Metals Recovery and recycling in zinc industry

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PROMETIA Scientific Seminar
Barcelona, 28-29.11.2017

Boliden operates mines and smelters in Nordic countries

- Main metals are zinc and copper
- Produces also gold, silver, lead and nickel

- Number of personnel 5 500
- of which 1 500 in Finland

- Turnover 4,2 mrd €
- Shares are quoted on the Stockholm Stock Exchange

- The discover of the large gold finding in Boliden, Sweden 1924, laid the foundation of the company

- Sweden, Finland, Norway, Ireland:
  - Six mining areas
  - Five smelters

Exploration

Mining

Smelting

Metals recycling

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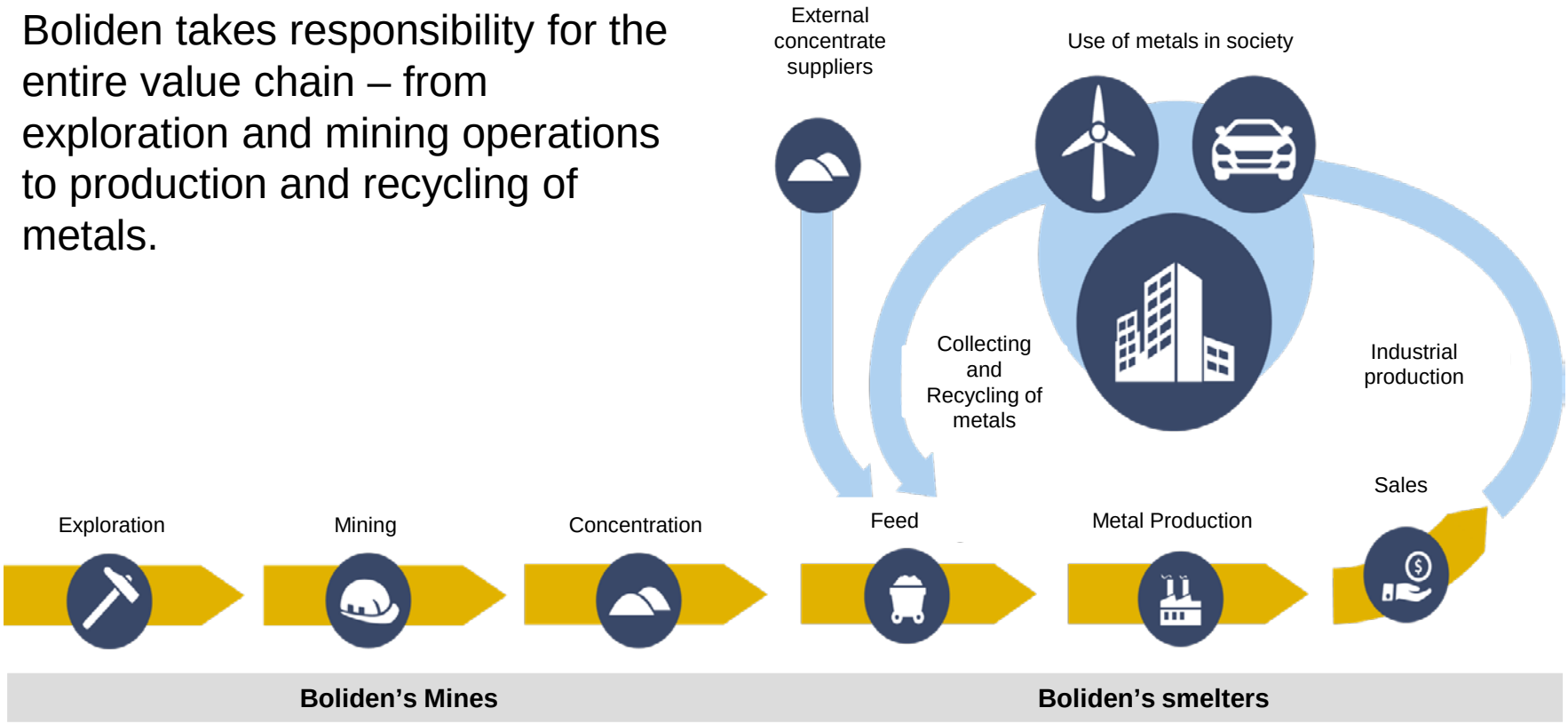
Boliden – a part of circular economy

Boliden takes responsibility for the entire value chain – from exploration and mining operations to production and recycling of metals.



