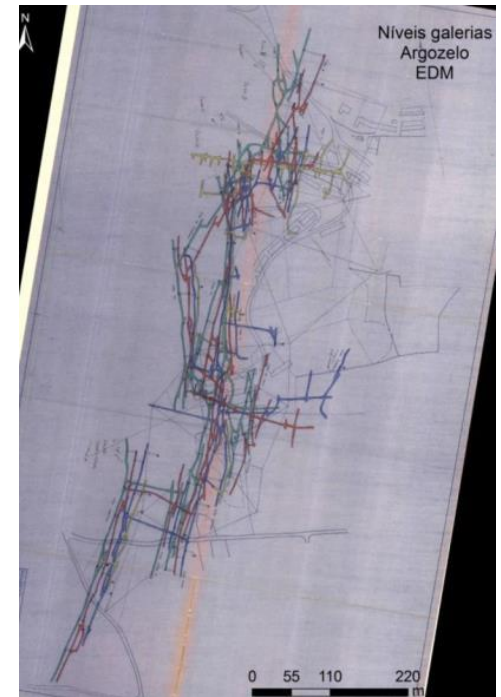
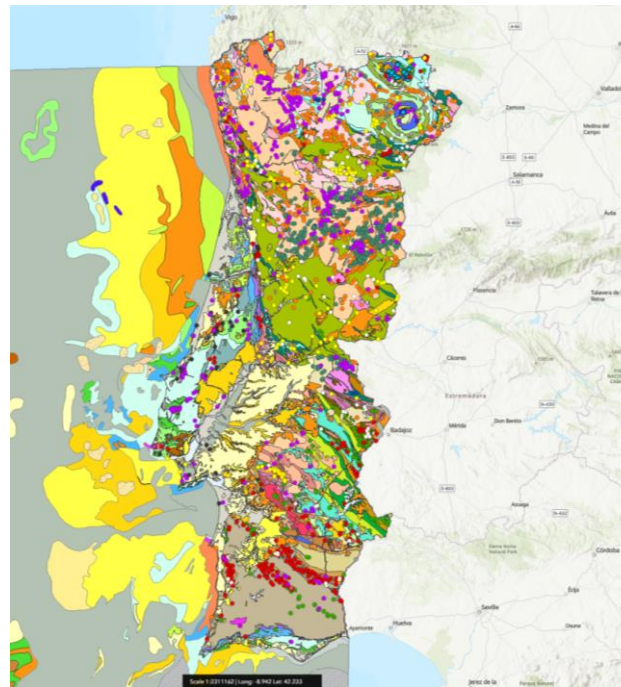
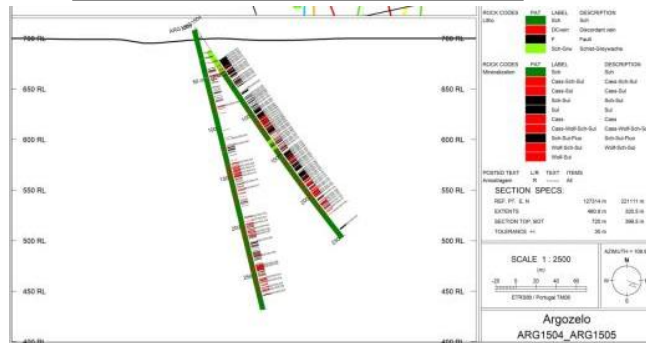
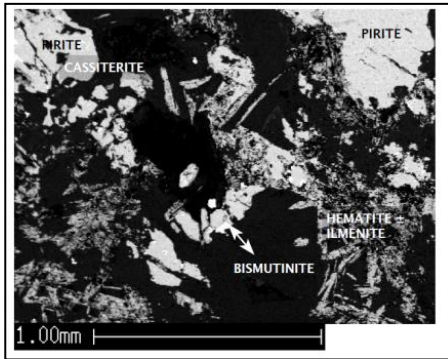


- **Mineral resources exploration**
 - Promote individually, or in joint venture, mineral exploration projects
 - Develop engineering and geosciences studies
 - Participate in national and international cooperation projects
 - Support the Portuguese Government in technical assistance and strategical intervention in geological and mining activities
- **Environmental remediation of old mining areas**
 - Act as a State representative operating under a concession granted by the Portuguese government
 - Responsible for monitoring and contamination assessment of old mining areas
 - Development of environmental remediation projects and works, and post-monitoring and management

Mineral Exploration EDM

Work from the office

Compilation of old geo-mining data, remote sensing, digital database construction, selection of targets, 2D & 3D modelling, petrology (sedimentary, igneous, metamorphic)



