



REMIX

Interreg Europe



European Union
European Regional
Development Fund

The Mineral Potential in Centro Region of Portugal: Geology, Industry and Challenges



FACULDADE DE
CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

José A. Almeida
José C. Kullberg
Frederico Martins
Vanda Lopes
Alexandra Ribeiro

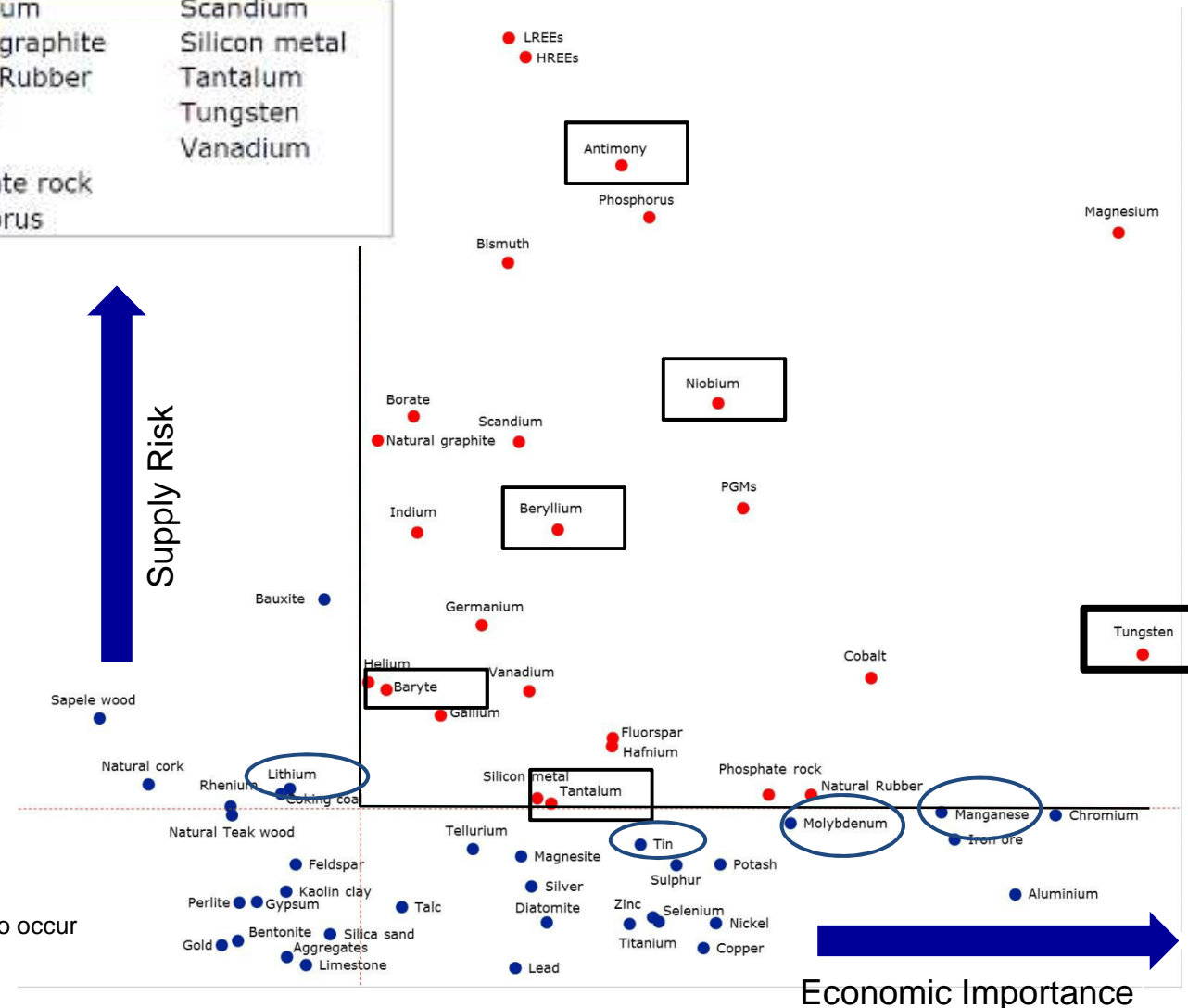


8th Peer Review, Fundão, Portugal, Dec. 11th, 2018

Critical Raw Materials (EU) 2017

2017 Critical Raw Materials (26)			
Antimony	Gallium	Magnesium	Scandium
Baryte	Germanium	Natural graphite	Silicon metal
Beryllium	Hafnium	Natural Rubber	Tantalum
Bismuth	Helium	Niobium	Tungsten
Borate	HREEs	PGMs	Vanadium
Cobalt	Indium	Phosphate rock	
Fluorspar	LREEs	Phosphorus	

Risk in:
Sn (Tin)
Li (Lithium)
 Mn (Manganese)
 Mo (Molybdenum)



Legend:

- Critical raw materials
- Non-critical raw materials

(The highlighted raw materials are known to occur in the Centro region of Portugal)

Critical Raw Materials

Industries



Defence



Automotive



Metals



Medical Devices

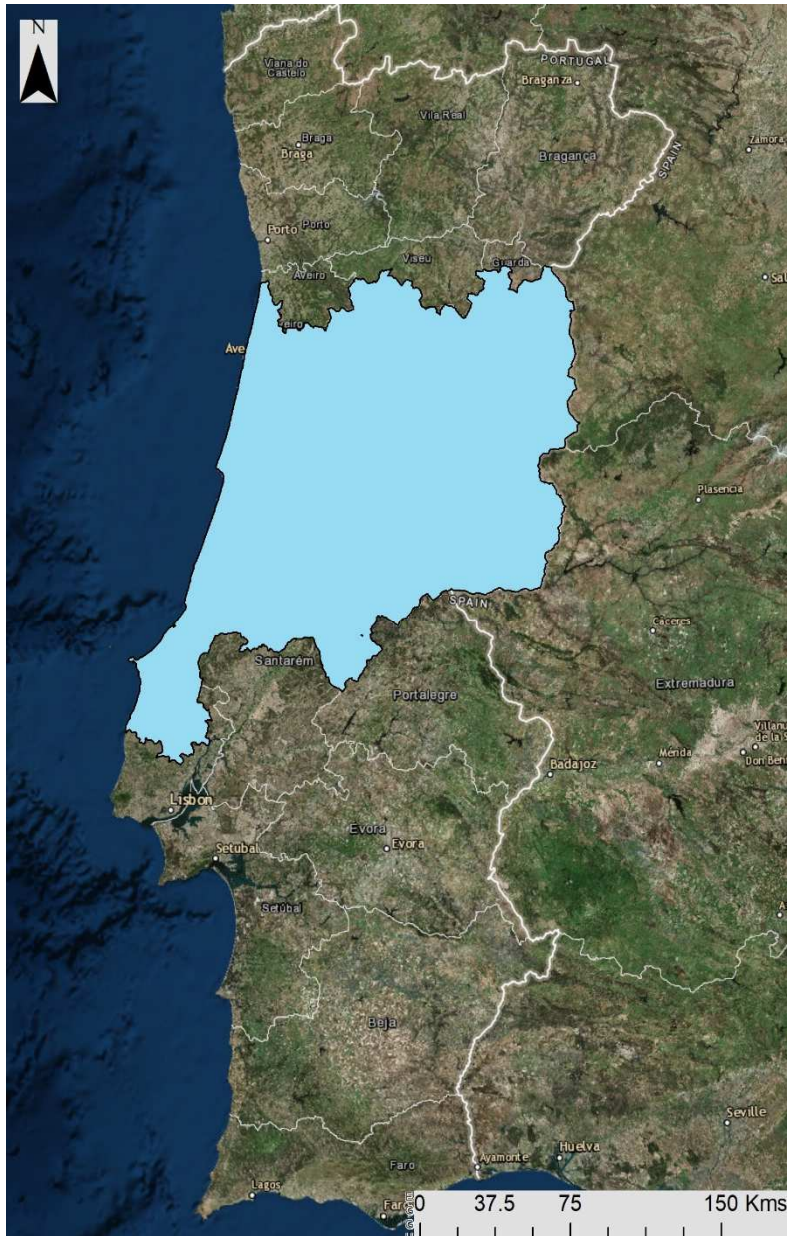


Consumer Electronics



Green Technology

Portugal Centro region

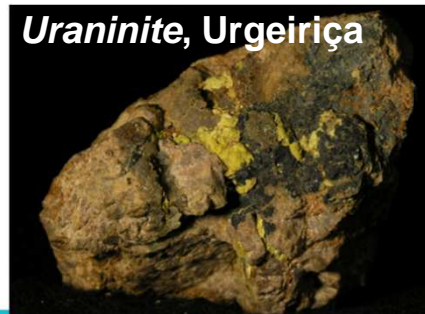


Wolframite and cassiterite, Panasqueira

Mineral Resources Abundance:

- Metallic (Tungsten, Lithium, Tin)
- Energetic (Uranium)
- Non-Metallic (Quartz, Feldspar, Kaolin)
- Ornamental Rocks (Granite, Limestone)

