PROMETIA
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Stéphane BOURG
PROMETIA EXCOM Chairman
Project Manager at CEA

www.prometia.eu
From a Commitment to an Association

EIP-RM Commitments

A European Hydrometallurgical Institute

A European Pilot Plant Network

A European research network on ore processing and extractive metallurgy

Mineral Processing and Extractive Metallurgy for Mining and Recycling Innovation Association

Non-Profit International Association
Officially created in Belgium (Jan.15)
Technical secretariat ensured by LGI

Stéphane Bourg
Metnet: European Pilot Plant Network for Extractive Metallurgy and Mineral Processing -


- Metnet brings together the competence and equipment of pilot plants in Europe to provide an overall solution for development, validation, and up-scaling of processes through pilot scale testing for mineral and metallurgical processes.
- Metnet provide upscaling infrastructure capability from raw materials to metals.
- More info on the website: [www.metnet.eu](http://www.metnet.eu)

Members of Metnet

- BRGM, France
- CEA, France
- CRM Group, Belgium
- ELKEM Technology, Norway
- ERAMET Research, France
- Extracthive, France
- GTK, Finland
- IMN, Poland
- Materials Processing Institute, UK
- Swerea MEFOS (coordinator), Sweden
Mineral processing and extractive metallurgy for mining and recycling innovation association

FROM basic research to pilot scale demonstration modelling to engineering

Mineral Processing

Pyrometallurgy

Hydrometallurgy

Process evaluation and optimisation (LCA, LCC...), Market studies
35 members (11/2016)

* At November 2016, 29 full members + 6 associated members
development of skills, instincts, abilities and resources that are needed to survive, adapt, and thrive in a fast-changing world

Prometia
contributing to Capacity Building

Develop innovative technological solutions for optimizing raw materials and waste treatment

R&D

Primary resource
Ore mining
(clean, efficient, accepted mines)

Secondary resources
Urban mines
(EoL products, recycling waste)

Industry
To boost innovation capacity of raw materials related sectors in EU and create wealth in Europe

Secondary resources
Industrial waste
(solving environmental issues by valorising by-products)

T&E
To enhance EU skills in mineral processing and extractive metallurgy and train next generation of engineers
In the CIRCULAR ECONOMY

From ERA.MIN2
Circular economy
Mining vs Recycling...

Recycling EoL products will never cover the needs of a metal in growing demand...
The recycling rate, the collect and the dilution in complex media are the main issues

We need to develop new mining strategies, relevant in the European context... cleaner, safer, more efficient, including the post-mine management. « sustainable mining »
The PROMETIA "value-flow": becoming an efficient link between industry and R&D

Promoting wealth creation and innovation by strengthening the link between industry and research

- Industrial needs
  - Gather the industries’ needs, structuration of the needs, coordination, identification of key R&D partners
  - Survey on potential funding sources, support to project writing
  - Transfer innovation to industry

- R&D partners
  - Funding sources

- Pilot Platforms
  - First qualification on pilot platforms before transfer to industry
  - R&D topics to the Network coming from pilot platforms tests
Creation of a common multi-stakeholder platform focused on the refractory metals across their whole value chain. This initiative involves partners from across the value chain, including mining, processing, recycling, application, public sectors (national/regional/local) and civil society.

21 consortium members + 30 External Experts

19 Months, 1.5M€
Project funded under the SC5 H2020 work-program, project n° 688993, 2016
For each metal:
- Mining/collection
- (mineral) processing
- Extractive metallurgy
  - Hydro
  - Pyro
- Waste/Environmental impacts
- Substitution
- Policy issues/regulations
State of the art
Stéphane Bourg

MAP OF THE PRIMARY RESOURCES IN EUROPE

MAPPING OF THE PRIMARY RESOURCES IN EUROPE

(Mo, Nb, Re, Ta, W)

MAP OF REFRACTORY METAL DEPOSITS IN EUROPE

(Deposits, reported amount of refractory metal)