Mineral Exploration EDM

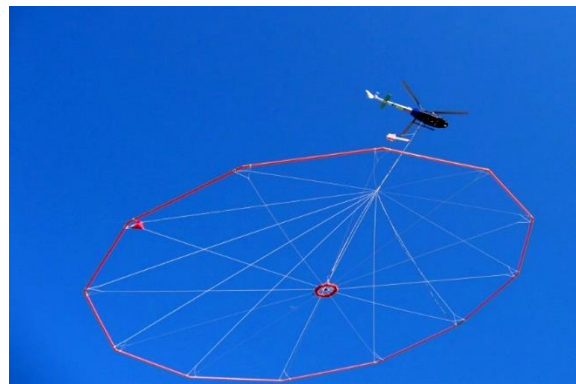
Work outside the office

Geological mapping

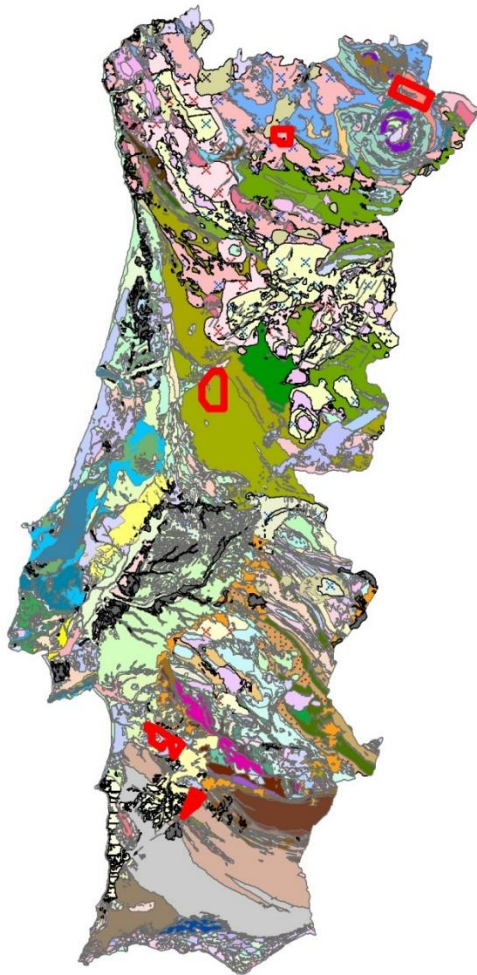
Geophysics

Sampling campaigns (sediments, soils, rocks)

Drillholes, trenches

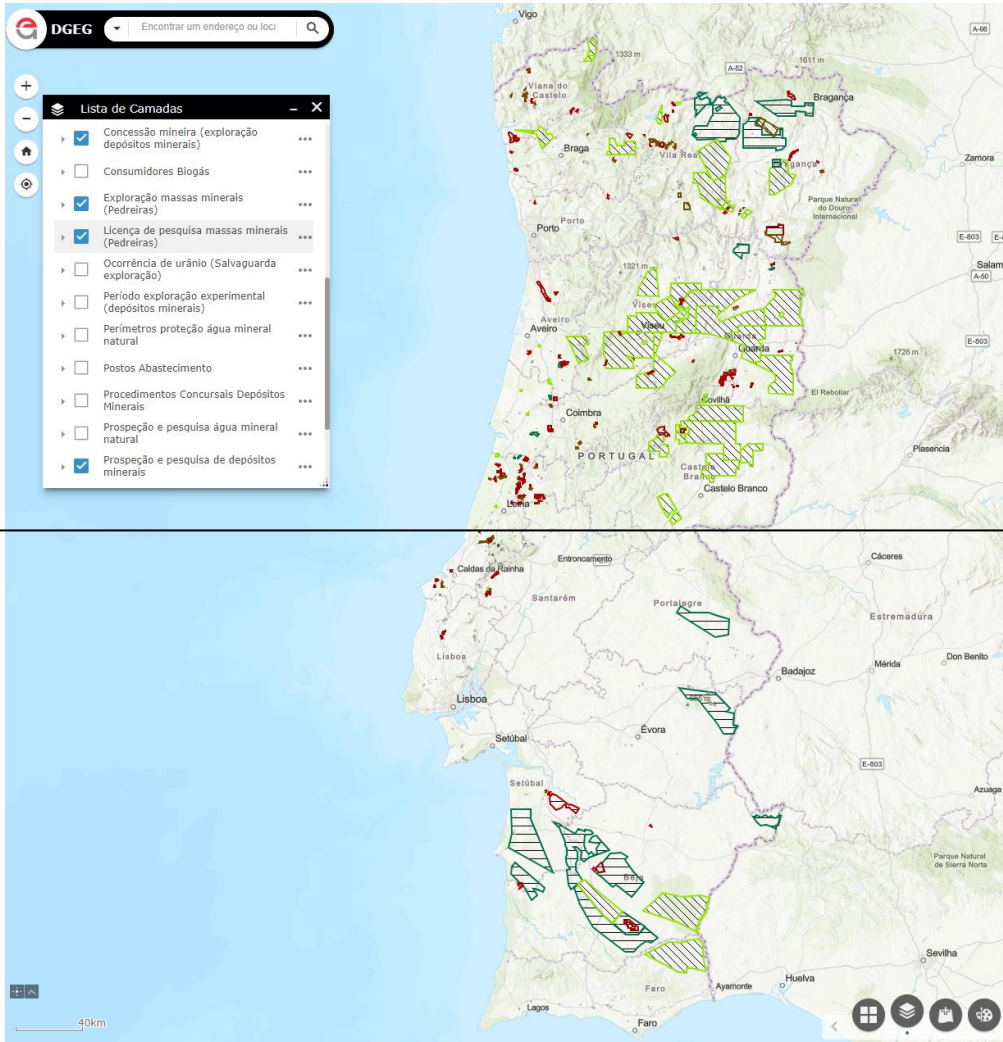


Historical EDM exploration areas



- Argozelo (W, Sn, Au)
- Jales/Gralheira (Au) (ALMADA Mining)
- Escádia Grande (Au, W, Sn)
- Lagoa Salgada (Cu, Zn, Pb) (REDCORP)
- Monte das Mesas (Cu, Zn, Pb)
- Gavião (Cu, Zn, Pb) (ALMINA)
- Semblana (Cu, Zn, Pb) (Lundin Mining)
- S Pedro Cabeças (Cu, Zn, Pb)
- Alcácer (Cu, Zn, Pb)