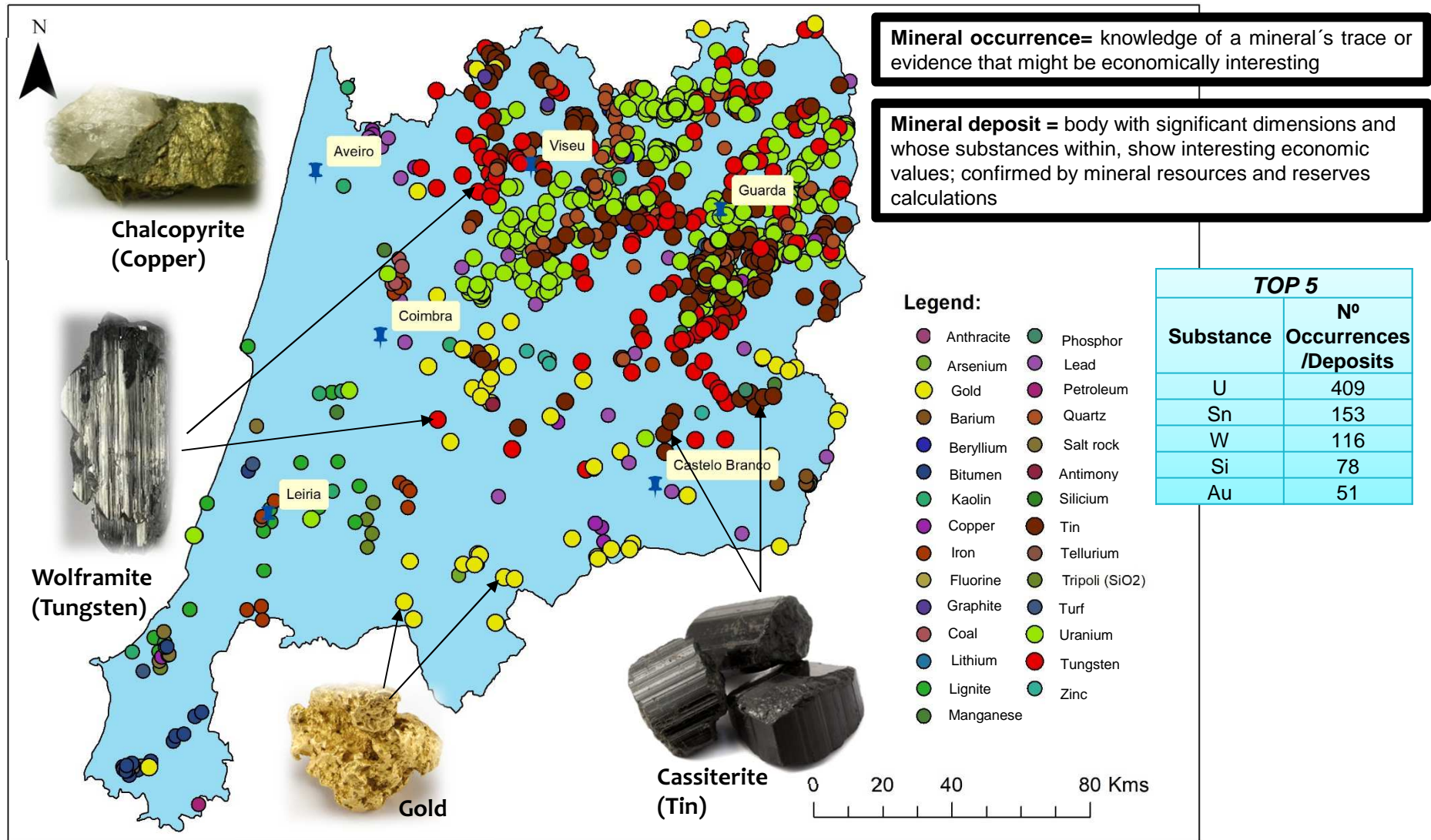
Uraninite, Urgeiriça



Lepidolite, Guarda

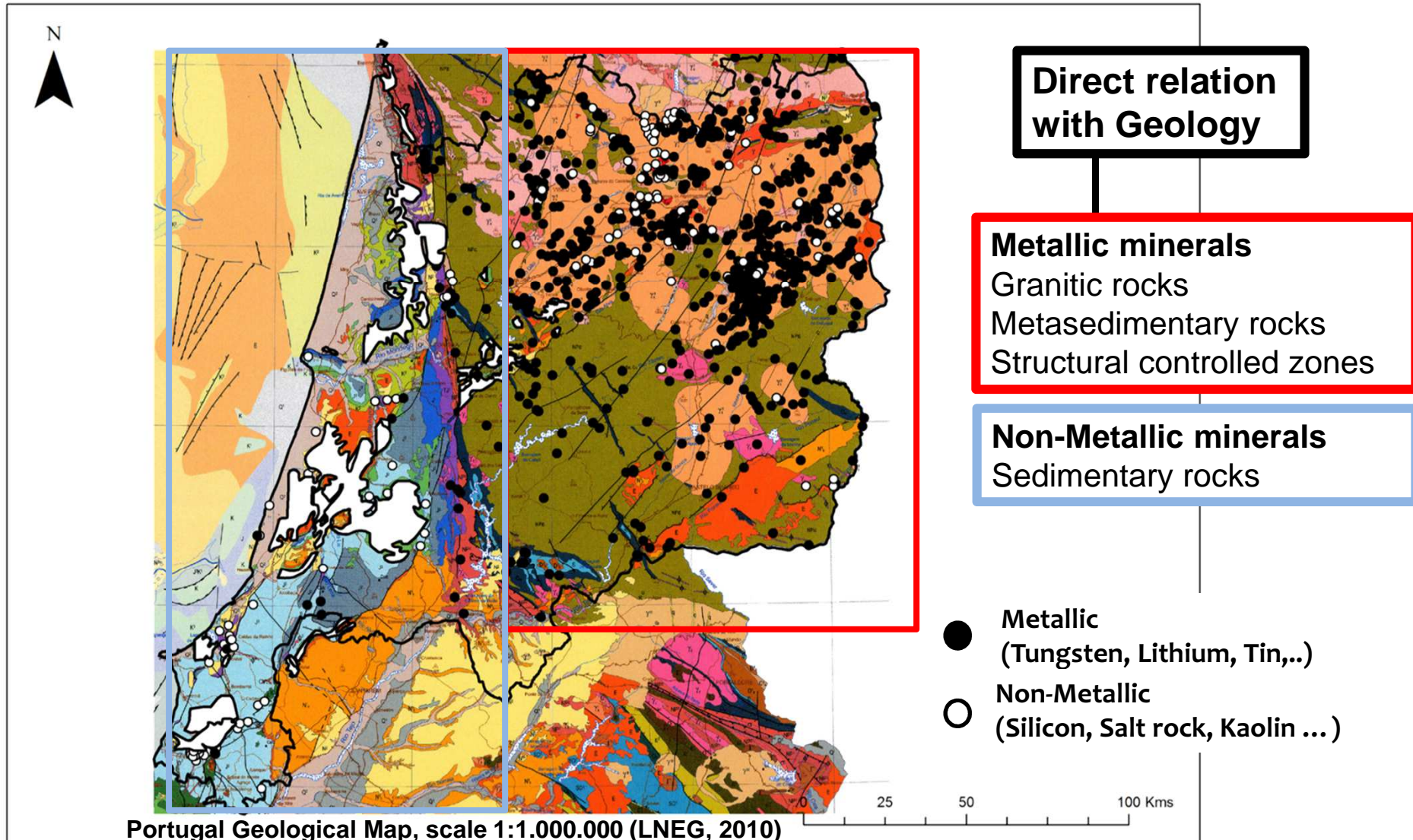


Mineral occurrences and deposits

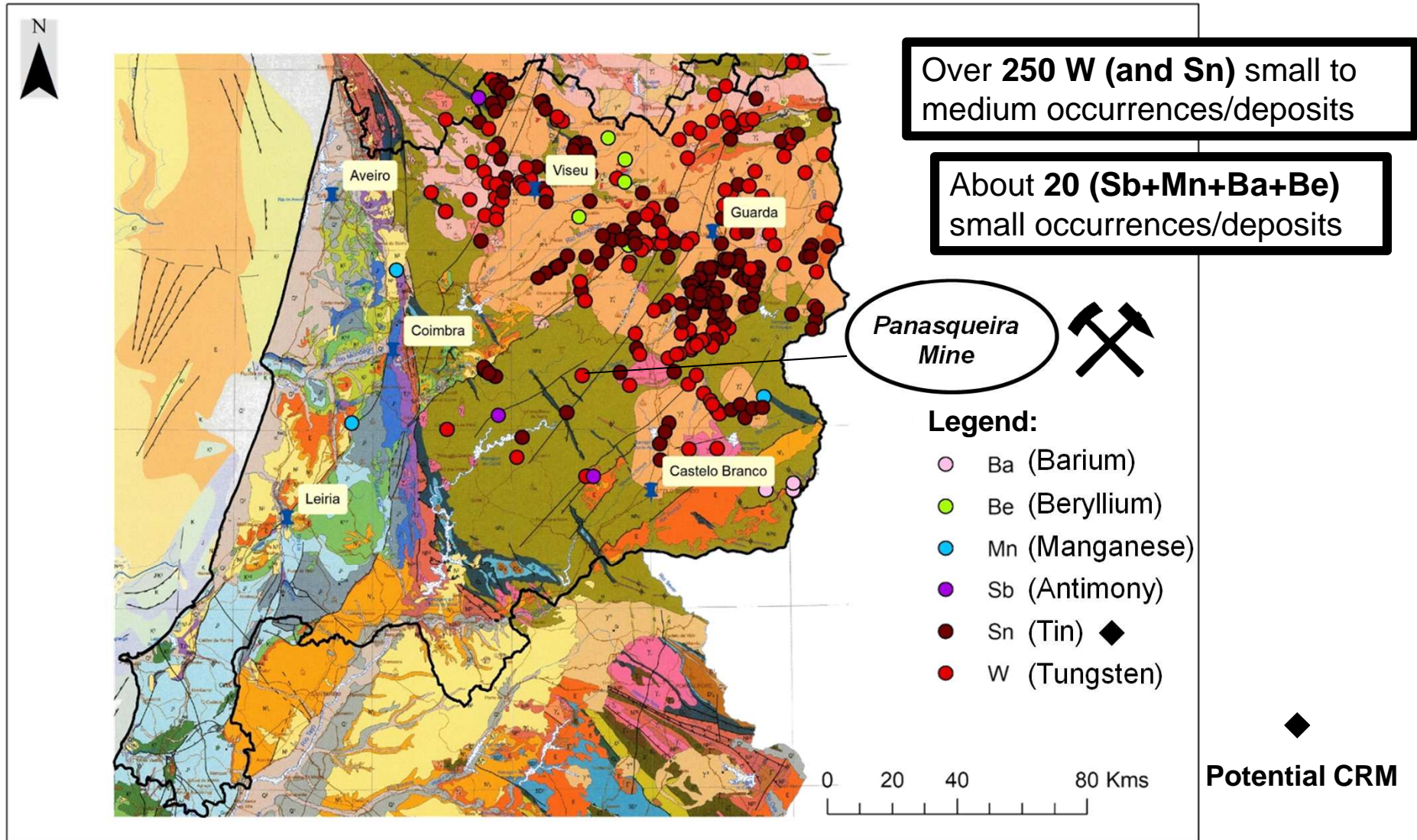


Metallic and non-metallic minerals

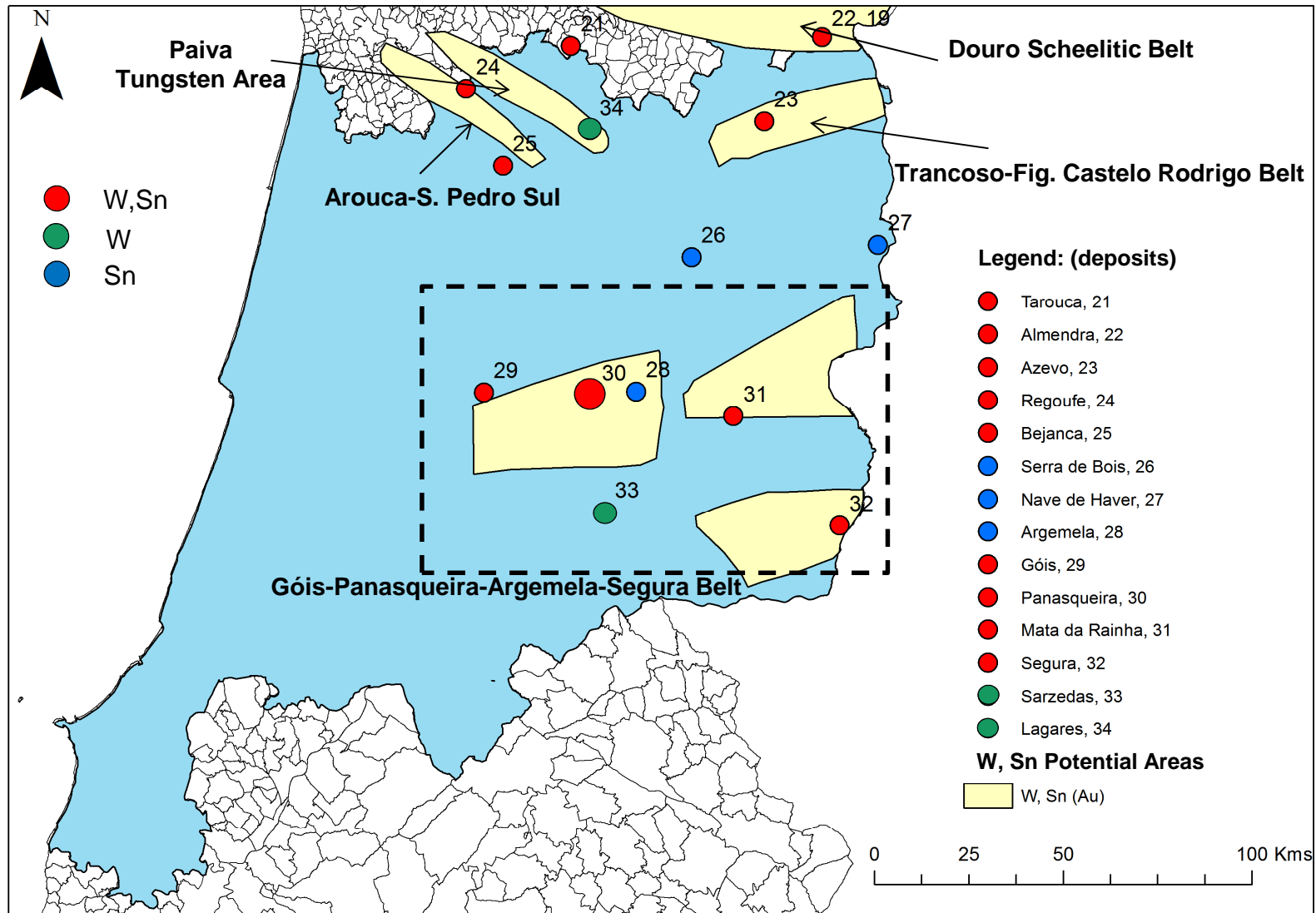
Occurrences/deposits



Critical Raw Materials (CRM) in Centro Region



Tungsten (W) and Tin (Sn)



Tungsten (W) and Tin (Sn)



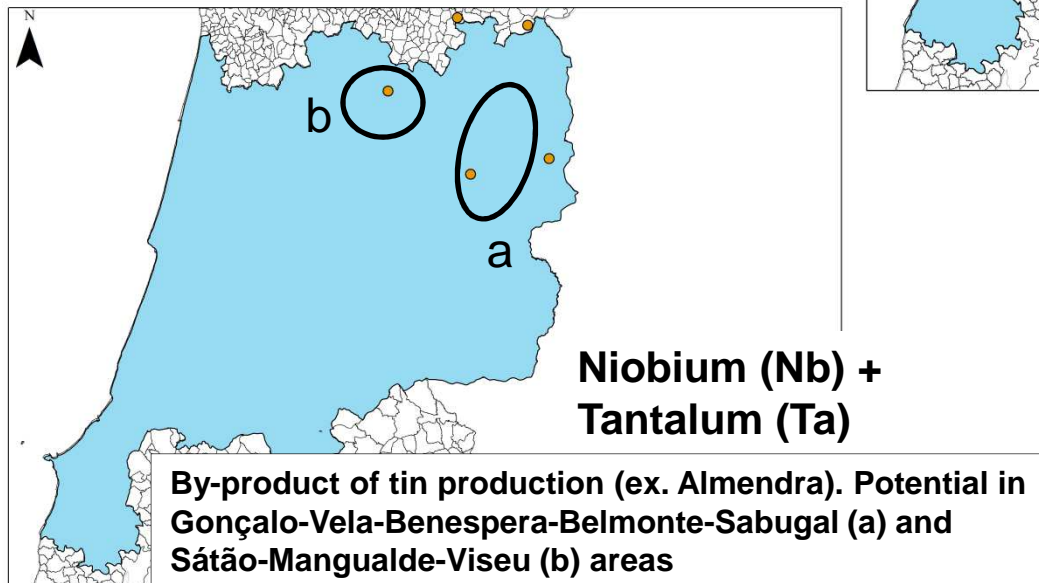
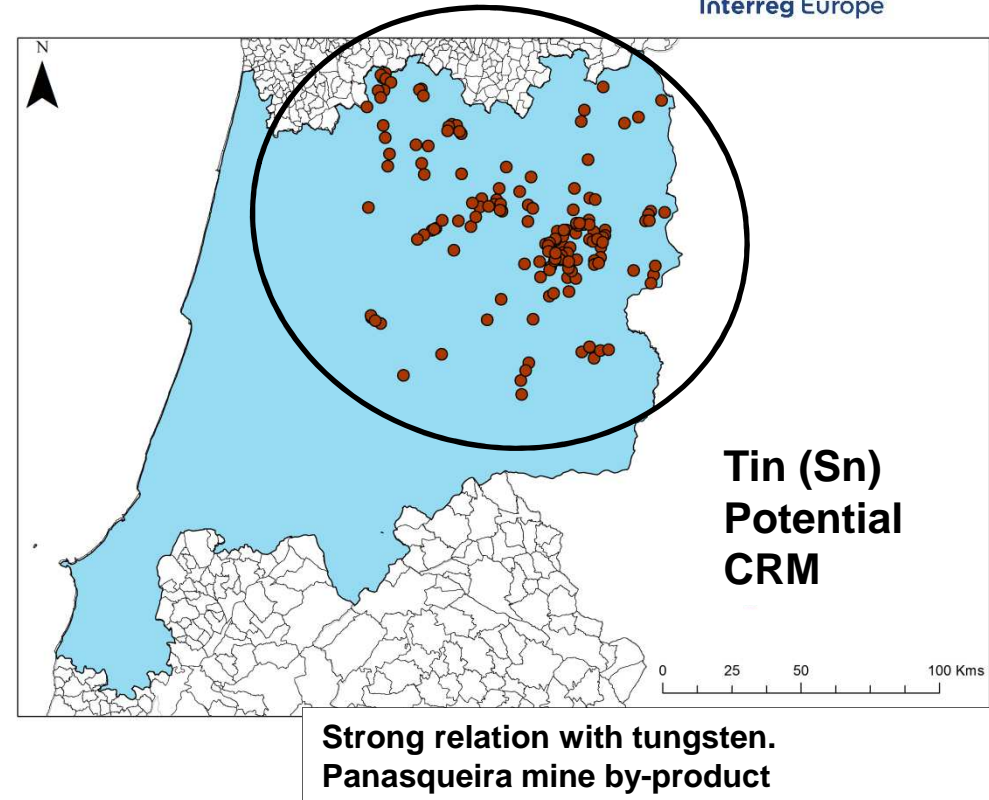
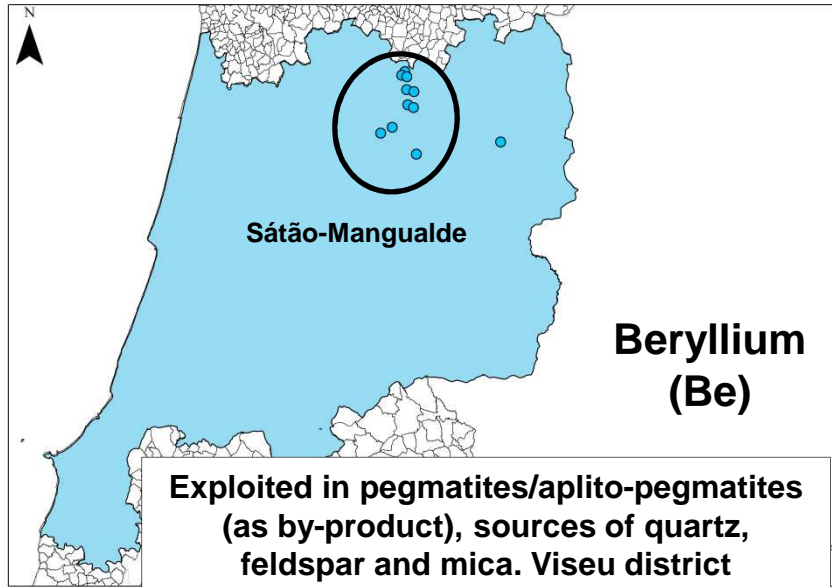
**WWI & WWII
(major periods of tungsten production in Portugal)**