- Deposit containing medium amount of metal (> 50,000 t of metal)
- Deposit containing large amount of metal (> 100,000 t of metal)
- Deposit containing very large amount of metal (> 500,000 t of metal)
- Deposit containing trace amount of metal (0-5000 t of metal)
- Deposit containing very low amount of metal (< 500 t of metal)
- Deposit containing low amount of metal (500-5000 t of metal)

- Small deposit containing metal
- Medium deposit containing metal
- Large deposit containing metal
- Very large deposit containing metal

- Small deposit containing trace amount of metal
- Medium deposit containing trace amount of metal
- Large deposit containing trace amount of metal

- Medium occurrence containing trace amount of metal
- Medium occurrence containing medium amount of metal
- Medium occurrence containing large amount of metal
- Medium occurrence containing very large amount of metal

- Small occurrence containing trace amount of metal
- Small occurrence containing medium amount of metal
- Small occurrence containing large amount of metal
- Small occurrence containing very large amount of metal

- Occurrences - unknown amount of refractory metal

- Ta, small

- Wartowice

- Niecka Gruzniecka (Mo, Lubin, Matejico)

- >100,000 t Mo

- >5000 t WO₃

- Berlin

- Prague

- Vienna

- Bratislava

April 2016
MAPPING OF THE SECONDARY RESOURCES

Secondary resources of Molybdene

<table>
<thead>
<tr>
<th>Type of Material</th>
<th>Company/ Mine</th>
<th>Location</th>
<th>Grade of Mo</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste tailings</td>
<td>Boliden Aitik</td>
<td>Sweden</td>
<td>0.00027%</td>
<td></td>
</tr>
<tr>
<td>Waste rock</td>
<td></td>
<td></td>
<td></td>
<td>[18]</td>
</tr>
</tbody>
</table>

- Aitik porphyry Cu-Au-Ag-Mo deposit Ore feed, 36 000 with a Mo concentration of 0.049 Mt. Tailings produced of 17 700 000 and 26 000 k/t/year of waste rock.

- 8 million tonnes of waste material produced and deposited in two ponds, 42 000 000 tonnes have been washed and deposited sediments of the river.

Chemical composition of tailing pond Cq 215, Mo S1.
Other materials: Ba, Cu, K, La, Li, Mg, Mn, Mo, S, Th, Y, Zr.

<table>
<thead>
<tr>
<th>Waste tailing</th>
<th>Company/ Mine</th>
<th>Location</th>
<th>Grade of Mo</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste tailing</td>
<td>Knaben</td>
<td>Norway</td>
<td>40 ppm acid-soluble Mo</td>
<td>[16]</td>
</tr>
<tr>
<td>Molybdenumines</td>
<td></td>
<td></td>
<td>Molybdate (MoO₄)²⁻</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Associate with fine-grained silicates or oxides.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size particle: 0.2-0.9</td>
<td></td>
</tr>
</tbody>
</table>

- Estimated Rhenium production from recycled materials

<table>
<thead>
<tr>
<th>Country</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>4.0</td>
</tr>
<tr>
<td>Poland</td>
<td>0.5</td>
</tr>
<tr>
<td>France</td>
<td>1.0</td>
</tr>
<tr>
<td>Estonia</td>
<td>1.0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>0.5</td>
</tr>
<tr>
<td>Global</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Total quantities of WEEE collected in the EU28+ Norway in 2012

| Large household appliances | 1 495 000 |
| Small household appliances | 224 500  |
| IT and telecommunications equipment | 615 000 |
| Consumer equipment         | 572 500   |
| Other                      | 187 000   |
| Total WEEE                 | 3 474 000 |
Molybdenum metal and alloy production in the value chains (shown in Figure 1).
Current and future value chains
As an example: Current value chain of tantalum (based on 290 MT/year)

**Sources of Ta outside EU to EU**
- Waste and scraps: 160 MT
- Slag, ash and residues containing mainly Ta and Nb: 75 MT
- Ore and concentrates: 75 MT/year

**Sources of Ta inside EU**
- EU mines: 5 MT
- Echassières (F) resources: 5,000 MT Ta+Nb

**Processing Plants**
- Extractive Metallurgy
- Mineral Processing
- Extractive Metallurgy

**Intermediate Products**
- Ta carbides
- Ta fabricated sheets, plates, rods, wires
- Ta powder
- Ta nitrides
- Ta ingot
- Others: Ta₂Os, LiTaO₃, etc.