Current scenario

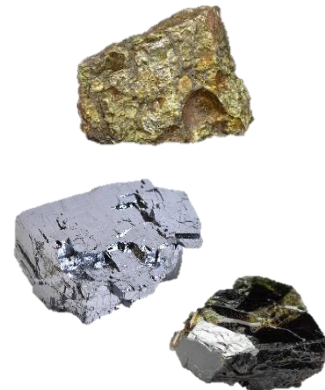


MAJOR METALLIC COMMODITIES

Lithium,
Tungsten, Tin,
Gold, Silver



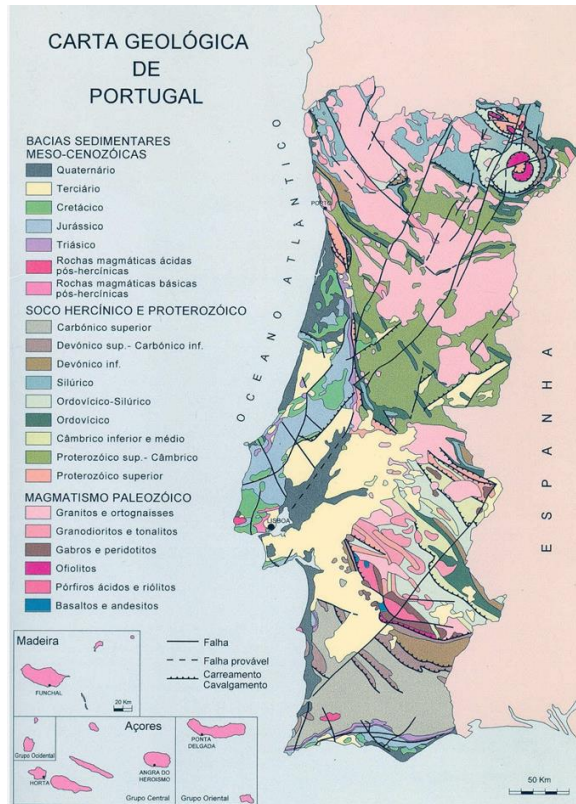
Copper, Zinc,
Lead



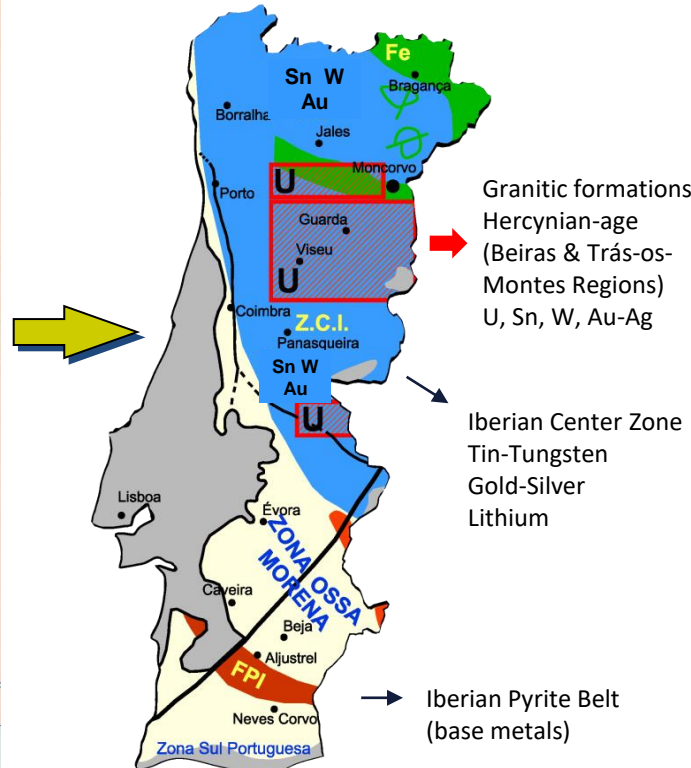
Lithium Public Tender
6 Exploration Areas

Inventory of former mine sites, geological diversity, legacy sites

- High geological, geotectonic and geodynamic diversity, which generate specific conditions for the formation of mineral resources.



Mainland Geology Map of Portugal
1:100.000 LNEG Edition



Metallogenic Portuguese Belts
Abandoned Mine Legacy, DGE & EDM
Edition

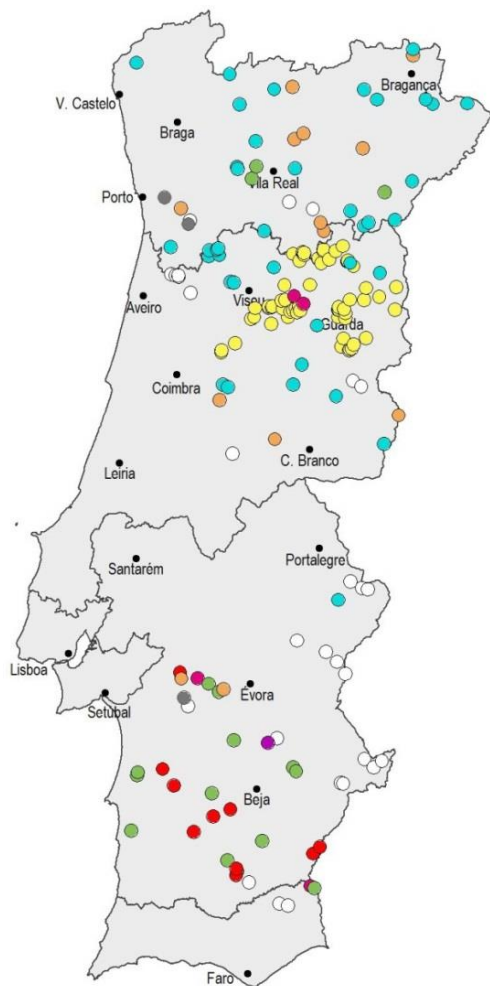


Portugal. NELLAS. Minas de Urânio da Urgeirica.



