W Production

Jason Yang, GTK

Final Conference 9-10/03/2017
Brussels, Belgium

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

W Production

W Production in EU 8,000 t, and demand 10,000 t

From Primary Resources
total mine production **2,830 t** from EU in 2015

From Secondary Resources (mine tailings & metallurgy wastes)
no separate recovery mining and extraction processes;
W recovered from mine talings is normally contributed into mine production

From Urban Mines
W production from recycling is about **5,000 t** in EU (recycling rate 50% (ITIA, 2013)

MSP REFRAM
Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Primary Resources

Minerals and deposits

W production is two minerals Scheelite ($CaWO_4$) and Wolframite (Fe, Mn) WO_4) and five major types ore deposits are (BGS, 2011):

Deposit type	Deposit size, t	Typical grade, WO_3%	Estimated W content, 1000 t	% of total
Skarn	$<10^4$–5×10^7	0.3-1.4	1764	41
Vein/breccia/stockwork	$<10^5$–10^8	variable	1475	35
Porphyry	$<10^7$–10^8	0.1-0.4	679	16
Disseminated	$<10^7$–10^8	0.1-0.5	217	5
Stratabound	$<10^6$–10^7	0.2-1.0	118	3
Total			4253	100

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Primary Resources

W mine production

Total mine production **2,830 t** (in the form of W concentrate) from EU in 2015

- Australia, production 870 t W in 2015
  Mittersill mine, scheelite deposit, Ostfeld open pit and Westfeld underground, 0.65 % WO3

- Spain, production 730 t W in 2015
  Los Santos mine, scheelite deposit, open pit, 3582,000 t @ 0.23% WO3,; Barruecopardo mine, scheelite deposit, open pit, 27.39 Mt @0.26%

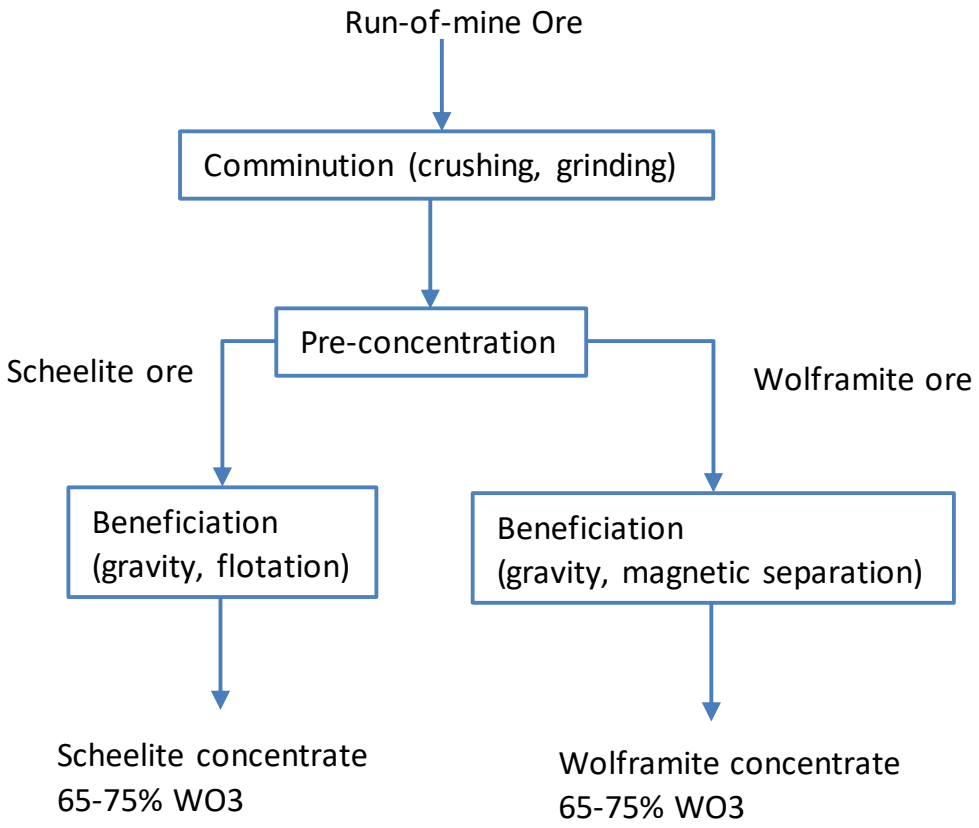
- Portugal, production 630 t W in 2015
  Panasqueira mine, wolframite deposit, underground mining, 4.91 Mt @ 0.22 % WO3,