Tungsten main deposits (centro region)

**Between years
1836 – 1930
Of a total 1793
mines - 530 (30%)
exploited
tungsten
(Portugal)**

Mineral Deposit	Main Substances	Historical Production	Dimension	Potential Resources
Panasqueira (30)	Tungsten	Production of more than 50.000 t of W, (over 100 years)	Large	Proven and Probable Reserves + Indicated Resources= 5,13 Mt with 0,26 % WO ₃ (total of 13.338 t WO ₃)
Bejanca-Bodiosa (25)	Tungsten and Tin	Production of 178 t of WO ₃ and 184 t of SnO ₂	Medium	5 mt with 2350 t of WO ₃ and 3070 t of Sn (1985 Assessment).

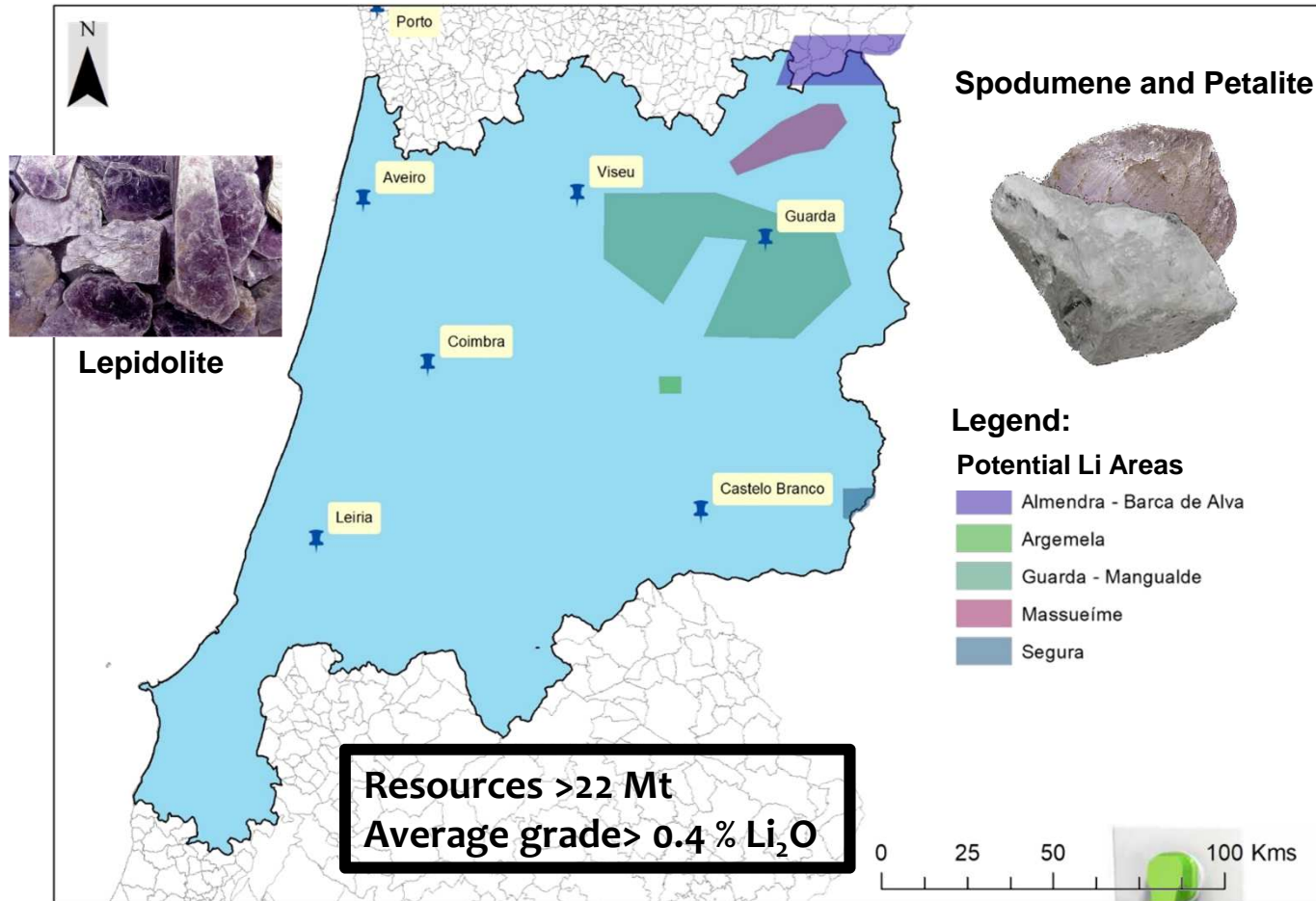
Other Critical Raw Materials



Li bearing aplite pegmatites in Guarda region, Alvarrões

Lithium (Li)

Critical metal in the green business



Designation	Area (km ²)	Short description
Almendra - Barca de Alva	343	0,42-0,52 % Li ₂ O (Barca d'Alva) + 0,05 % Sn 0,5 % Li ₂ O (Feli mine) + 0,05 % Sn 0,16 % Li ₂ O (Pombal) + 0,05 % Sn
Argemela	15	Inferred Resources of 20,1 Mt, 0,4 % Li ₂ O
Guarda - Mangualde	1725	Measured Resources of 1,4 Mt, 0,42 % Li ₂ O
Massueime	258	Deposit with: < 150 t Li ₂ O < 1500 t Sn
Segura	34	Mineralization in lepidolite and REE

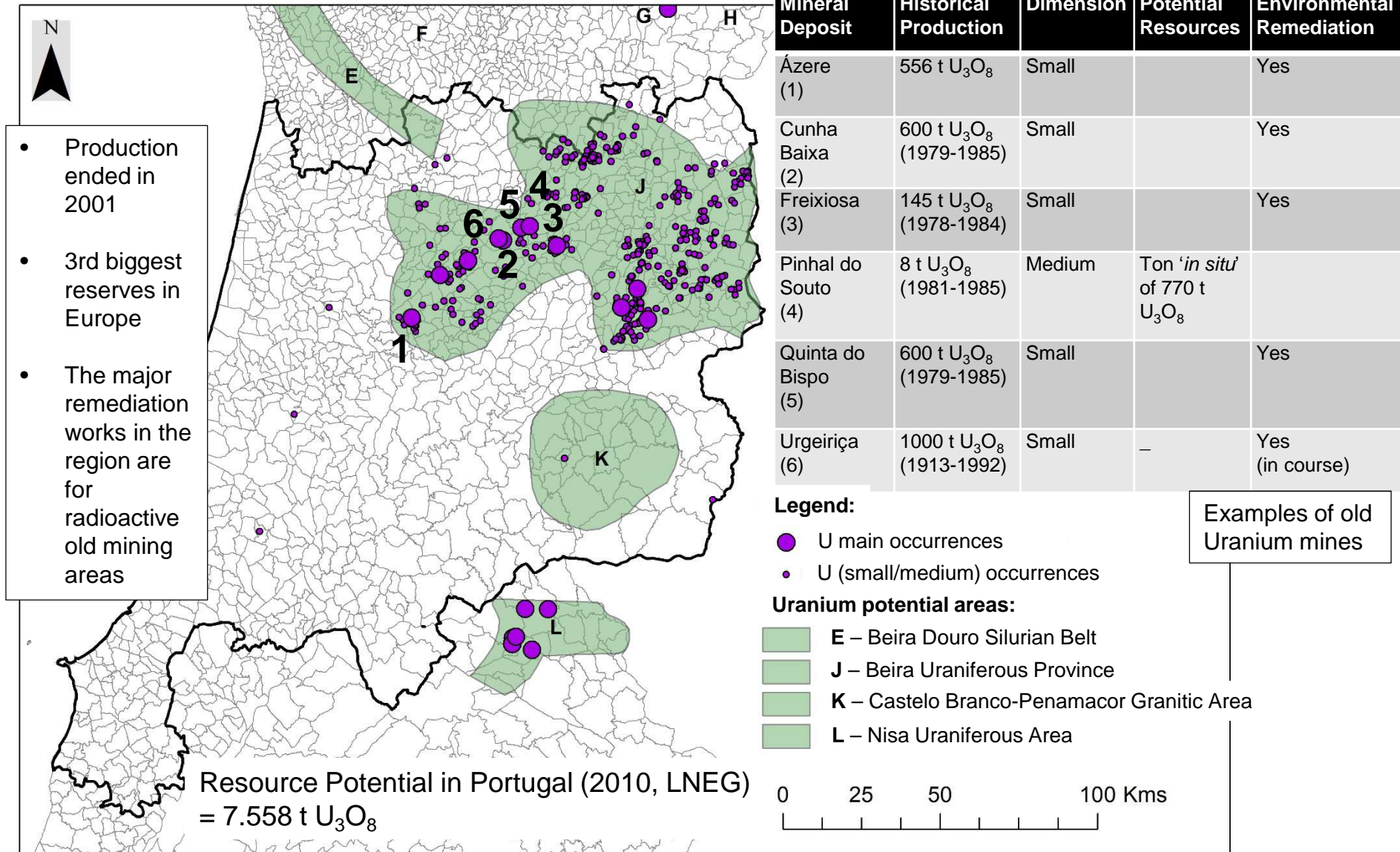
Aplitepegmatites can also be source of **Tin, Niobium, Tantalum and REE**

Only in **2016** arrived at DGE (Directorate General for Energy and Geology), **30 requests for research and exploration areas.** (Investment of **3,8 M€**)



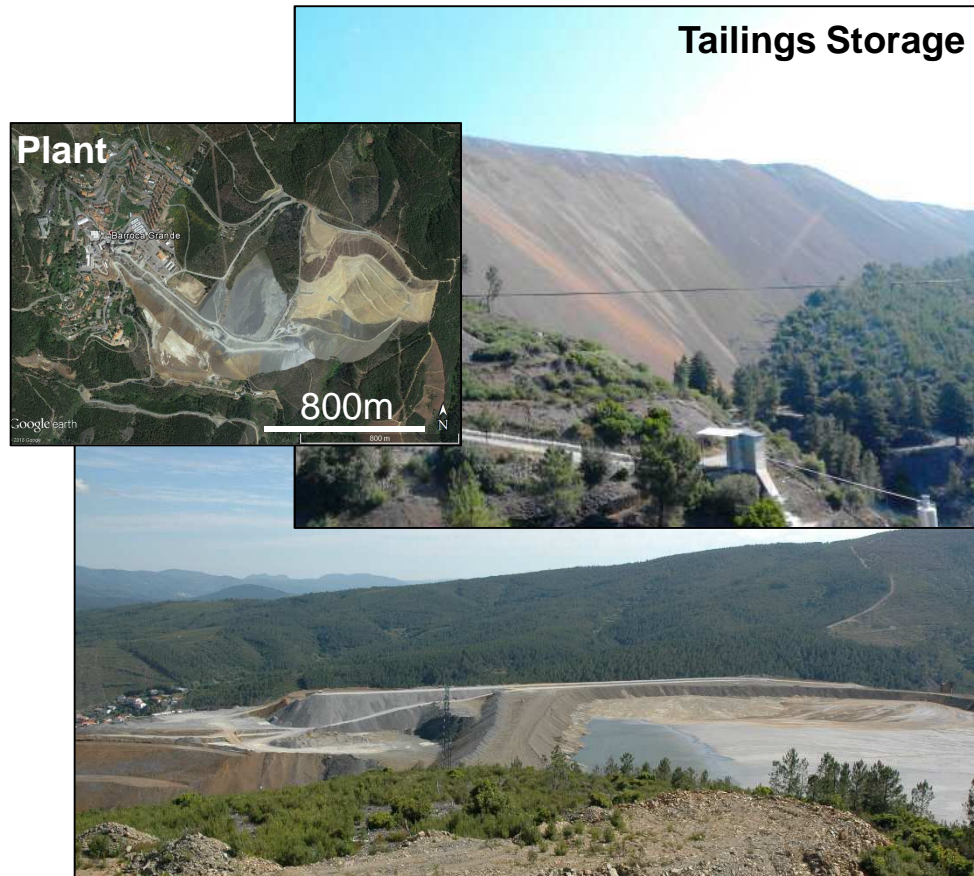
Uranium (U)