Boliden mines

Aitik – 680 employees

Copper, gold, silver, 36 051 ktn
Open-pit mine

Boliden - 580 employees

Zinc, copper, lead, gold, silver, 2 138 ktn
Three mines, one open-pit mine

Garpenberg - 430 employees

Zinc, silver, lead 2 622 ktn
Expansion 2014

Kevitsa - 380 employees

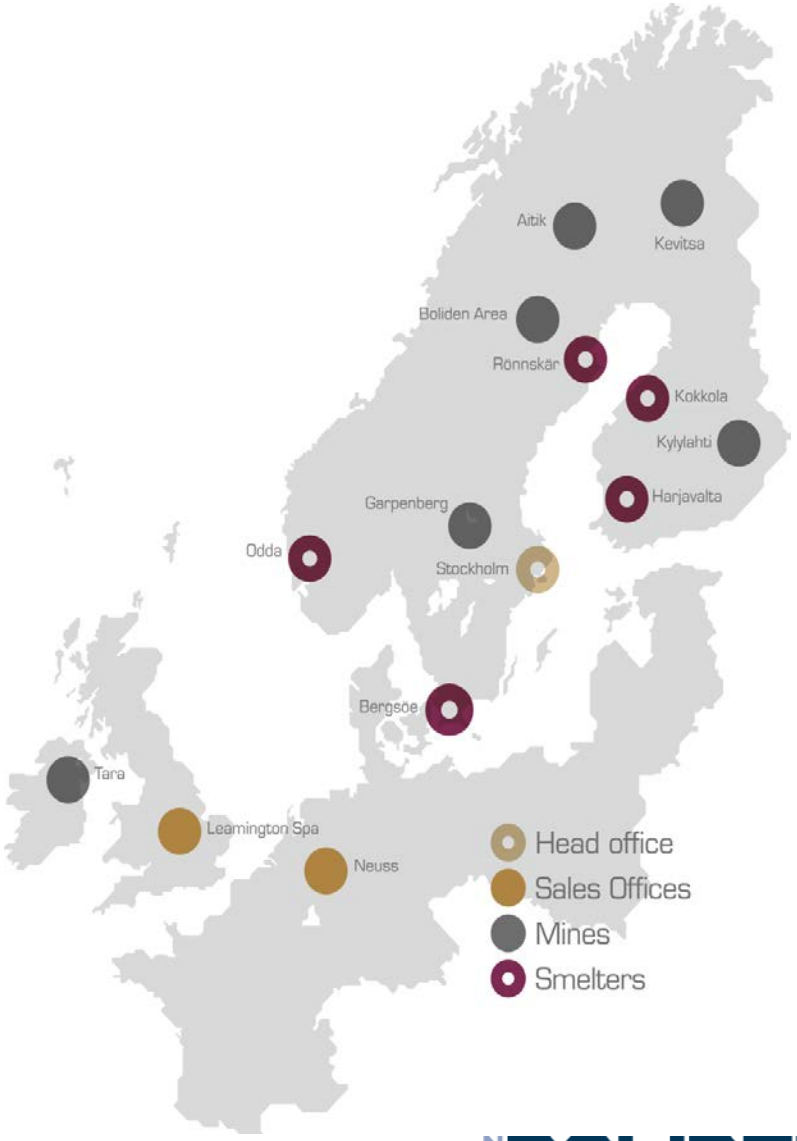
Nickel, copper, gold, platinum 4 518 ktn
Acquired 2016