- UK, production 600 t W in 2015
  Hemerdon mine, wolframite deposit, open pit, 35.7 Mt @ 0.18% WO3

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Primary Resources

W concentrate production



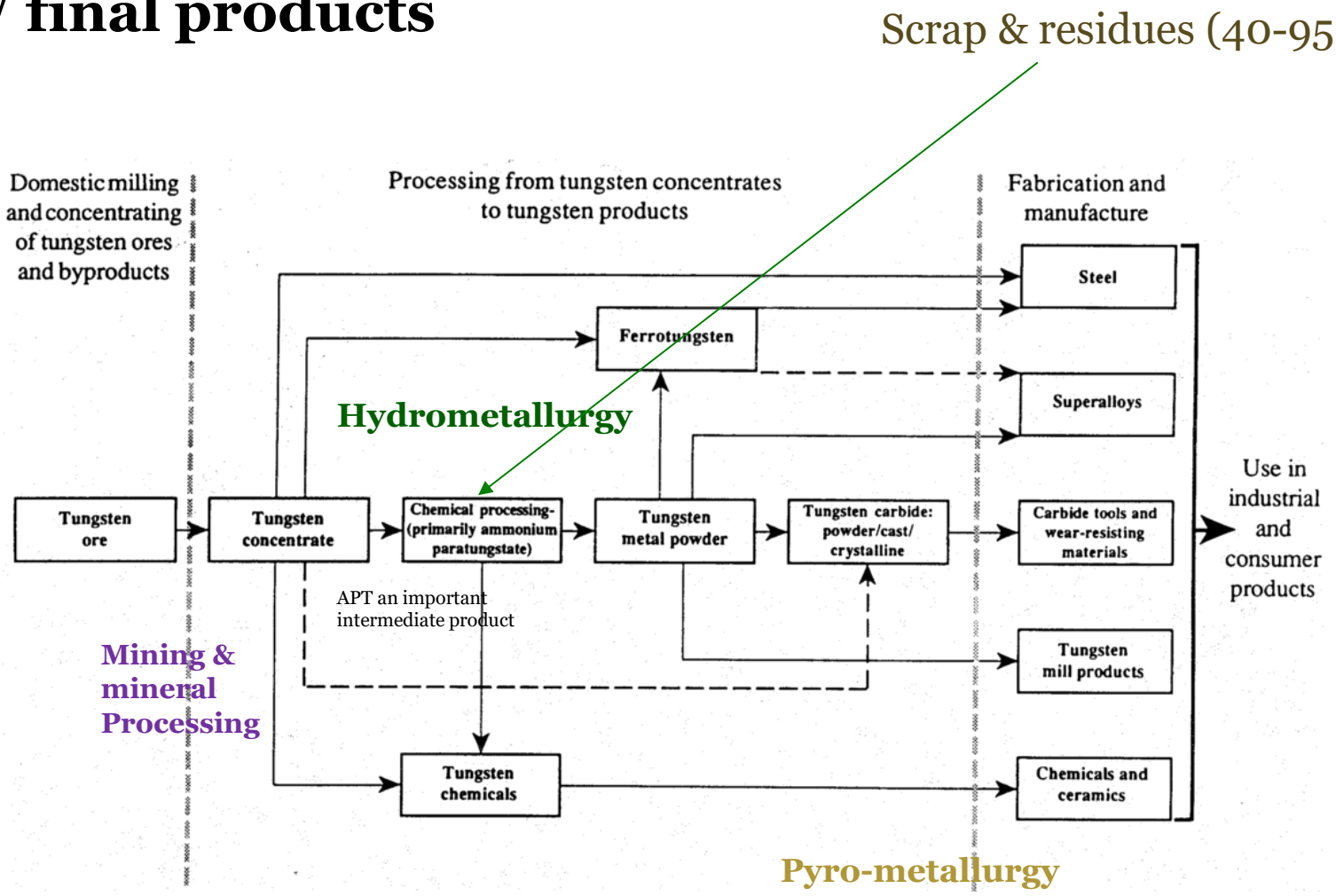
Operational Problems

- Fine liberation of tungsten minerals such as 10-20 µm.
- Weathering and other alteration processes
- Scheelite is often associated with other Ca-bearing minerals (such as calcite, fluorite and apatite)
- Losses of tungsten occur in slimes

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Primary Resources

W final products



Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Secondary Resources

Tailings dump at La Parrilla Mine

Mine & milling tailings:

- Waste-rock derived from rock blasting, slimes from milling processes in Panasqueria mine, Portugal;
- W-bearing dumps in Barruecopardo mine, Spain, 0.02-0.04% WO_3;
- Coarse and fine rejects from milling in Los Santos mine, Spain, 0.1-0.2% WO_3, and coarse tailings and slimes in La Parrila mine, Spain, 0.28% WO_3
- Mo flotation tailings in Luanchuan mine in China, 0.14% WO_3

Metallurgy wastes

W-containing grinding sludge/swarfs: during grinding processes the forming of metal objects, extremely fine metal fragments are cut off from the objects.
Mill scale: generated during the continuous casting and rolling mill processes, where steel is subjected to hot working in the oxidant atmosphere. **Others,** e.g. steelmaking dust, grinding dust, floor sweeps