Great mining legacy in the Centro region



Circular economy

Turn mine waste into resource



- ✓ Mine waste = extraction, beneficiation and mineral processing
- ✓ Causes: Pollution of water, soils and air
- ✓ Has: Large potential as a (secondary) resource
- ✓ Requires: Characterization (chemistry, physics, mineralogy), volume, grade,..
- ✓ Concepts: Recycling, reuse, beneficiation
- ✓ Resource maximization and environmental hazard mitigation

Panasqueira mine tailings and dam

Potential areas for beneficiation on tailings in Centro Region: **Góis** (Tungsten, Tin), **Bejanca** (Tin, Tungsten), **Talhadas** (Copper, Lead, Silver) e **Braçal** (Lead), with volume of tailings between 50.000 - 100.000 m³

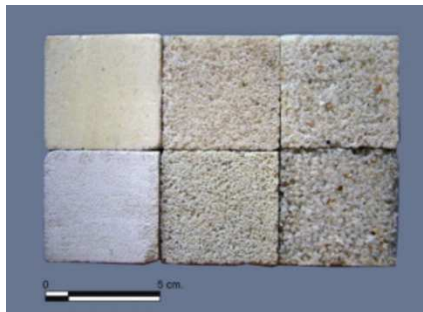
Circular economy

Turn mine waste into resource

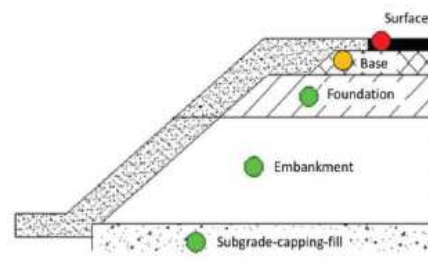
Case studie: Panasqueira mine

> **8.000.000 m³ tailings** (coarse, crushed and milled waste-rock)
About 100-200 tons of tailings per day (presently)

Use in road construction (coarse material), bituminous products (coarse and fine material), artificial aggregates (mud), road furniture, polymer-based composite materials (conservation, restoration of buildings, monuments, etc); (**Universities of Beira Interior, Granada and Bologna**)



Polymer-based mortar



Road construction



Road furniture

- **Tailings studies examples (Collaboration of Universities and Companies)**

- ❑ **PT-W** – Biotools for a sustainable supply of tungsten from biodetection to bioleaching and biorecovery (**University of Coimbra**) - **Detect and extract tungsten from tailings**

- ❑ **ENVIREE** - Environmentally friendly and efficient methods for extraction of rare earth elements (REE) from secondary sources

IST ID (Instituto Superior Técnico for Research and Development), EDM (Empresa de Desenvolvimento Mineiro), and other european partners

And more.....

An integrated investigation of the Rio tailings - Panasqueira mine (Centre Portugal)

C. Grangeia¹, P. Ávila^{1,2}, M. Matias¹, E. Ferreira da Silva¹

¹GeoBioTec – Geobiosciences, Geotechnologies and Geengineering, University of Aveiro, 3810-193 Aveiro, Portugal (corresponding author; Email address: cgrangeia@ua.pt);
²LNEG –



MSP-REFRAM
Coordination and Support Actions (Coordinating) (CSA-CSA)
Co-funded by the European Commission under the Euratom Research and Training Programme on Nuclear Energy within the Seventh Framework Programme
Grant Agreement Number : 688993
Start date : 2015-12-01 Duration : 19 Months



Mapping the secondary resources in the EU (mine tailings, industrial waste)

Authors : Dr. Santiago CUESTA-LOPEZ (ICCRAM) Rocio Barros (ICCRAM), Mroueh Ulla-Majja (VTT), Stefan Willemsinn (UNIKL), Yang Xiao Sheng (GTK)

Geochemistry and Mineralogy of Mill Tailings Impoundments from the Panasqueira Mine (Portugal): Implications f....

Article // Mine Water and the Environment · December 2008
DOI: 10.1007/s10230-008-0046-4

CITATIONS	READS
34	126

4 authors, including:



-  **Ávila Paula**
Laboratório Nacional de Energia e Geologia
48 PUBLICATIONS 315 CITATIONS
[SEE PROFILE](#)
-  **Eduardo Ferreira**
University of Aveiro
240 PUBLICATIONS 2... CITATIONS
[SEE PROFILE](#)
-  **Rita Salgueiro**
Universidade Federal do Ceará
36 PUBLICATIONS 354 CITATIONS
[SEE PROFILE](#)

Feasibility of alkali-activated mining waste foamed materials incorporating expanded granulated cork

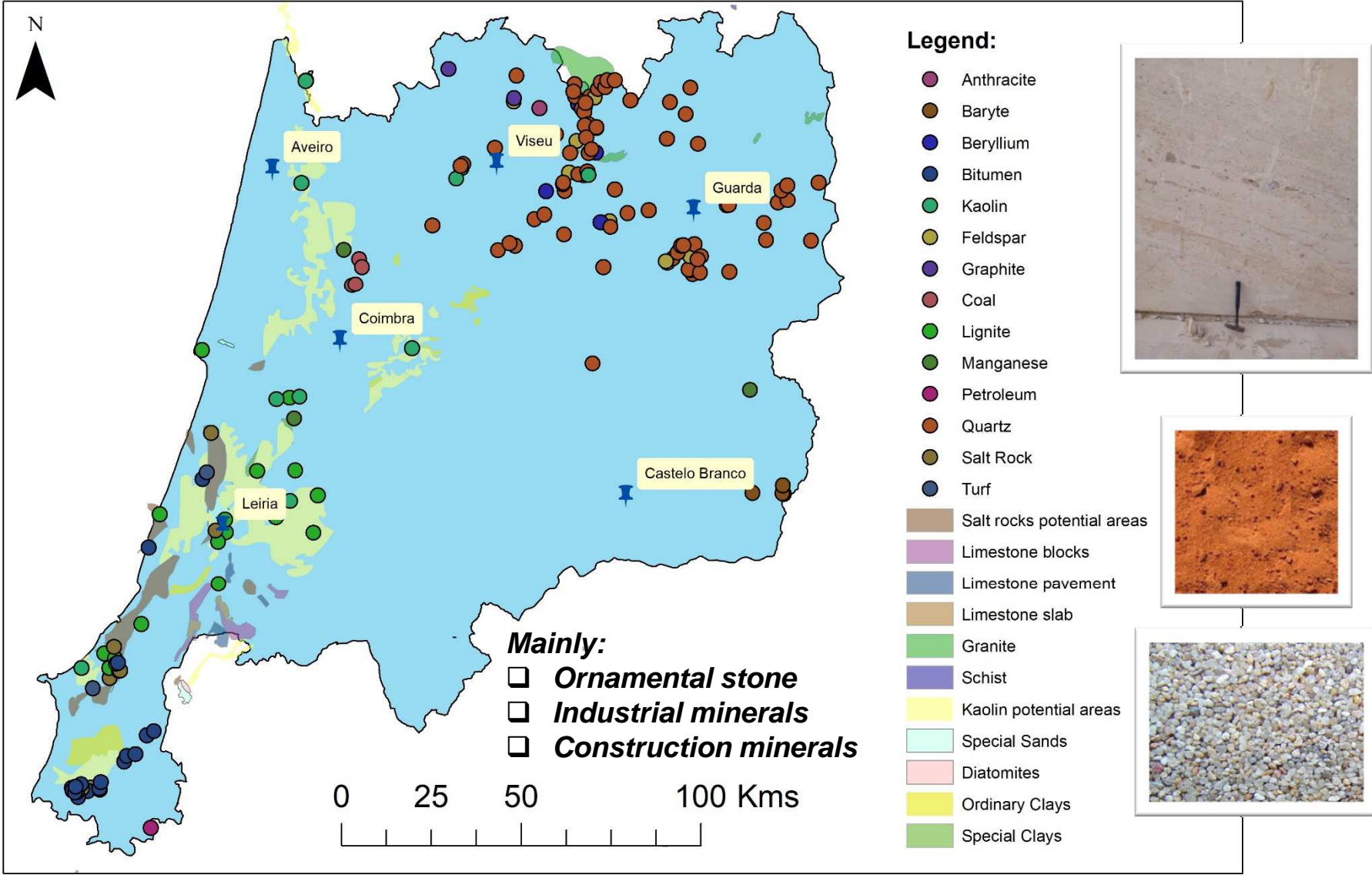
Article · January 2017
DOI: 10.5277/msc172401

CITATIONS	READS
0	180

4 authors, including:

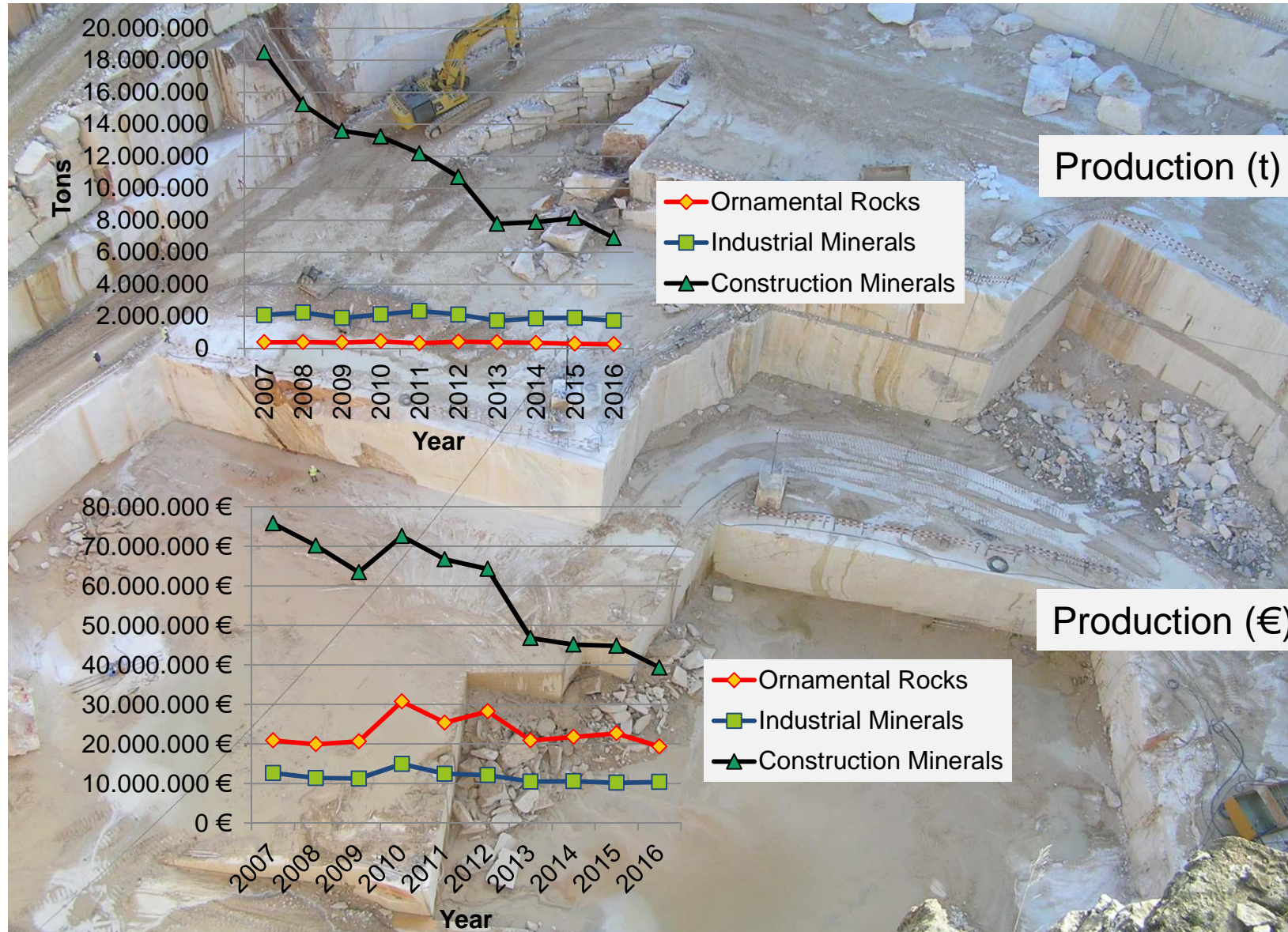
-  **Imed Beghoura**
Universidade da Beira Interior
2 PUBLICATIONS 0 CITATIONS
[SEE PROFILE](#)
-  **João P. Castro-Gomes**
Universidade da Beira Interior
158 PUBLICATIONS 1,883 CITATIONS
[SEE PROFILE](#)