Inventory of former mine sites

Abandoned Mine Inventory



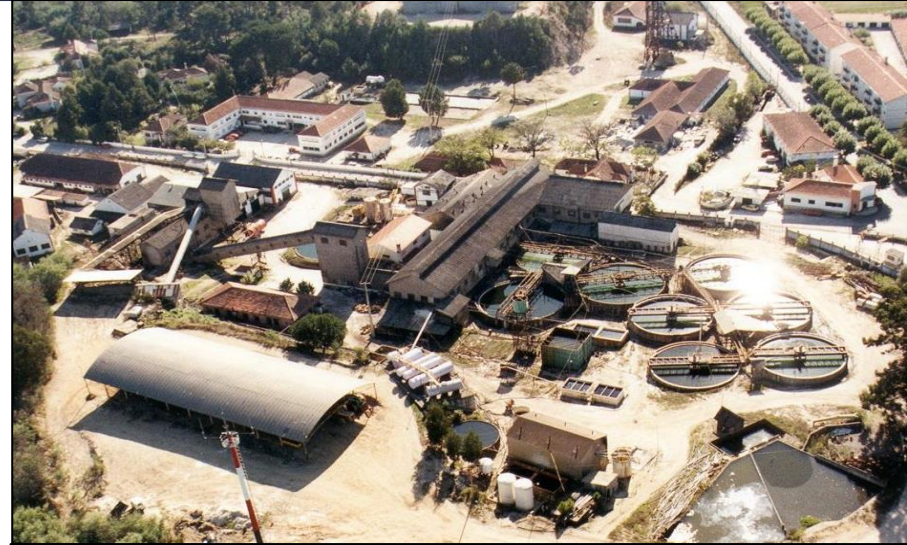
MINERAL TYPE GROUPS	NUMBER OF MINES	MOST RELEVANT OLD MINES
Radioactive minerals	● 62	Urgeiriça, Quinta do Bispo, Cunha Baixa e Bica
Polymetallic Sulphides	● 10	São Domingos, Aljustrel, Lousal e Caveira
Tin and Tungsten	● 40	Argozelo, Covas, Montesinho e Terramonte
Base Metals	○ 28	Terramonte, Coval da Mó e Miguel Vacas
Iron and Manganese	● 16	Orada, Cercal / Rosalgar e Ferragudo
Coal	○ 3	São Pedro da Cova e Pejão
Gold	● 12	Jales, Penedono e Freixeda
Others	● 4	Gouveia de Baixo e Cortes Pereira
Asbestos	● 1	Arado do Castanheiro
TOTAL	175	→ 199

Environmental remediation of mining legacy sites

Starting point in the radioactive mines:

- Uranium exploitation since 1907
- Villages grew around mines
- Existing exposure situations above recommended limits
- Environmental liabilities
- Degraded mining infrastructures
- Complex social situation after mine “closure”
- Social Pressure on “old workers” vindications
- Mistrust about “remediation” process

Urgeirica mine
Chemical treatment plant
Old Tailing dam



Environmental remediation of mining legacy sites

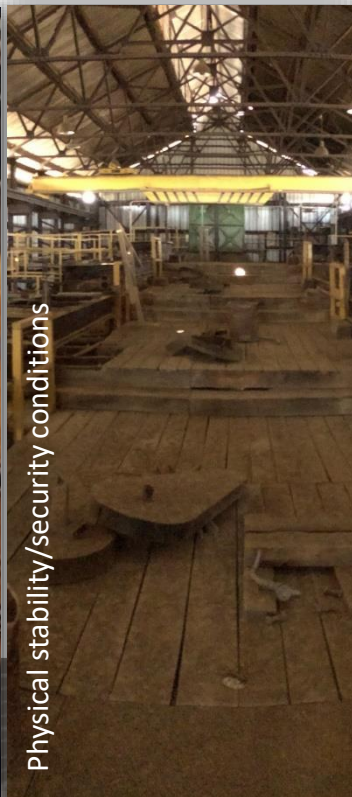
Main environmental impacts:

- Heaps, tailings dams and other mining wastes
- Acid mine drainage and other contaminated effluents
- Contamination of soil and waters
- Physical stability/security risks
- Landscape impacts
- Degradation of industrial heritage

Waste dumps, tailing ponds and heap leaching ponds



Physical stability/security conditions



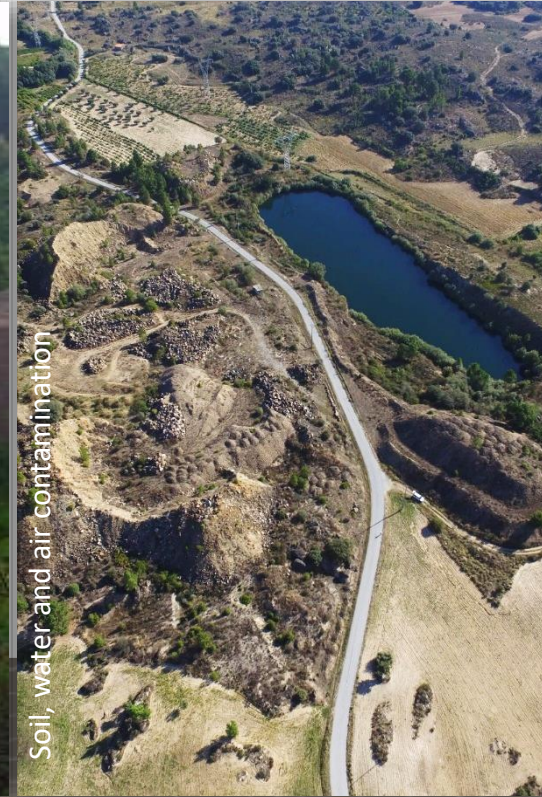
Excavation/exploitation works – open pits



Effluent mine and acid drainage



Soil, water and air contamination



Environmental remediation of mining legacy sites

Since 2001, **EDM - Empresa de Desenvolvimento Mineiro, S.A. (EDM)**

has been granted the responsibility for the environmental remediation of all mining legacy sites in Portugal, including **62 radium and uranium legacy sites**.