**End-Use Products**
- Cutting tools
- High temperature furnace parts
- Chemical process equipment
- Prosthetic devices
- Capacitors
- Electronic parts
- Sputtering targets
- High temperature alloys
- Projectile for missiles
- Surface acoustic wave filters, optical modulators, X-ray films

**End-Use by Industries**
- Machinery and equipment
- Chemistry
- Medical industry
- Automotive
- Electronics
- Aerospace
- Military
- Various industries

**EU Recycling**
- 50 MT

**Metallurgical wastes (slag, dust, …)**

**Ta loss in the waste to the environment**

**Very little recycling of scraps and out of specification products**

**GLOBAL Ta RECYCLING <20%**

(work rate ~20 %)

MT = metric tonne
**The future value chain**

**Example on tantalum**

### As an example: Future value chain of tantalum (based on 400 MT/year)

<table>
<thead>
<tr>
<th>Sources of Ta outside EU to EU (MT of Ta)</th>
<th>Processing Plants</th>
<th>Intermediate Products</th>
<th>End-Use Products</th>
<th>End-Use By Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste and scraps (~160 MT)</td>
<td>Processing</td>
<td>Ta carbides</td>
<td>Cutting tools</td>
<td>Military and equipment</td>
</tr>
<tr>
<td>Slag, ash and residues containing mainly Ta and Nb (~75 MT)</td>
<td>Processing</td>
<td>Ta fabricated sheets, plates, rods, wires</td>
<td>High temperature furnace parts</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Ore and concentrates (~30 MT/year)</td>
<td>Mineral Processing</td>
<td>Ta powder</td>
<td>Chemical process equipment</td>
<td>Medical industry</td>
</tr>
</tbody>
</table>

### New Resources

**New processes**

**Stabilisation of imports**

**New processes**

**Increase the recycling of scraps and out of specification products**

<table>
<thead>
<tr>
<th>SOURCES of Ta inside EU (MT of Ta)</th>
<th>Extractive Metallurgy</th>
<th>Innovative Processing</th>
<th>Extractive Metallurgy</th>
<th>Innovative Processing</th>
<th>Extractive Metallurgy</th>
<th>Innovative Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU mines: * Echassières (F)*</td>
<td>~5,000 MT Ta+Nb</td>
<td>~20 MT</td>
<td>~2 MT</td>
<td>~5 MT</td>
<td>~1,600 MT Ta</td>
<td>~20 MT</td>
</tr>
<tr>
<td>EU mines: * Tréguennec (F)*</td>
<td>~3,600 MT Ta</td>
<td></td>
<td></td>
<td></td>
<td>~2 MT</td>
<td>~5 MT</td>
</tr>
<tr>
<td>Secondary Cu meltter slags</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary High Grade Sn slags</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### New processes

**Recycling of some EoL products**

**Metallurgical Wastes (slag, dust, ...)**

**GLOBAL Ta RECYCLING in EU > 40 %**

**Assumption:**

- EU Recycling ~120 MT
- New processes
- New facilities

**Ta loss in the wastes to the environment**

**Recycling of some EoL products**

- Ta loss in the wastes to the environment
- Increase the recycling of scraps and out of specification products
- New resources
Innovation pathways
1. Recovery From Slags

High-grade tin slags (>10% Nb+Ta)
   → could be developed in Europe with no further R&D efforts

Low-grade tin slags (<10% Nb+Ta)
   → no economic reason to be recycled

Copper smelting slag
   - a limited R&D programme could be proposed, including recovery of the different valuable metals (not only W)