Non-metallic resources in the Centro region



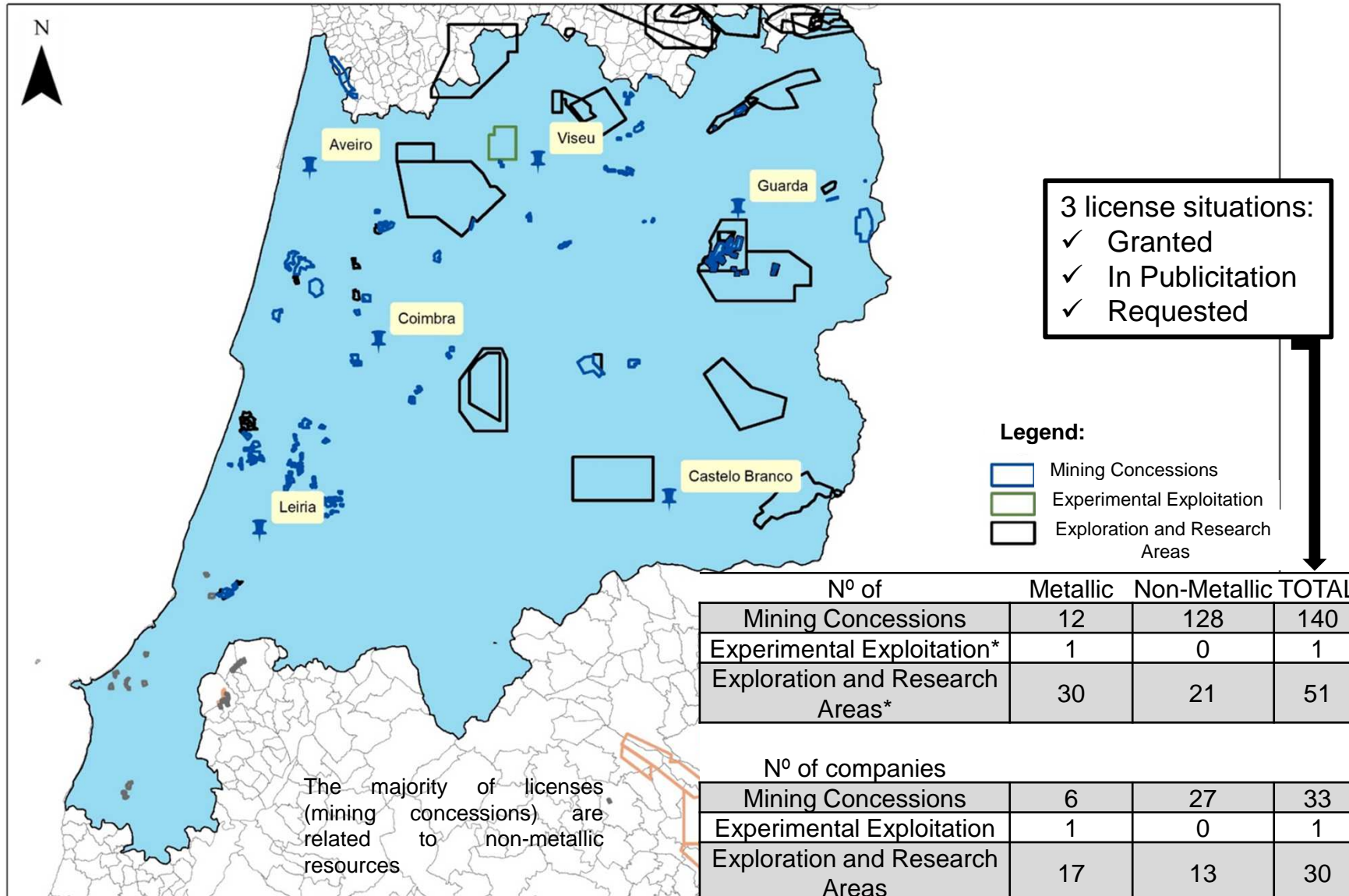
Non-metallic resources

Production of Centro region



Source: DGE, 2017a

Centro region mining activity (2017)



Portugal strategies for mineral resources



(2012)



ESTRATÉGIA NACIONAL PARA OS RECURSOS GEOLÓGICOS | NATIONAL STRATEGY FOR GEOLOGICAL RESOURCES

- Promotion : sustainability, dynamics, national and regional growth, supply of raw materials
- Development of knowledge and national potential on resources, national propaganda and promotion, economical, social, environmental and territorial sustainability



(2016)

CLUSTER MINERAL RESOURCES

- Promote knowledge, sustainable economic value of mineral resources.
- Exporting, R&D, Investment, Increase technical, technological and management capacities

59 partners (companies, universities, associations, institutes)

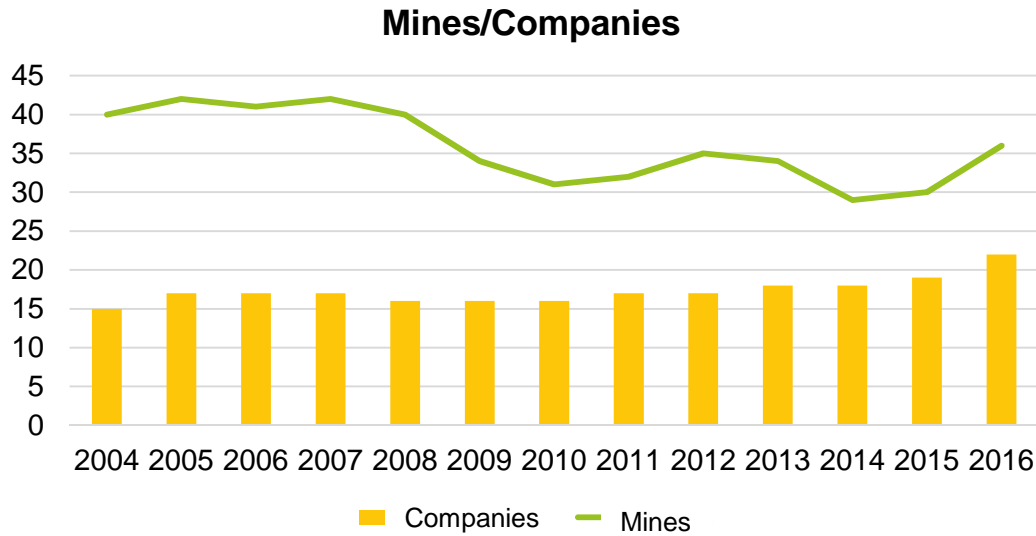


(2016)

GRUPO DE TRABALHO “LÍTIO” | LITHIUM GROUP WORK

- Increase the Li market in Portugal
- Identification and characterization of Li deposits
- Increase economic value
- Create processing plants

Active mines in Centro region



Companies:

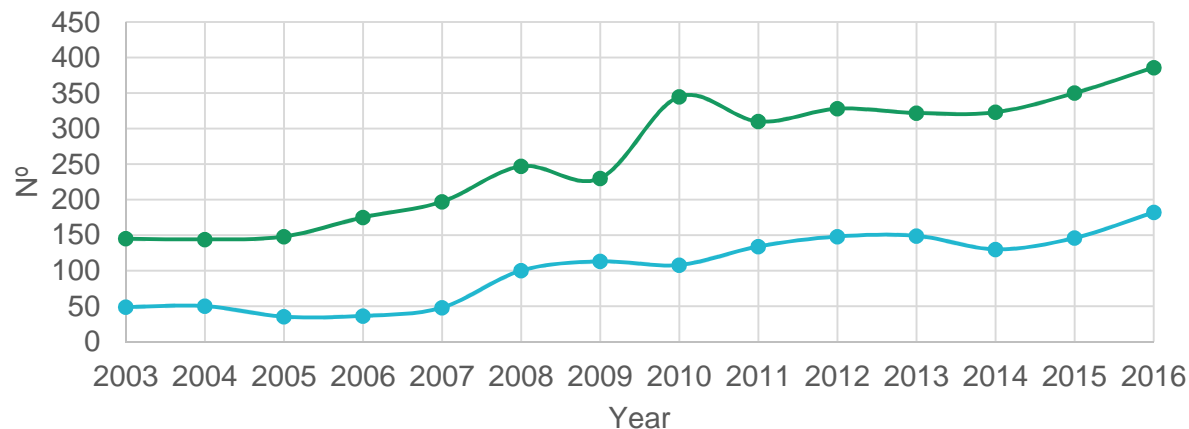
BERALT TIN AND WOLFRAM (PORTUGAL), S.A.
 Minas de Cassiterite de César de Almeida Figueiredo & Filho, Lda
 Minas de Cassiterite Sobreda, S.A.

José Aldeia Lagoa & Filhos, Lda.
 Pegmatitica - Sociedade Mineira de Pegmatites, Lda.
 Sociedade Mineira Carolinos, Lda.
 Felmica - Minerais Industriais, S.A.

Year	Nº Companies		
	(Substances)		Industrial Minerals
	Tungsten, Tin and Titanium	Lithium	
2004	3	3	13
2005	3	3	16
2006	3	3	16
2007	3	4	16
2008	3	4	13
2009	3	3	13
2010	3	3	13
2011	3	3	14
2012	3	3	14
2013	3	3	15
2014	3	3	15
2015	3	3	16
2016	3	2	19

Mining sector employment in Portugal

Executives, Administratives and Technicians

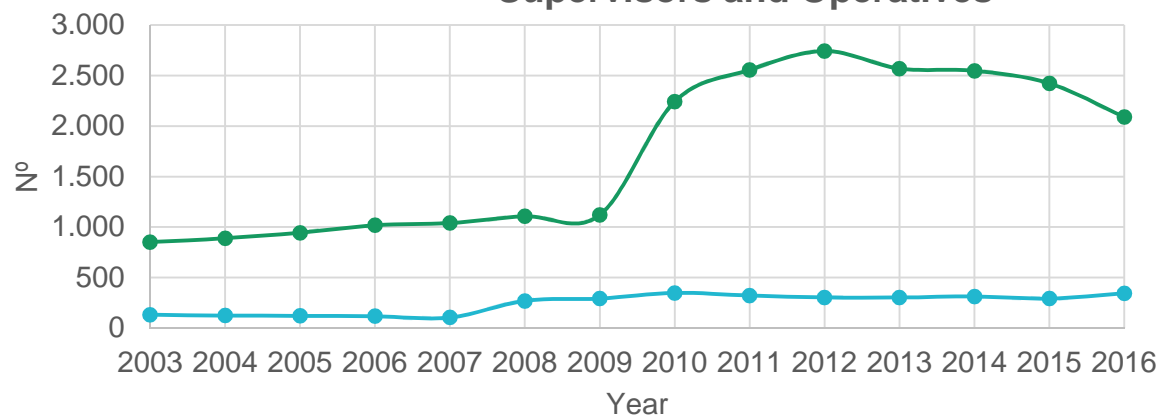


More employment related to the metallic sector

Sector growing from 2011 to 2016

—●— Metallic Minerals —●— Non-Metallic Minerals

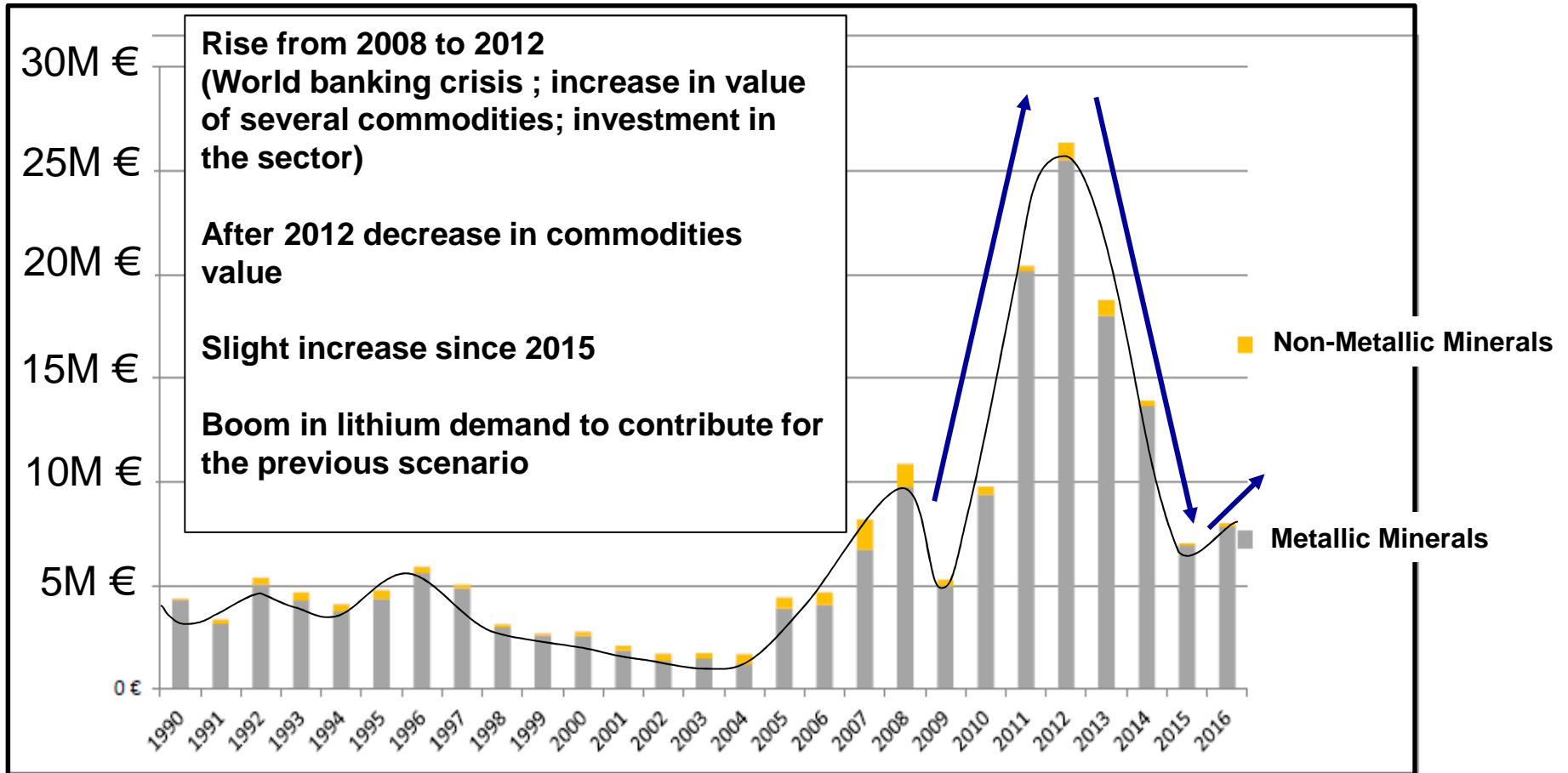
Supervisors and Operatives



Significant rise between 2009-2010 (metallic sector)