Applicable conditions to mine legacy sites:

- a) Abandoned / “orphan” sites
- b) Past mining activities explored not according to current standards (operation ceased until 1990 DL)
- c) Radioactive mines in relation to which the public interest of the State intervention is recognized

“Polluter Pays Principle” is not applicable

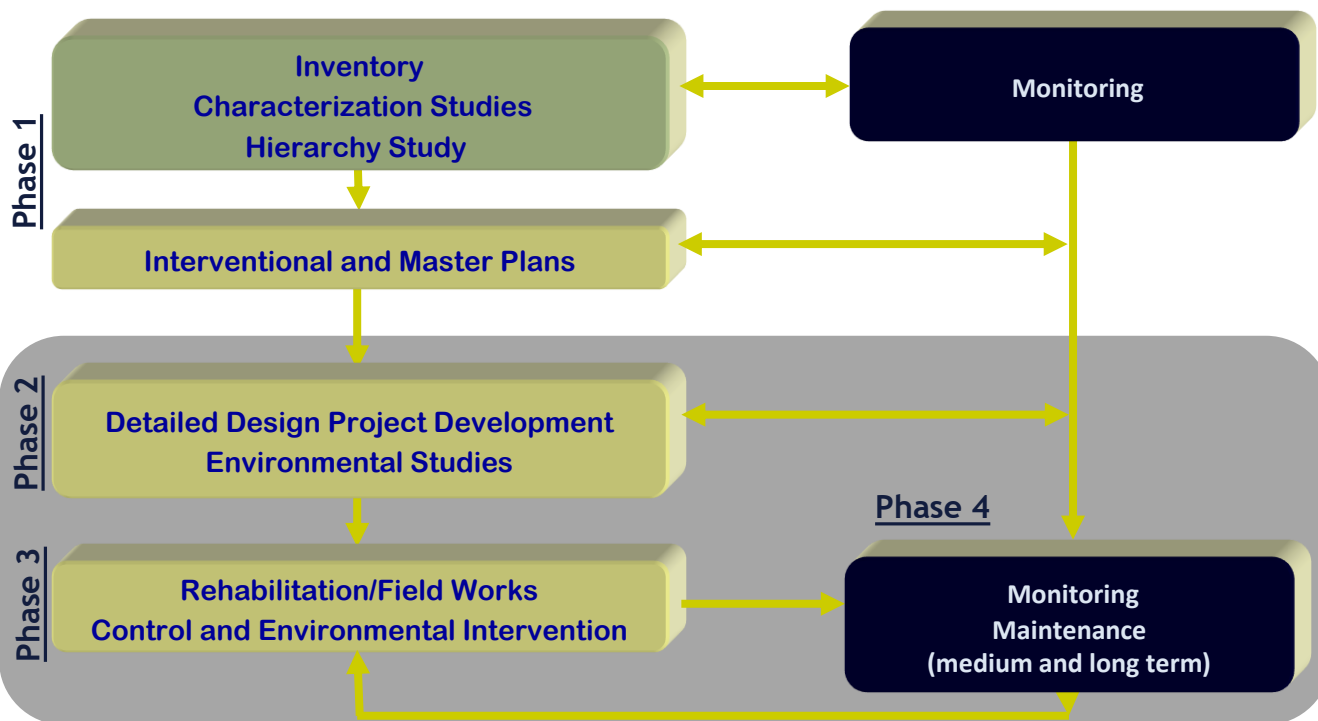
That aims to:

- ☐ Eliminate the risk factors for public health and safety, resulting from water pollution, soil contamination, heaps and any unprotected areas;
- ☐ Rehabilitate the surrounding landscape and natural conditions of development in accordance with the previous habitat;
- ☐ Ensure the preservation of significant heritage of old mines, both economic and archaeological and the valorization of archaeological remains related to mining activity;
- ☐ Provide conditions for future use of reclaimed areas such as agricultural or forestry use, tourist and cultural promotion, or another that promotes the community development.

The concession contract signed on September 5, 2001, was recently renewed for 8 years until **2031**, thus reaffirming, the Portuguese government the interest in the continuation of the Environmental Remediation of Legacy Mining Sites

Portuguese approach

Developed strategy (2001-atual)



Base-Study for the rehabilitation of former mine sites (2001)



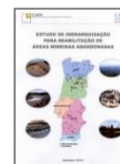
Master Plan for the polymetallic sulphides mines 1st and 2nd Phase (2000-2003)



Master Plan for former radioactive mine sites 1st and 2nd Phase (2000-2003)

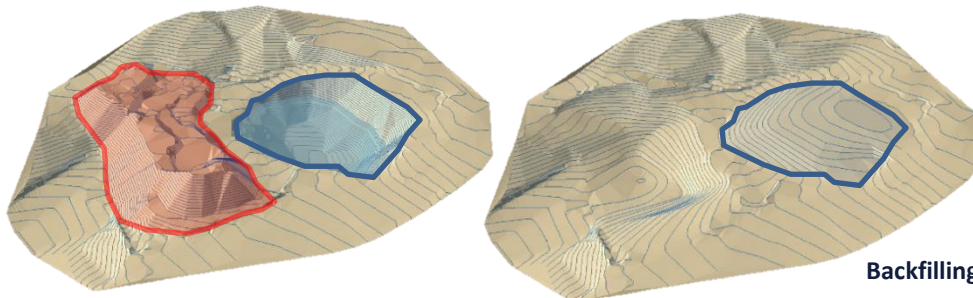


Hierarchy Study for the remediation of abandoned mine sites (2002-2003)