REFRAM MSP

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Secondary Resources

Mining & milling of W-containing tailings:

About 450 million metric tons per year of mill tailings are generated from various ores concentration processes.
Reprocessing testwork & activities at mines by grinding, garvity & magnetic separation, flotation. In Cantung Mine, Canada, tailings reprocessing locked cycle flotation tests to determine the feasibility of recovering a marketable concentrate; In La Parrila mine, Spain, a pilot plant testing is currently being undertaken to assess the concentration on the fraction -2 mm tailings existing in the dumps of La Parrilla Mine; In Panasqueira Mine in Portugal flotation, magnetic separation and gravity concentration testwork, was undertaken at both laboratory and pilot scale on the historical mine tailings and on the current slimes tailings of the plant; The containing scheelite tailings of Molybdenum flotation from Luanchuan mine in China was re-concentrated to recover scheelite by flotation.

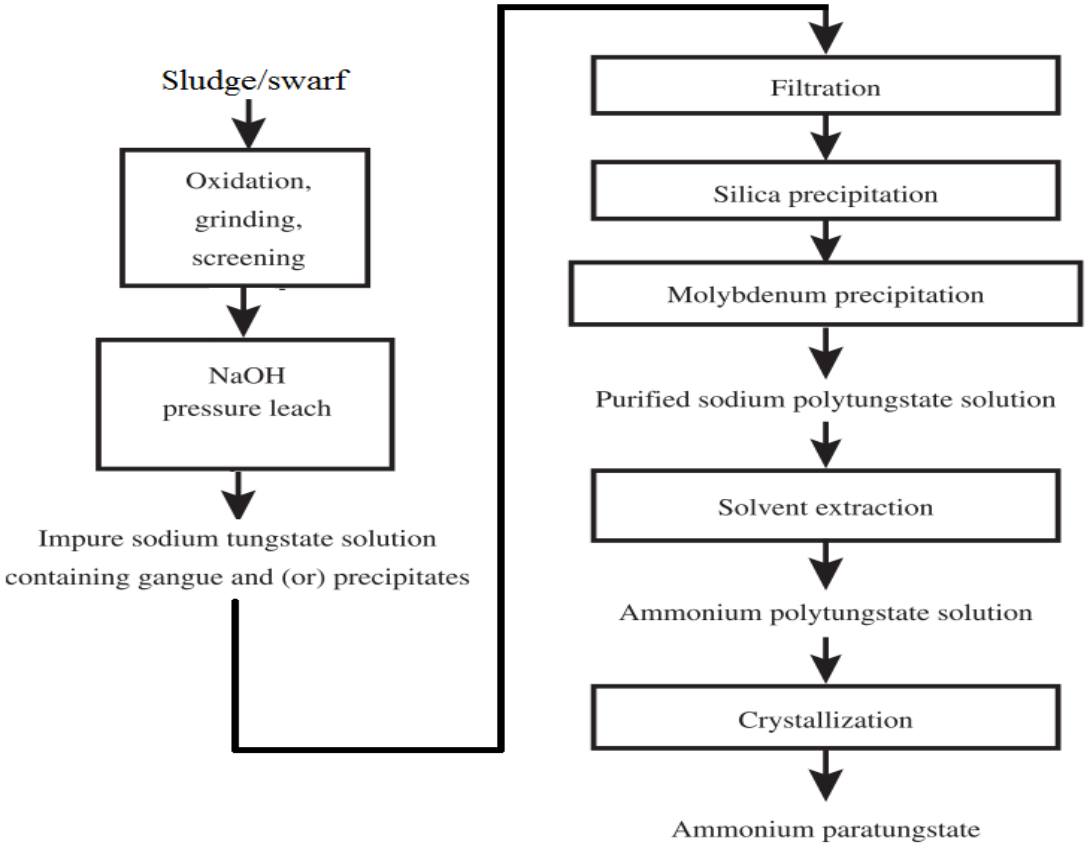
Pre-treatment of W-containing residues
The W-containing mill scale normally needs to be crushed or even ground into fines and made into briquettes before it can be charged into the reduction reactor to extract the W.