Kylylahti - 110 employees

Copper, gold, zinc, silver, 797 ktn
Acqcuired 2014

Tara - 590 employees

Zinc, gold, silver, 2 603 ktn
Biggest zinc mine in Europe



* Production figures 2016

Boliden smelters

Kokkola - 540 employees

Zinc, 290 000 tn
Second largest zinc plant in Europe

Odda – 290 employees

Zinc, 170 000 tn
Expansion project

Harjavalta - 500 employees

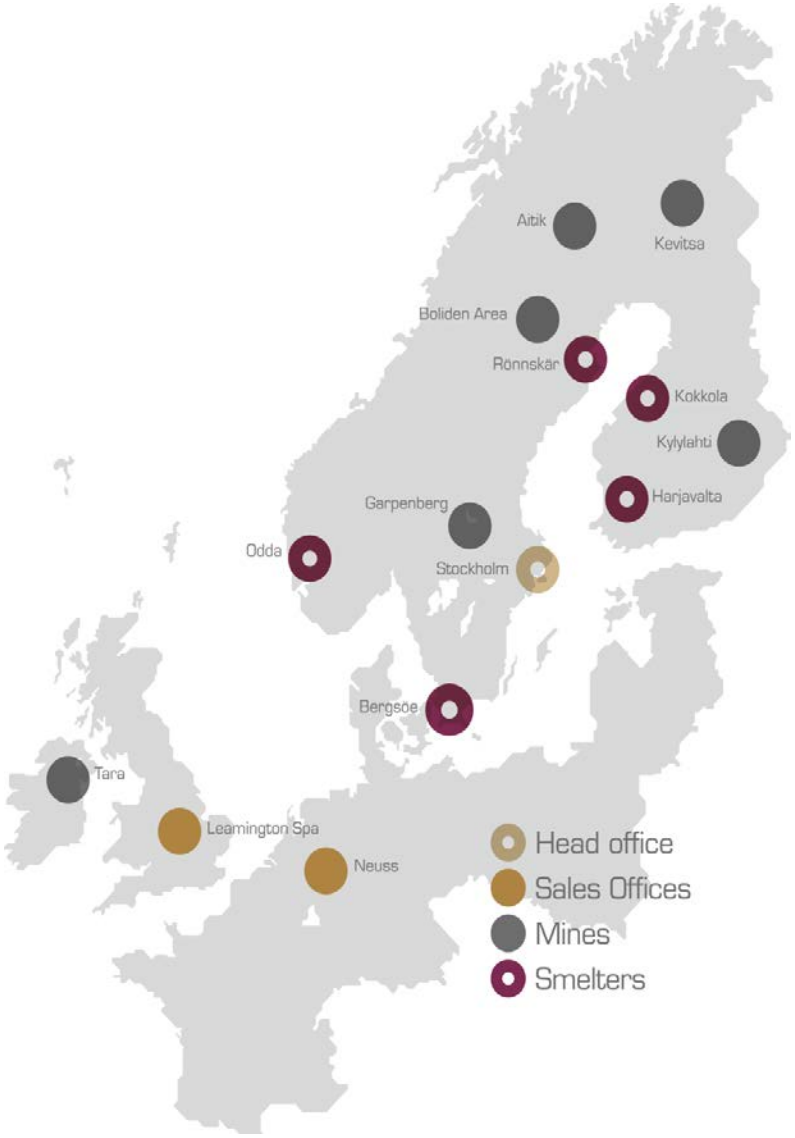
Copper, 129 000 tn, nickel 31 000 tn
Operations in Harjavalta and Pori