—●— Metallic Minerals —●— Non-Metallic Minerals

Exploration and research in Portugal



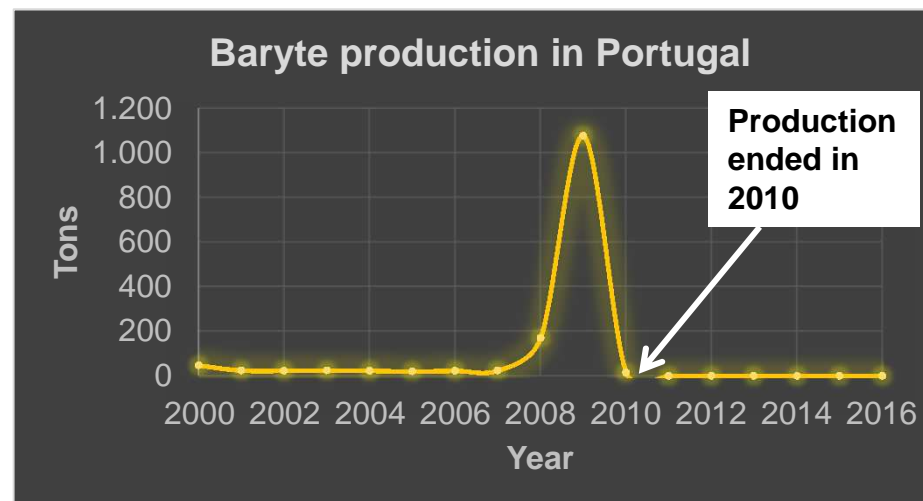
Investment evolution in exploration and research contracts (1990-2016)

Critical raw materials production

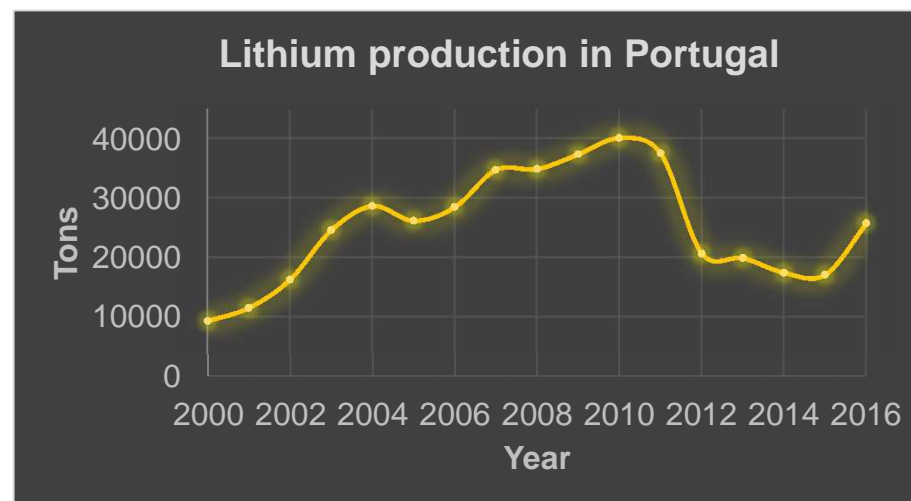
Panasqueira mine production (2000-2016)

Year	Concentrate Produced			ROM Ore
	WO ₃ t	Sn t	Cu t	
2000	1,269	12	132	332
2001	1,194	23	118	378
2002	1,179	21	81	346
2003	1,213	20	99	355
2004	1,277	50	138	432
2005	1,405	44	187	574
2006	1,342	28	235	642
2007	1,456	48	258	762
2008	1,684	32	186	782
2009	1,410	36	164	720
2010	1,364	25	198	792
2011	1,399	45	238	905
2012	1,303	47	228	830
2013	1,174	103	352	789
2014	1,131	98	732	775
2015	799	53	361	518
2016	926	69	384	643

Source: Almonty Industries, 2016



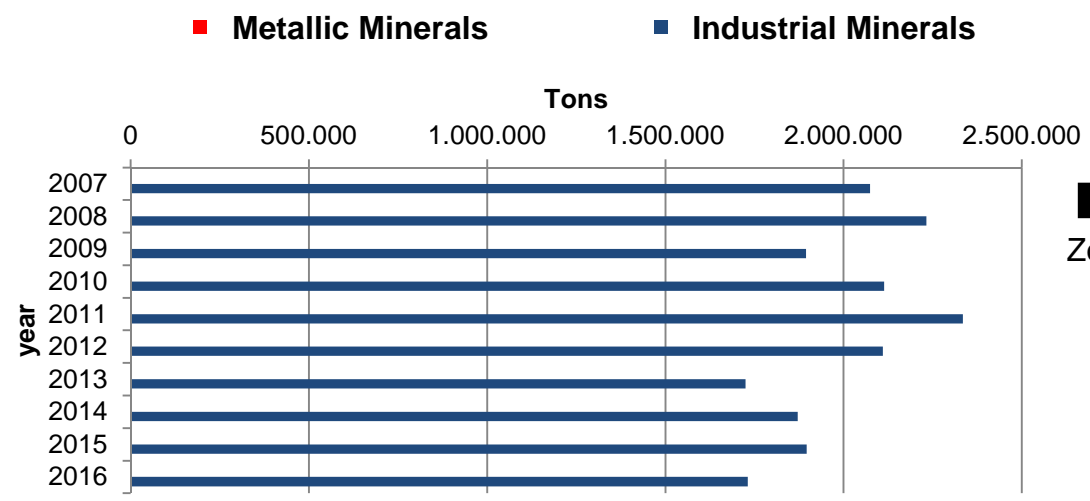
Source: DGEG, 2017d



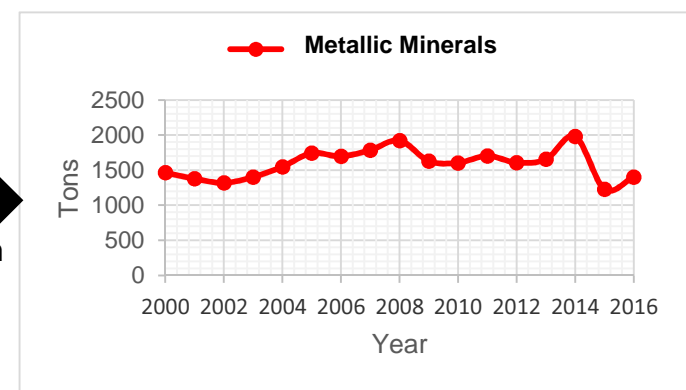
Source: BGS, 2018

Extractive industry in Centro region

Production (t)



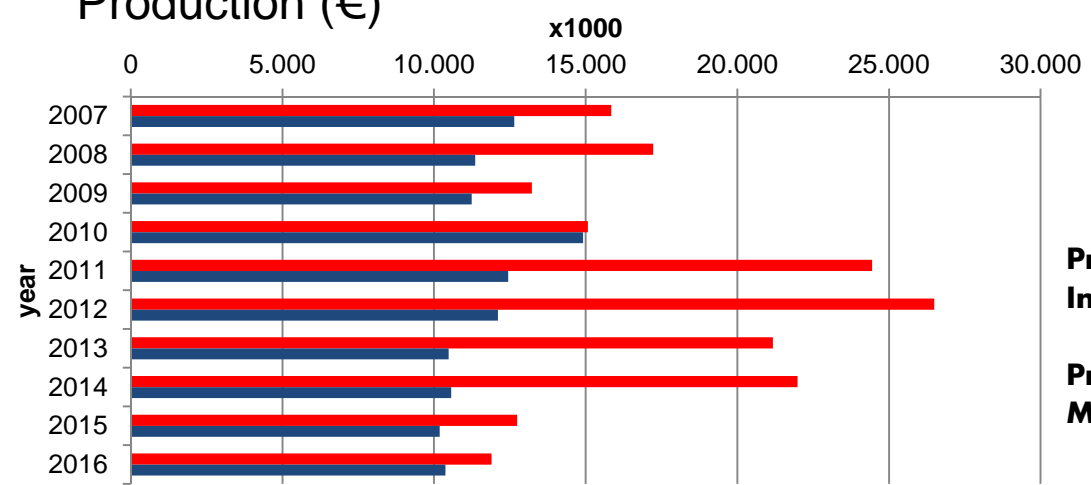
Zoom in



Metallic Minerals
(Metals: Tungsten, Tin, Copper, Titanium)

Industrial Minerals
(Clay, Kaolin, Feldspatic sands, Feldspar, Pegmatites, Quartz, Salt rock)

Production (€)