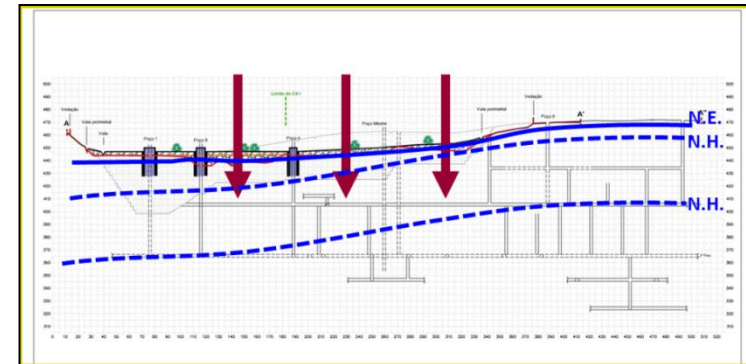
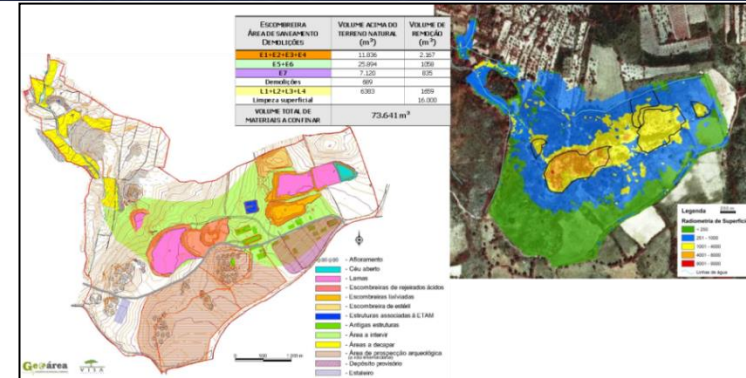


Portuguese approach

- Design of technical solutions
 - Confinement and sealing of **Mining Waste**
 - **Mine water** control and treatment
 - **Soil** decontamination
 - Landscape and **habitat** restoration
 - **Heritage** preservation
- Achieve desired **End-state** according to potential uses
- Ensure **radiological protection**
- **Optimize investment** and long-term operation, maintenance and monitoring costs



Backfilling



Portuguese Status (2001-2023)

After two decades of remediation ...

❑ Results for legacy mine sites (2023)

- 108 mining areas remediated
- 9 mining areas with ongoing works
- 82 planned interventions

Legacy sites	Planning	Implementation	Post-remediation	Total
Radioactive	9	8	45	62
Polymetallic	73	1	63	137
Total	82	9	108	199

❑ Total investment

- Aprox. 127 M€ investment between 2001-2023

❑ Main funding sources

- EU Cohesion Funds / Portuguese mining royalties

❑ Planned investment 2024-2030

- Aprox. 80 M€ investment in remediation projects
- Aprox. 1.5 to 2.0 M€ annually in Post-remediation



Video summary of some interventions

(4min30s)

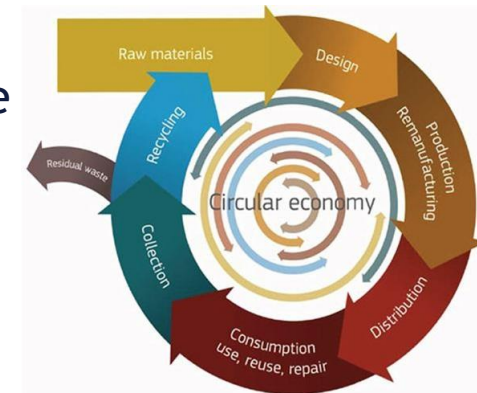
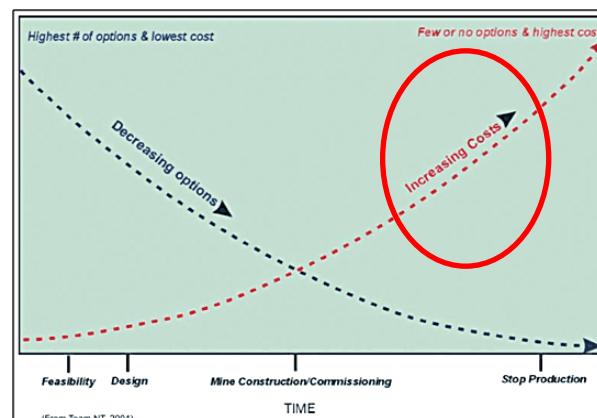


Challenges in mining remediation

New vision/paradigma:

“mining waste not only as an environmental issue, but as a secondary source of mineral raw materials”

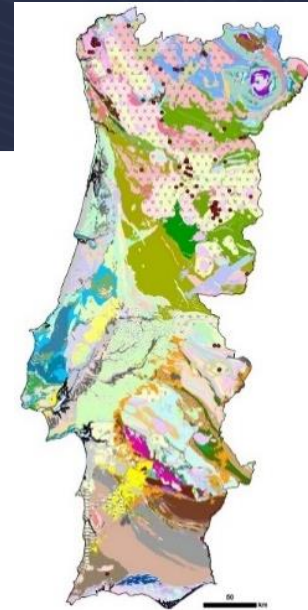
- More efficient use of resources, although with a time delay
- More efficient environmental remediation
- Potential economic profits:
 - Business development / profit generation
 - Partially compensation of remediation, maintenance and monitoring costs



Challenges in mining remediation

More sustainable approach

- General characterization of old mines and wastes:
 - *Available volume? Which minerals? Available grades?*
- Detailed chemical and geochemical characterization:
 - *Volume, internal structure, particle size, petrography, mineralogy, chemistry, microbiological content,...*
- Conventional vs innovative solutions:
 - Type of remediation measures implemented
 - Mobilization/reprocessing waste
 - In situ solutions
 - Remine final closure/remediation
- Viability for remining ...