Rönnskär - 860 employees

Copper, 207 000 tn
Recycles electronic scrap

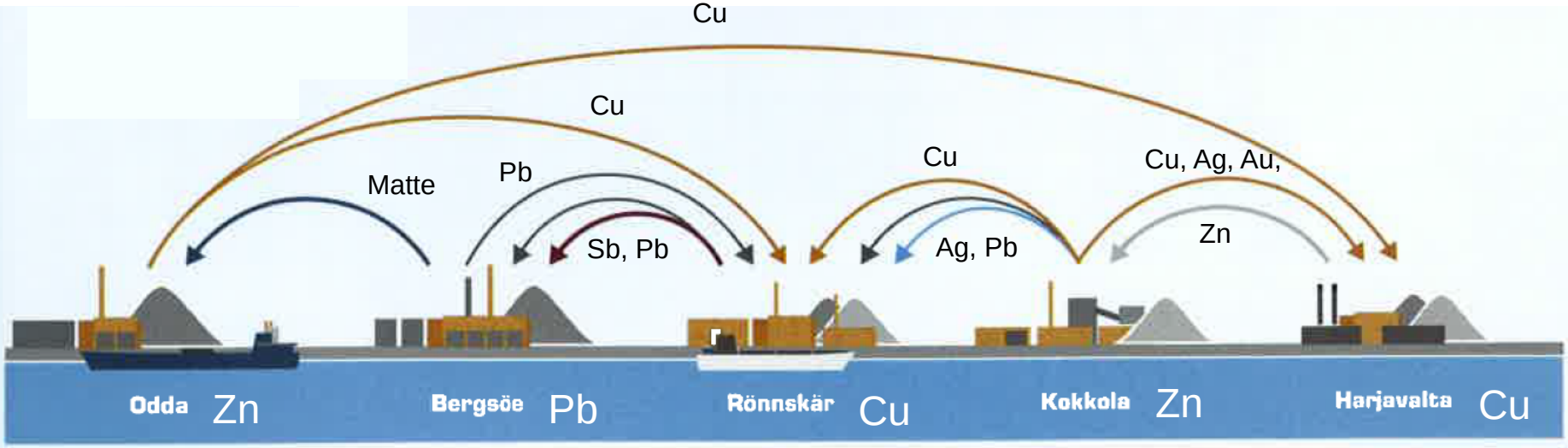
Bergsöe - 70 employees

Lead, 46 000 tn
Recycles lead batteries



* Production figures 2016

Boliden smelters material circulation



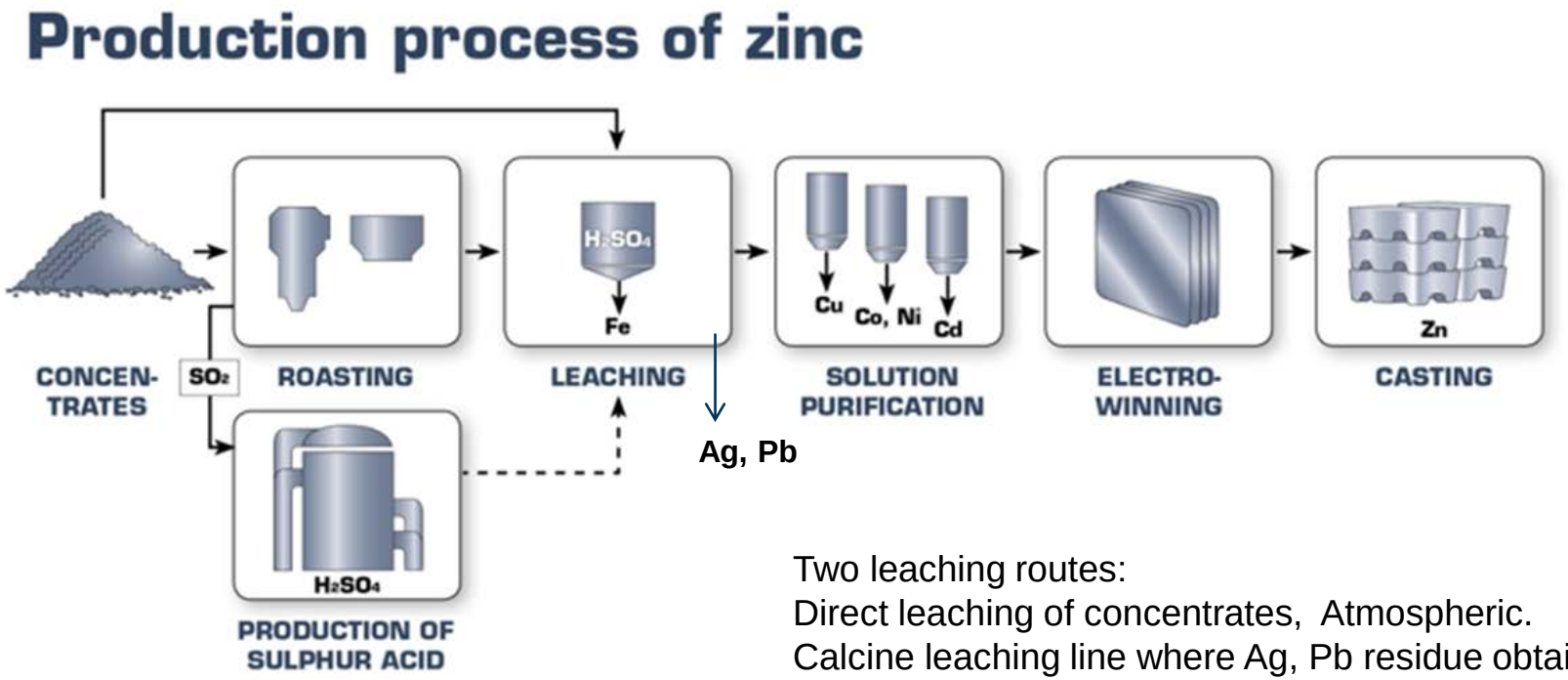
Copper-bearing waste
Lead-bearing dust
Antimony
Silver
Zinc-bearing filter dust
Matte