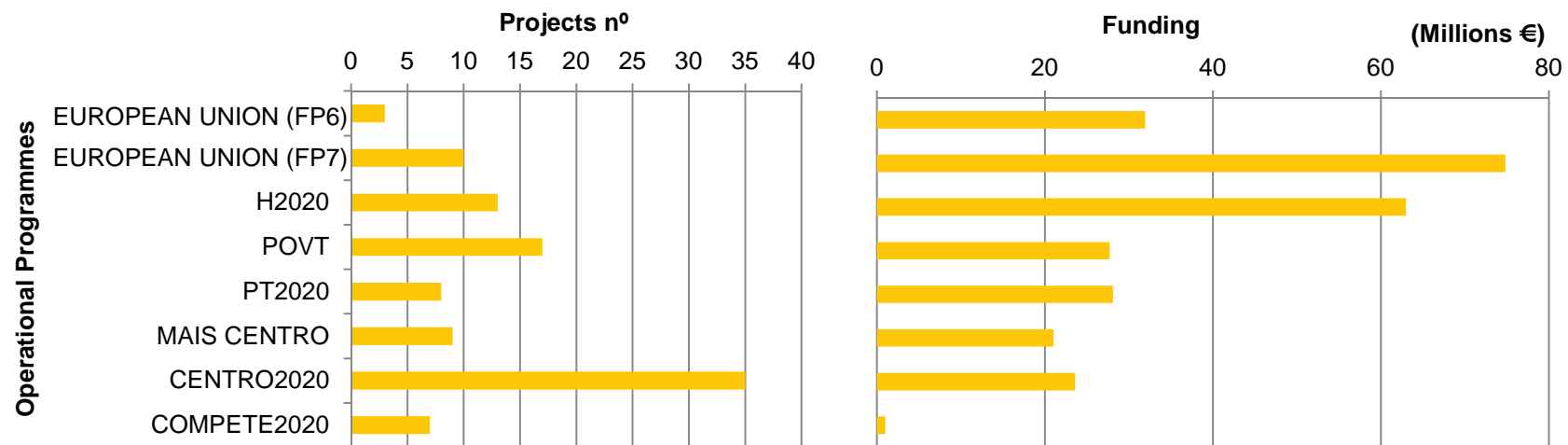


Production (t)
Industrial Minerals >> Metallic Minerals

Production (€)
Metallic Minerals > Industrial Minerals

Programmes & Projects Portuguese and European

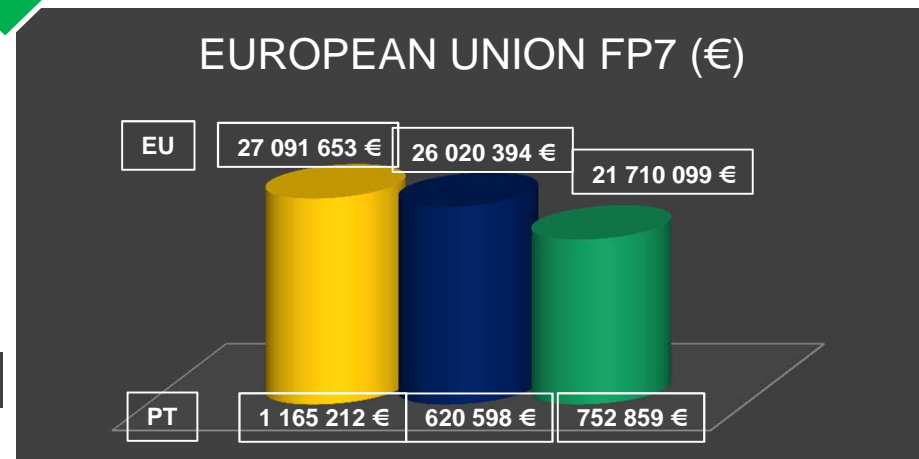
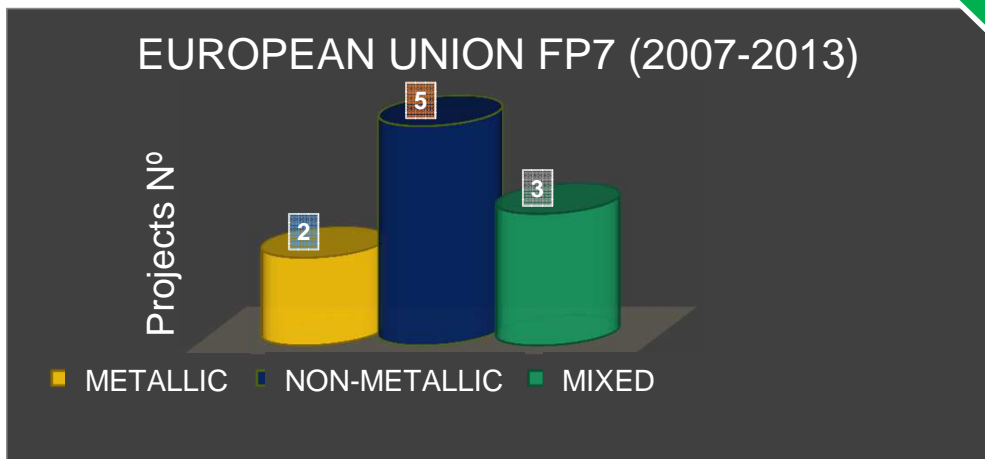
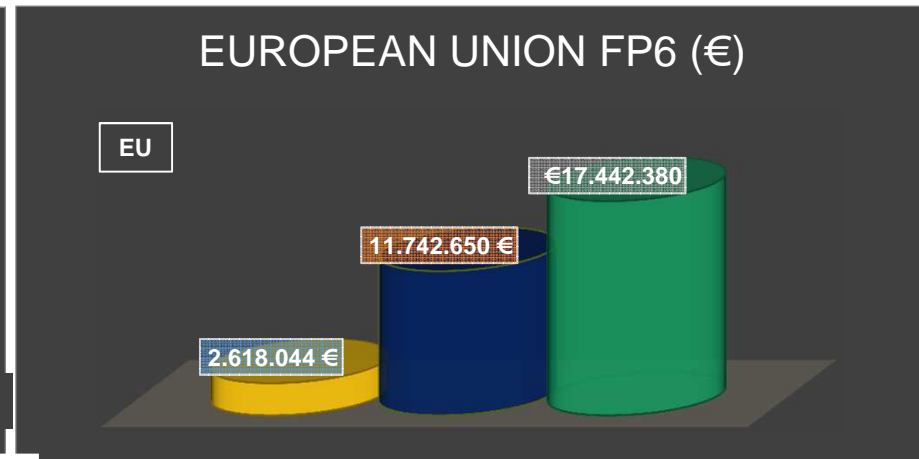
- ❑ **EUROPEAN UNION (FP6, FP7) e H2020**, related to Europe (including Portugal)
- ❑ **POVT** (Territory Valorization Operational Program)
- ❑ **POSEUR** (Sustainability and Efficiency in the Use of Resources Operational Program)
- ❑ **MAIS CENTRO**
- ❑ **CENTRO2020**
- ❑ **COMPETE2020**, all related with the Centro Region (Portugal)



FP 6,7 - Framework Program 6,7

European research programmes

Portuguese Participation

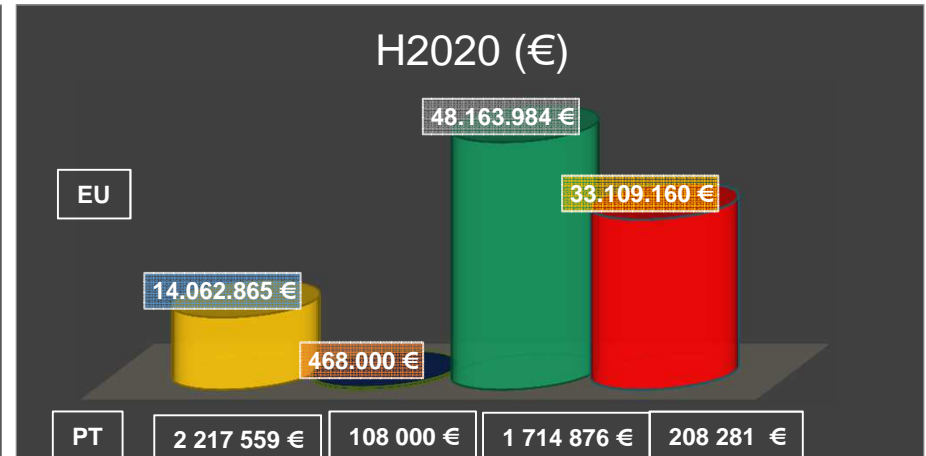
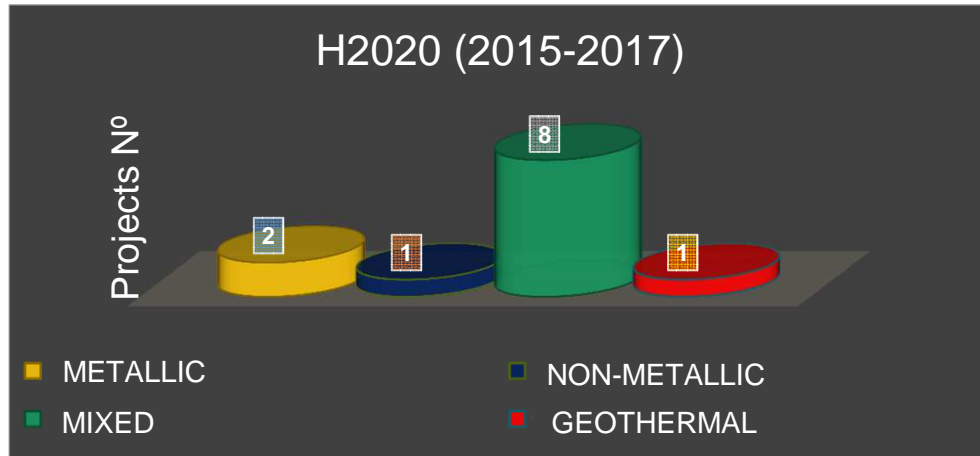


 = Transition of programs

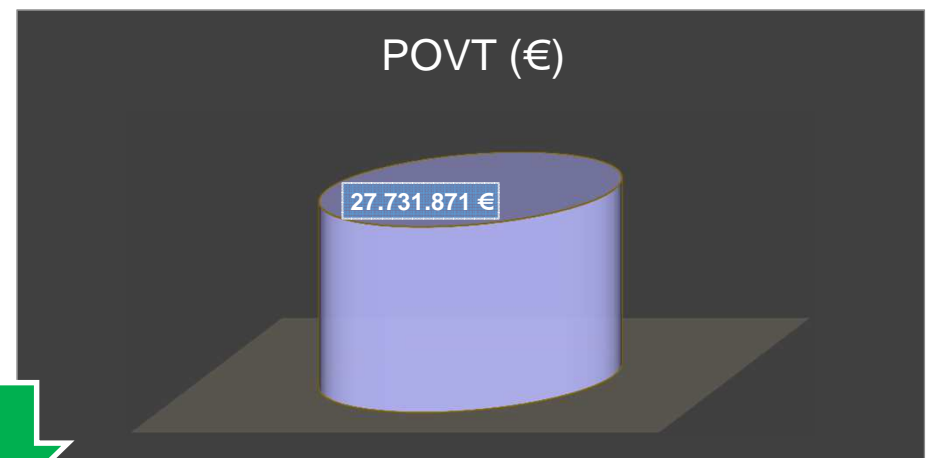
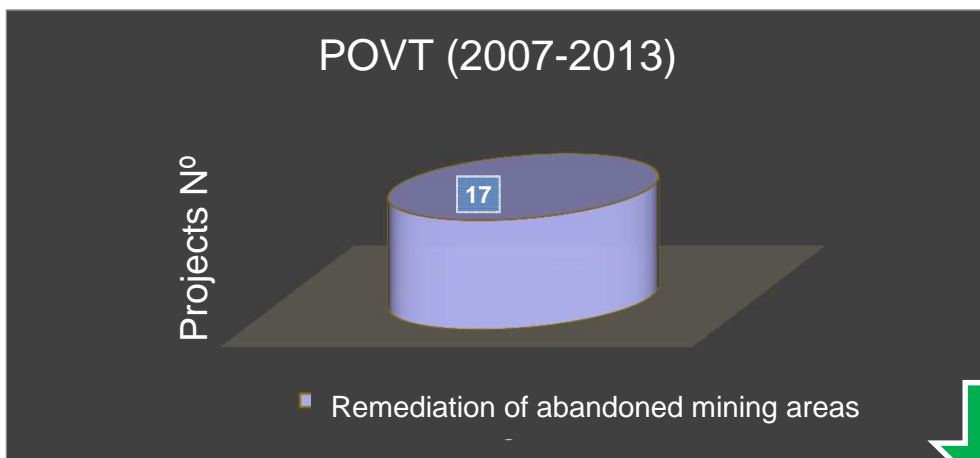
Mixed=Metallic and Non-Metallic

Sources: European Commission, 2018; 2018b

European research programmes Portuguese Participation

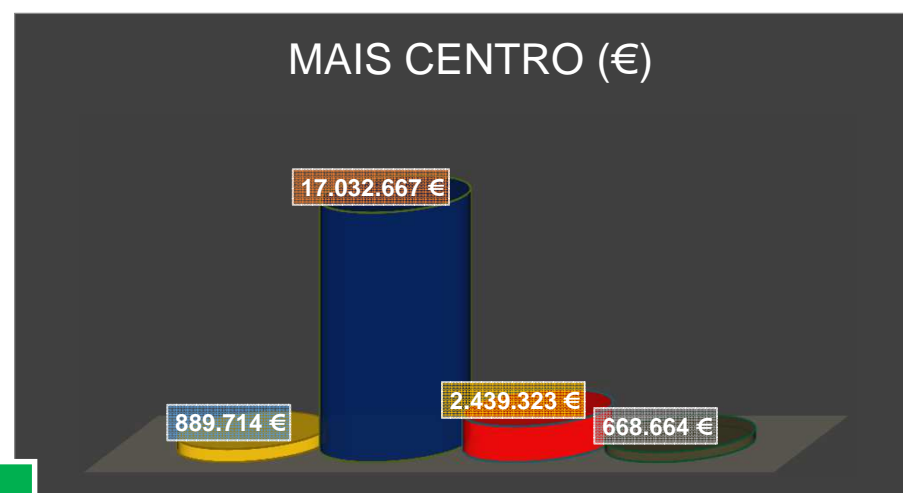
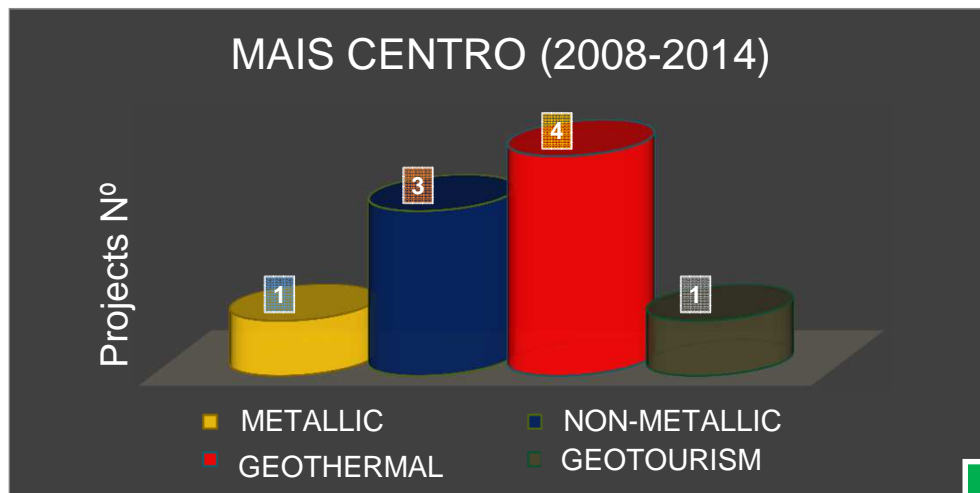
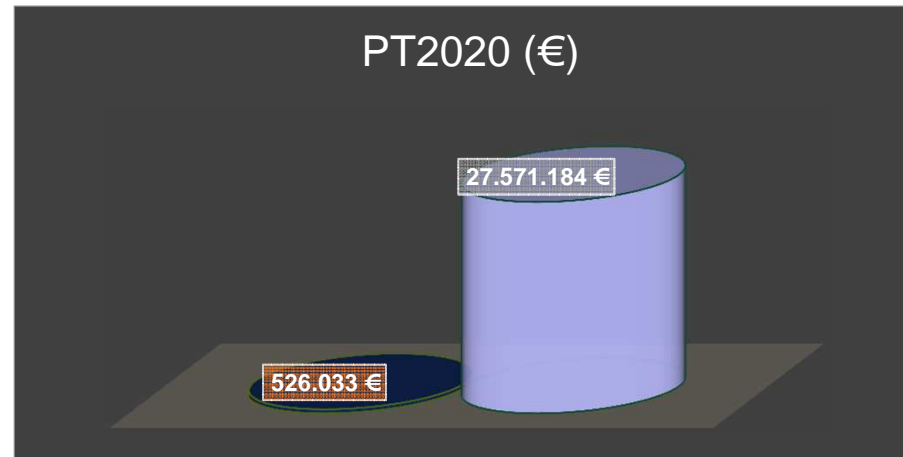
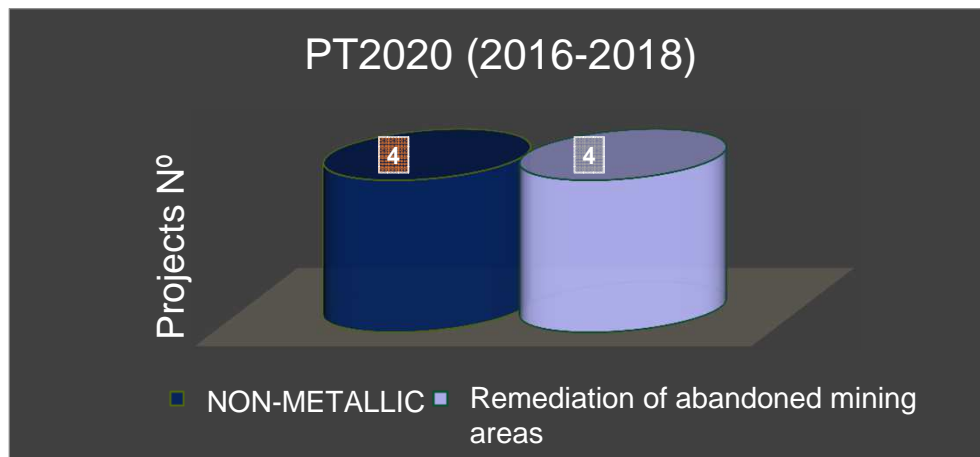