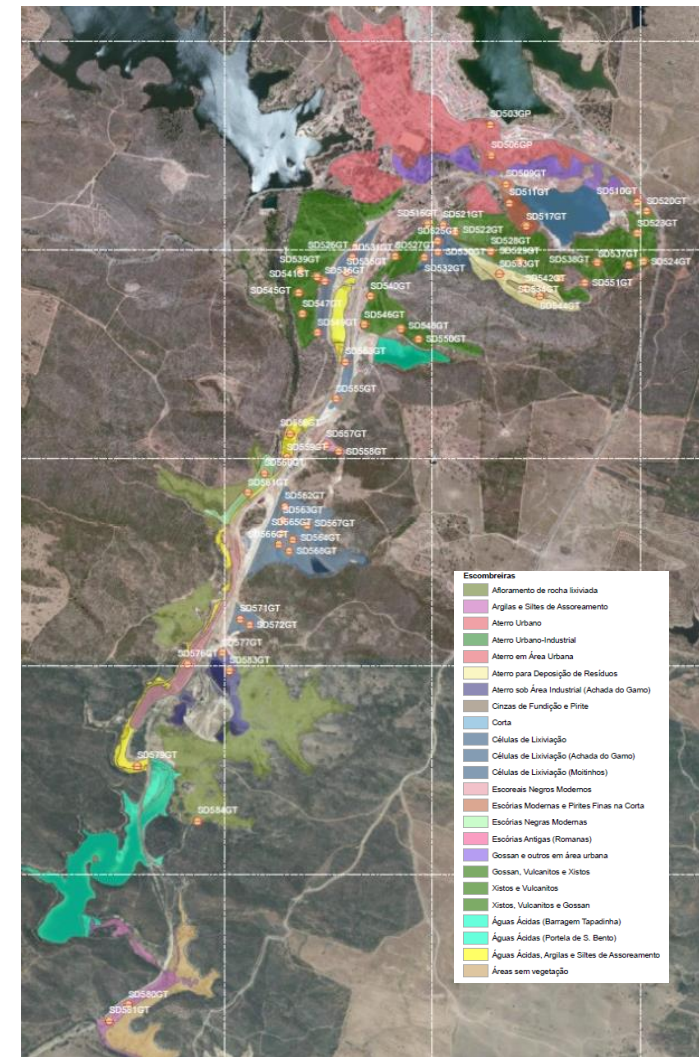


Mining Site	Primary Raw Material	Waste Type	Confined waste	Volume of wastes ('000 m³)
Jales	Au	Tailings	X	> 250
Penedono	Au	Waste rock and Tailings		100 - 150
Aljustrel-Algares	Cu, Pb, Zn	Waste rock and Tailings		> 250
São Domingos	Cu, Pb, Zn	Waste rock; Tailings, slags		> 250
Caveira	Cu, Pb, Zn	Waste rock		200 - 250
Aparis	Cu	Waste rock		50 - 100
Miguel Vacas	Cu	Waste rock		50 - 100
Mostardeira	Cu	Waste rock		50 - 100
Talhadas	Cu, Pb, Ag	Waste rock		50 - 100
Tinoca	Cu	Waste rock	X	50 - 100
Terramonte	Pb, Zn, Ag	Tailings	X	150 - 200
Braçal	Pb	Waste rock and Tailings		50 - 100
Argozelo	Sn, W	Waste rock and Tailings	X	100 - 150
Montesinho	Sn (w)	Waste rock		100 - 150
Bejanca	Sn, W	Waste rock and Tailings		50 - 100
Góis	Sn, W	Waste rock		50 - 100
Ribeira	Sn, W	Waste rock		50 - 100
Murçós	Sn, W	Waste rock and Tailings	X	50 - 100
Borralha	W	Waste rock and Tailings		150 - 200
Covas	W	Waste rock and Tailings	X	100 - 150
Fonte Santa	W	Waste rock	X	50 - 100

Challenges in mining remediation

São Domingos Mine detailed characterization:

- Chemical, geochemical and mineralogical analysis
- 61 core drills / 600 m extension
- 250 composite samples of mine wastes
- *Static Net Acid Generation and Acid Base Accounting test*
- *Humidity cells (ASTM5744-96)*
- *Column Percolation Extraction tests (ASTM E2242)*



R&I Projects - cooperation with Scientific Community

➤ EU Horizon H2020 Program

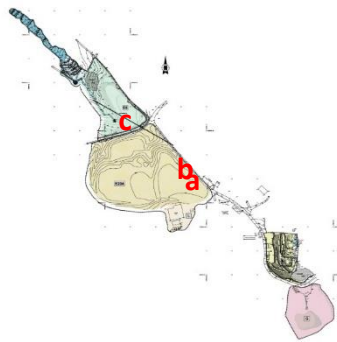
7th Framework Program / ERAMIN (2015-2017)



ENVIREE “Environmentally friendly & efficient methods for extraction of REE from secondary sources”

- Screening process of Portuguese secondary sources of REE
- Characterization of pre-selected sites
- Selection of Covas mining area tailings for pilot tests for W, Ce, La and Nd extraction
- Reports available on website <http://www.enviree.eu/>

enviree



Associações mineralógicas	Perfil A	Au (ppb)	Associações mineralógicas	Perfil B	Au (ppb)	Associações mineralógicas	Perfil C	Au (ppb)
ARG + GOE + SULF	1	110	(instabilidade recente)	1	23	(escorregão superficial)	GOE + MO	1334
GOE			ARG + SULF	2	82	GOE + ARG	2	36
ARG + SULF	2	30	ARG + GOE + SULF			ARG + GOE		
ARG + MO + GOE	3	1128	GOE	3	19			
ARG + GOE + SULF	4	45	ARG + GOE					
ARG + SULF + GOE			ARG + GOE + MO	5	1613			
GOE			ARG + SULF + GOE		421			
ARG + SULF + GOE			ARG + SULF	6	42			



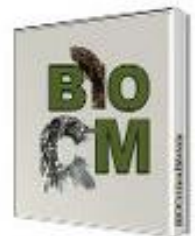
R&I Projects - cooperation with Scientific Community