2. Recovery of Ta from alloy scrap

- Currently Ta from alloy scrap is recycled to low-value mill products
- New process based on iodization of Ta scrap (Lessard, 2015)
  - Process designed for the production of electronic grade Ta nanopowders
    → clearly innovative but what about its cost at industrial scale?
FIRST TRENDS FOR INNOVATION: SUBSTITUTION

NIIOBIUM

EU consumption of niobium → 24% of global niobium consumption.
No primary niobium production in Europe → scrap is the only available intra-European raw material source
Ores and concentrates, oxides and niobium metal → Imported
Need to recycle and find potential substitutes to satisfy increased demand
Potential (partial) substitutes for Nb in steel: ‘Titanium & Molybdenum’ and ‘Vanadium & Molybdenum’ combinations

TANTALUM

No primary production of tantalum in Europe
Clear need for substitution or increasing recycling rate
Most substitutes have higher costs or adverse properties.
In low performance capacitors, possible substitutes exist (by aluminium and ceramics),
In other application areas possible substitution of tantalum by niobium (CRM) is possible – rationale?
  • In cemented carbides also titanium carbides (TiC) and nitride (TiN) are possible
  • In corrosion-resistant equipment: glass, platinum, titanium, and zirconium
  • In high-temperature applications: hafnium, iridium, molybdenum, rhenium, and tungsten
SCRREEN
Solution for critical raw materials, a European Expert Network
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730227

30 Partners in the Consortium + 60 in the wide Network
30 month (+1?) , (Nov-16 – Mai-19) (Jun-19?)
3M€

Coordinated by CEA
Objective


Addressing all the CRMs issues including mining, processing, recycling, substitution and final applications in relation with the crosscutting aspects: policy/society, technology, standards and markets.

Strengthening the CRM strategy in Europe.
Structure

1. Network creation and management

2. Current and future use of CRM

3. Mapping the resources

4. Production, State of the art:

5. Substitution of CRM

6. Technology gaps/barriers and innovation pathways in CRM's value chain

7. Policy issues

8. The WEEE issues

9. Knowledge management

10. Communication/Dissemination

11. Clustering

12. Project Management

EXPERT NETWORK

Association, Networks, Clusters, Projects, Public bodies, NGO, RTO, Academia, Industries, ...

Market Expert Group

Ressource Expert Group

Technology Expert Group

Substitution Expert Group

Circular Economy Expert Group

Regions/Governments/Policy Expert Group
A Comprehensive Knowledge Management Structure

As an input to the EURMKB/RMIS: the SCRREEN unified vision of Knowledge Management
CONCLUSION
Activities

Support to ERA.MIN2 – PROMETIA is member of the Advisory Board (advising on the orientation of the calls)

PROMETIA support partner of the EIT-RawMaterials

Presentation of MSP-REFRAM at ECO-Recycling

Presentation of PROMETIA and MSP-REFRAM at ReinEU conference in Bratislava, invited by DG-GROW

Presentation of PROMETIA at the EU-US-Japan trilateral conference on CRM as an association contributing to capacity building in Europe, invited by DG-GROW

A position paper sent to the DG-GROW commenting the H2020 SC5 work-program (and exchanges with Mattia Pellegrini on this paper)

Three MSP-REFRAM workshops

Videos and pictures at www.prometia.com
Conclusion

PROMETIA:

- a focused network (mineral processing, extractive metallurgy),
- about 35-40 members up to now
- with people
  - who meet and know each other
  - who can work together, learn the ones from each others,
  - who create synergism
- With a high visibility at the EU level

For academia, being in contact with SMEs/Industry is a driver for orienting R&D and making it attractive. It is also a driver for an up to date education program.

For Industry, having direct access to research organisations can help when they have specific issues to be solved rapidly. It is also an access to training forces.

R&D is better focused – **importance of TRL 3-5 to fill the shelves and prepare the future**
THANK YOU

www.prometia.eu
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