Portuguese research programmes Centro Region

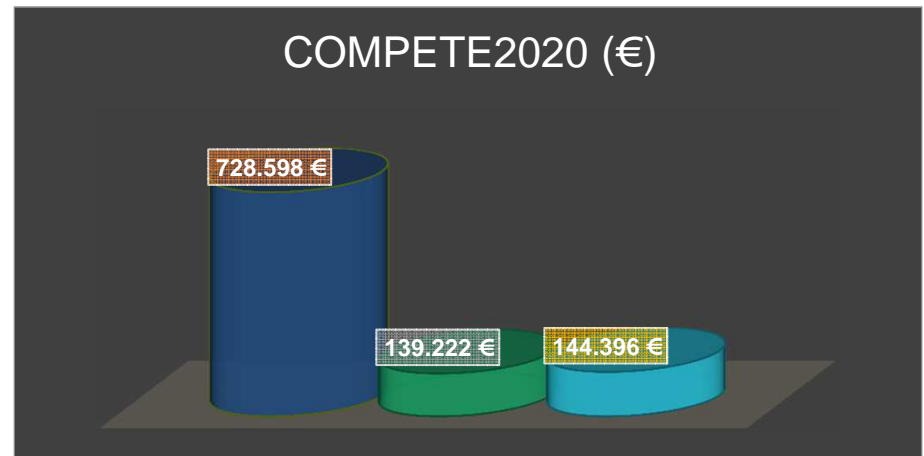
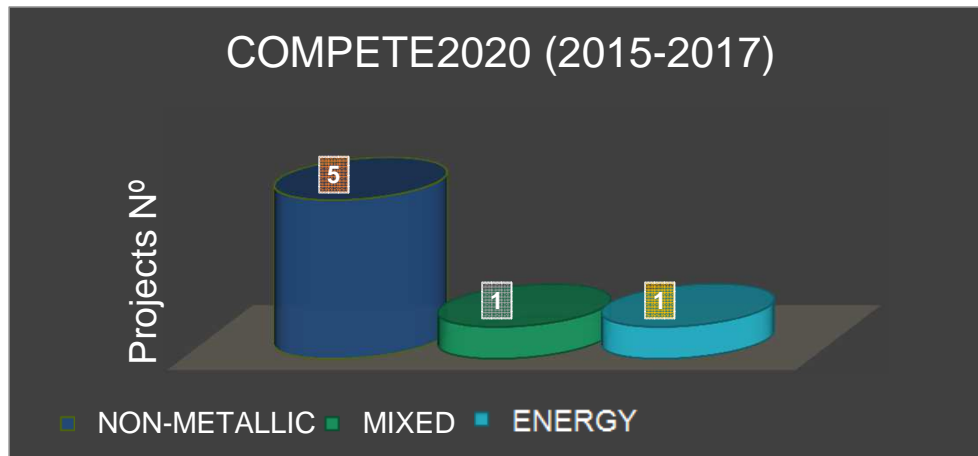
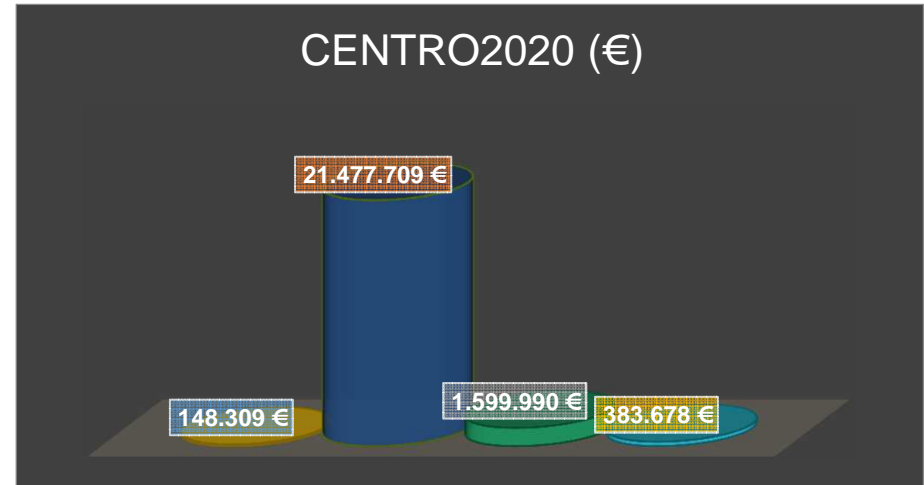
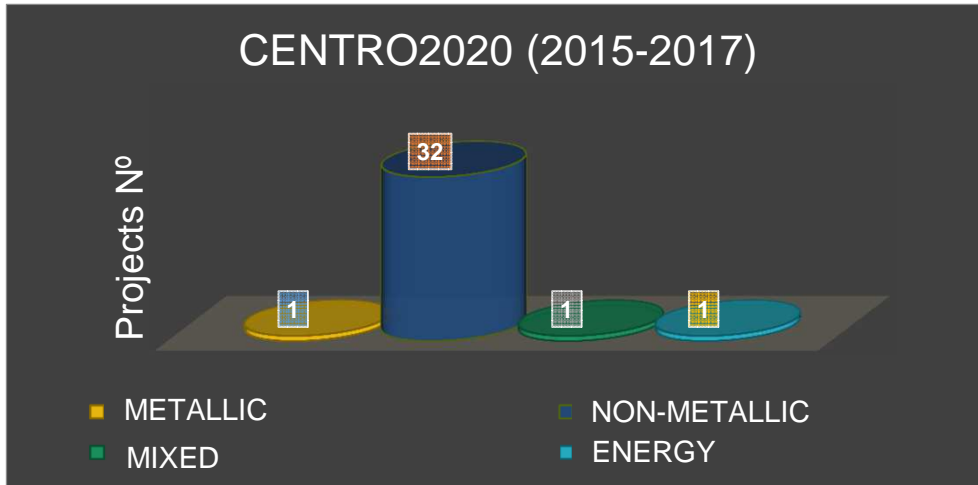


PT2020

Portuguese research programmes Centro Region



Portuguese research programmes Centro Region



**Much less projects (sometimes inexistent) with focus in metallic resources
[Non-Metallic (47) >>>> Metallic (9)]**

**Investment in metallic resources lower than in the non-metallic
[Non-Metallic ≈78 M€ >>>> Metallic ≈22 M€]**

‘It’s necessary to change this vision and reinforce the investment in the metallic sector (mainly critical raw materials), reducing the (high) dependency on importation of the European Union’

Considerations

- ✓ **The Centro Region is rich in number and diversity of metallic (and non-metallic) mineral resources**
- ✓ Among the metallic there is:
 - ✓ **High potential in Tungsten and Lithium** > Tantalum, Niobium, Tin, Rare Earth Elements, Beryllium, Barium (By-products). Tungsten sold as WO_3 concentrate from Panasqueira mine
 - ✓ **Moderate potential for Tin**
 - ✓ Although there are some occurrences of **Niobium, Tantalum and Beryllium**, more exploration is needed
 - ✓ Existence of old mines (W, Sn, Au) with estimated resources and reserves
 - ✓ High potential for deep deposits (higher costs)
- ✓ **Strong demand in Lithium (growing investment) – Required:**
 - ✓ Improved separation of Li metal other elements
 - ✓ Sustainable refining process of Li oxide in Li carbonate for higher economic value in international market

Savannah believes the site in Portugal to be “the largest deposit of spodumene lithium in western Europe.” Mr Archer said: “Portugal could be the first European supplier” of spodumene concentrate, the dominant lithium product to be traded internationally.

Wise, P. (2018, May 2). *Financial Times*

References (1/2)

- Almonty Industries (2016). Report NI 43-101 - Technical report on the mineral resources and reserves of the Panasqueira mine, Portugal. Accessed in April 2018, http://www.almonty.com/_resources/Panasqueira_43-101_Tech_Rep_Dec16_SEDAR.PDF
- BGS - British Geological Survey (2018). World mineral statistics data. Accessed in April 2018, <https://www.bgs.ac.uk/mineralsuk/statistics/wms.cfc?method=searchWMS>
- Carvalho, J., Diamantino, C., Rosa, C.J.P. and Carvalho, E. (2016). Potential recovery of mineral resources from mining. ResearchGate.
- Castro-Gomes, J. P., Sangiorgi, C., Lantieri, C., Tataranni, P. and Gabriel, N. (2016), Reuse of mining waste into innovative alkali-activated-based materials for road pavement applications. Functional Pavement Design. Erkens et al. (Eds). Taylor & Francis Group, London.
- Castro-Gomes, J. P., Silva, A. P., Cano, R. P., Durán Suarez, J., and Albuquerque, A. (2012). Potential for reuse of tungsten mining waste-rock in technical-artistic value added products. *Journal of Cleaner Production*, 25, pp. 34–41.
- Centro2020 (2018). Projetos aprovados. Accessed in April 2018, <http://www.centro.portugal2020.pt/index.php/projetos-aprovados>
- Clustermineralresources (2018). Cluster Portugal mineral resources association. Accessed in September 2018, <https://www.clustermineralresources.pt/home-en>
- Compete 2020 (2018). Projetos. Accessed in April 2018, <http://www.poci-competite2020.pt/Projetos>
- Criticalrawmaterials (2018). Critical Raw Materials. Accessed in April 2018, <http://criticalrawmaterials.org/critical-raw-materials/>
- Despacho n.º 15040/2016 de 13 de dezembro. D.R, 2ª Serie. Relatório do grupo de trabalho “Lítio”. Accessed in April 2018, <http://www.Ineg.pt/download/13166/i015115.pdf>
- DGEG – Direção Geral de Energia e Geologia (2017a). Production (Quantities and value) in the Centro region – Mines and quarries
- DGEG – Direção Geral de Energia e Geologia (2017b). Mines with declared production in 2016
- DGEG – Direção Geral de Energia e Geologia (2017c). Mines – Employees by subsector
- DGEG – Direção Geral de Energia e Geologia (2018a). DGEG. Accessed in April 2018, <https://agserver.sg.min-economia.pt/arccgis/rest/services/DGEG>.

References(2/2)

- DGEG – Direção Geral de Energia e Geologia (2018b). Industrial minerals production (1999-2017)
- European Commission (2018a). Horizon 2020 projects. Accessed in April 2018, <https://ec.europa.eu/programmes/horizon2020/en/h2020-sections-projects/>
- European Commission (2018b). Community Research and Development Information Service. Accessed in April 2018, https://cordis.europa.eu/guidance/archive_en.html
- Leal Gomes, C. (2018) - Panorâmica sobre condições naturais de ocorrência de minérios de lítio no Norte de Portugal – Perspectivas de valorização de recursos de Lítio metálico. Recursos geológicos de Trás-os-Montes - Passado, presente e perspetivas futuras. Balsa, C. e Teixeira, J. (Eds.), Instituto Politécnico de Bragança, p. 57 – 95 (in Portuguese).
- Lèbre, E. and Corder, G., (2015). Integrating industrial ecology thinking into the management of mining waste. *Resources*, 4, pp. 775-786.
- LNEG - National Laboratory of Energy and Geology (2018). SIORMINP - Sistema de Informação de Ocorrências e Recursos Minerais Portugueses. Accessed in April 2018, http://geoportal.lneg.pt/index.php?option=com_content&id=69&lg=pt
- LNEG - National Laboratory of Energy and Geology (2010). Recursos Minerais: O Potencial em Portugal. Ministério da Economia.
- Mais centro (2018). Projetos aprovados. Accessed in April 2018, <http://www.maiscentro.qren.pt/index.php?acao=projectos&m=m7&s=0>
- Martins, L. (2012). Mineral Resources of Portugal. Direção Geral de Energia e Geologia. Ministério da Economia.
- Pais, J.M. (2016). Análise estatística da evolução do investimento realizado no âmbito dos contratos de prospeção e pesquisa de depósitos minerais.
- Portugal2020 (2018). Lista de Operações Aprovadas. Accessed in April 2018, <https://www.portugal2020.pt/Portal2020/OperacoesAprovadas>
- QREN – Quadro de Referência Estratégico Nacional (2018). Noticias. Accessed in April 2018, <http://www.povt.qren.pt/>
- Resolução do Conselho de Ministros n.º 78/2012. DR Diário da República n.º 176/2012, Série I de 2012-09-11. Accessed in April 2018, <https://dre.pt/pesquisa-avancada/>
- /asearch/176025/details/maximized?perPage=100&anoDR=2012&types=SERIEI&search=Pesquisar
- Watson, G. (2014, June 6). World War One: Tungsten 'the armour plate of conflict'. BBC News. Accessed in April 2018, <https://www.bbc.com/news/uk-england-25596167>
- Wise, P. (2018, May 2). Savannah raises Portugal lithium estimate by more than 50%. Financial Times. Accessed in April 2018, <https://www.ft.com/content/b58c9286-4df4-11e8-97e4-13afc22d86d4>



REMIX

Interreg Europe



European Union
European Regional
Development Fund

Thank you!

<https://www.interregeurope.eu/remix/>



Project smedia