➤ EU Horizon H2020 Program

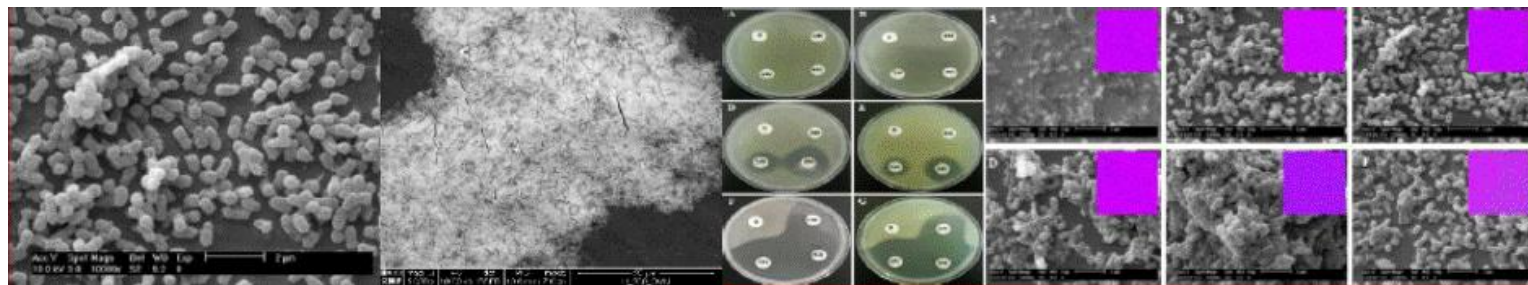
7th Framework Program / ERAMIN (2016-2019)

BIOCRITICAL METALS - Recognition of microbial functional communities and assessment of the mineralizing potential (**bioleaching**) for high-tech critical metals

- Identification and characterization of new microorganisms
- Evaluation in tailings with potential in critical raw materials (In, Ga, Te and W) and pollutants (As, Sb)
- Bio solubilization, biomineralization and bioaccumulation applications



Project total funding: € 549.694
Project total costs: € 573.267
Duration: 36 months (2016-2019)
Website:
<http://www.uc.pt/en/org/biocriticalmetals>



R&I Projects - cooperation with Scientific Community

➤ EU Horizon H2020 Program

UNEXMIN “Autonomous Underwater Explorer for Flooded Mines” (2016 - 2019)

- Use non-invasive methods for autonomous 3D mine mapping for gathering valuable geological, mineralogical and spatial information
- Pilot test in Urgeiriça Mine, Portugal, 2019



*Santa Bárbara mine shaft
Mission in a real underground mine*

<https://www.unexmin.eu/>

Project starting date: 1 February 2016
Duration: 45 months
Budget: EUR 4 862 865
Output: 3 working prototypes



R&I Projects - cooperation with Scientific Community

➤ EU Horizon H2020 Program

PANORAMA “European Training Network on Rare Earth Elements environmental transfer: from rock to human” (2020-2024)

H2020-MSCA-ITN-2019 Call Marie Skłodowska-Curie Actions

ITN Project Innovative Training Networks



<https://itn-panorama-h2020.univ-rennes.fr/>

RAWMINA “Integrated innovative pilot system for Critical Raw Materials recovery from mines wastes in a circular economy context” (2021-2024)



RadoNorm “Towards effective radiation protection based on improved scientific evidence and social considerations - focus on Radon and NORM” (2020-2024)



<https://www.radonorm.eu/>

R&I Projects - cooperation with Scientific Community

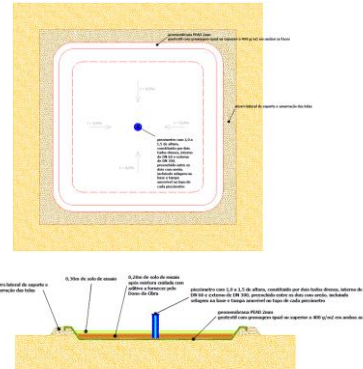


➤ LIFE Program

LifeNoWaste “Management of Biomass Ash and Organic Waste in the Recovery of Degraded Soils: A Pilot Project set in Portugal” (2016-2020)



- Construction of a experimental pilot project or soil recovery in São Domingos Mine



LIFE14 ENV/PT/000369
<http://www.lifenowaste.pt/>



LeaRn4LIFE “Learning Radon: professional qualification and social awareness as a strategy for reducing radon exposure” (2022-2024)

- Implementation of EU Directive 2013/59/EURATOM (Decree Law 108/2018 radiological protection framework)
- Application of best constructive solutions for radon mitigation
- Professional qualification
- Action to reduce exposure to indoor radon and public awareness

Final Considerations

- Better to prevent environmental impacts than to remediate.
- With the conclusion of the *Environmental Remediation of Old Mining Areas Plan*, Portugal will correct environmental liabilities and impacts of centuries of mining activity.
- Strong improvements in safety issues, soil, water and air quality, mining heritage preservation and reclamation of these degraded areas for further uses.
- Mining waste should be seen as **potential secondary sources of mineral resources** considering **circular economy** and **sustainability** in the long term approach.
- Involvement in research projects aiming to develop new forms of remining of remediated areas; application of residues for the remediation are important tasks to be considering for a more sustainable approach.

The background of the entire slide is a photograph showing the silhouettes of industrial structures, including a tall tower and various scaffolding-like frameworks, against a bright sunset sky with scattered clouds. The sun is a large, glowing orb in the center of the horizon.

Taking care of the past, challenging the future.

Rua Sampaio e Pina, nº 1 - 3 Dtº 1070-248 LISBOA
Geral - Tel: (+351) 213 859 121 - Fax (+351) 213 856 344
E-mail: edm.mineira@edm.pt
www.edm.pt