REFRAM MSP
Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Secondary Resources

Extractive metallurgy

A flow sheet for the recovery of tungsten as ammonium paratungstate (APT) from sludge/swarf by the hydrometallurgical process has been reported.



Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Urban Mines

W production from recycling is about 5,000 t (recycling rate 50% in Europe according to ITIA, 2013)

- Cemented carbide scrap:
  62% W used in cemented carbides (WC) in EU
- Heavy metal alloy scrap:
  17% W used in steel alloys
- Mill products scrap:
  15% W used in “mill products e.g. rod, sheet and wire, electrical contacts
- Other (Ni-W catalysts, W electrodes etc.)

REFRAM

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Urban Mines

Pre-treatment

Depending on the types of wastes these techniques include the following:

- Physical dismounting/sorting and/or sorting by chemical analysis into different grades. The sorting will lead to a purpose-oriented recycling of various W-bearing waste;
- Crushing, screening, milling and grinding. This will produce a waste being adapted to a specific recycling process;
- Acid cleaning to remove the impurities;
- Roasting, chlorination, alkali fusion, oxidation and electrolytic dissolution, etc.

REFRAM MSP

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Urban Mines

Extraction techniques

The methods for extracting W from the wastes include direct recycling, semi-direct recycling, pyro-metallurgy and hydro-metallurgy:

a) Direct recycling. The wastes are transformed into powder with the same chemical composition of the wastes by chemical and/or physical treatment; thereafter the powder is used to produce new products.

b) Semi-direct recycling. Heavy metal pieces (such as cemented carbide scrap pieces) are selectively dissolved by chemical method, leaving undissolved tungsten carbide to be recycled.

c) Pyro-metallurgy. Scrap is smelted in the furnace and the tungsten in the scrap is used as alloying element and thereby recycled.

d) Hydro-metallurgy. Chemical methods are applied to recycle tungsten in the form of compounds, which can be used as a substitute of tungsten ore concentrate.

REFRAM MSP

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)

Growth of W production in EU

Potential pathways

Extending mine production:

possible but depending on market; Wolf Minerals (UK) and Tungsten Resources (Spain) have invested to increase the mine production

Increase of W production from mine tailings and metallurgical wastes:
Strong challenges faced on technology, economy and environment

Increase W production from Urban mines:

Higher recycling rate is expected. Challenges faced: a steady supply (collection), feasibilities (technology, economy), environmental impact

REFRAM

Funded by the Horizon 2020 Framework programme of the European Union (Grant Agreement Number 688993)