Copper-bearing by-products are sent from the Odda and Kokkola zinc smelting plants to Rönnskär and Harjavalta for recovery of the copper. Bergsöe sends lead-bearing dust to Rönnskär and matte to Odda for final storage in rock caverns. Rönnskär sends a residual product containing lead and antimony to Bergsöe. Lead and silver slag is sent from Kokkola to Rönnskär for lead and silver production. Zinc-bearing filter dust from the Harjavalta copper smelting plant is sent to Kokkola for zinc recovery.

Boliden Kokkola is the second largest zinc plant in Europe

Ref.: Boliden Kokkola zinc plant

Conventional zinc production Roast Leach Electrowinning (RLE) process and direct leaching



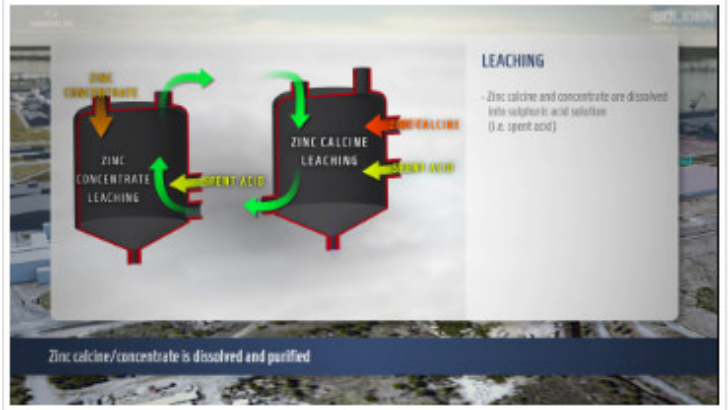
Two leaching routes:
Direct leaching of concentrates, Atmospheric.
Calcine leaching line where Ag, Pb residue obtained
-Iron mostly as jarosite residue to a pond.
-Sulphur from direct leaching to a pond.

Ref.: Boliden Kokkola general flowsheet

Boliden Kokkola
- Second largest zinc plant in Europe

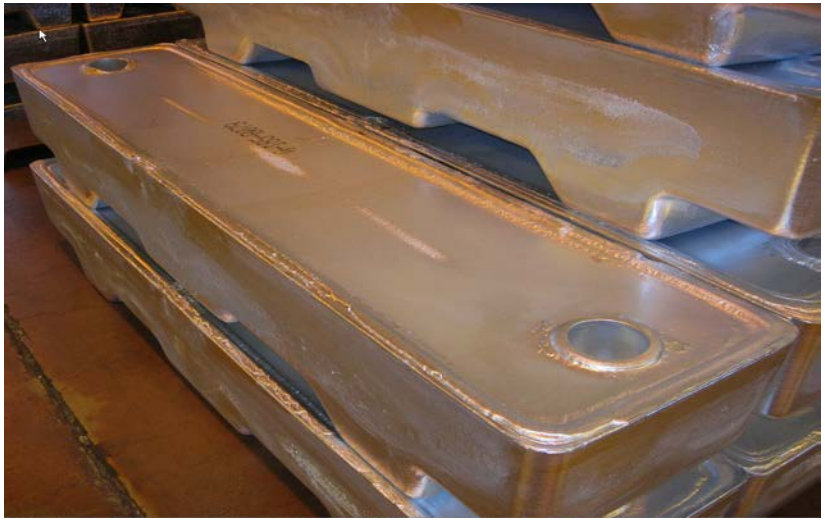
- Production capacity 315 000 tonnes annually.
- Main products: zinc and zinc alloys.
- 85 % of production is exported.

Animation: Overview Kokkola



Animation: Production process

Zinc ingots



Ore bodies are more complex including more unwanted impurities

- The demand of metals will increase.
- Recycling will be more important part of the metals circulation but it will not replace the need of primary production.

Need for

- Cost effective innovations and technologies.
- Improved energy efficiency.
- Full benefit from the side streams and minimization of the amount of generated wastes.
- Outlet and safe disposal or usage for the unwanted impurities (As, Cd, Hg, Ca, Fe, Si, F, Cl…).

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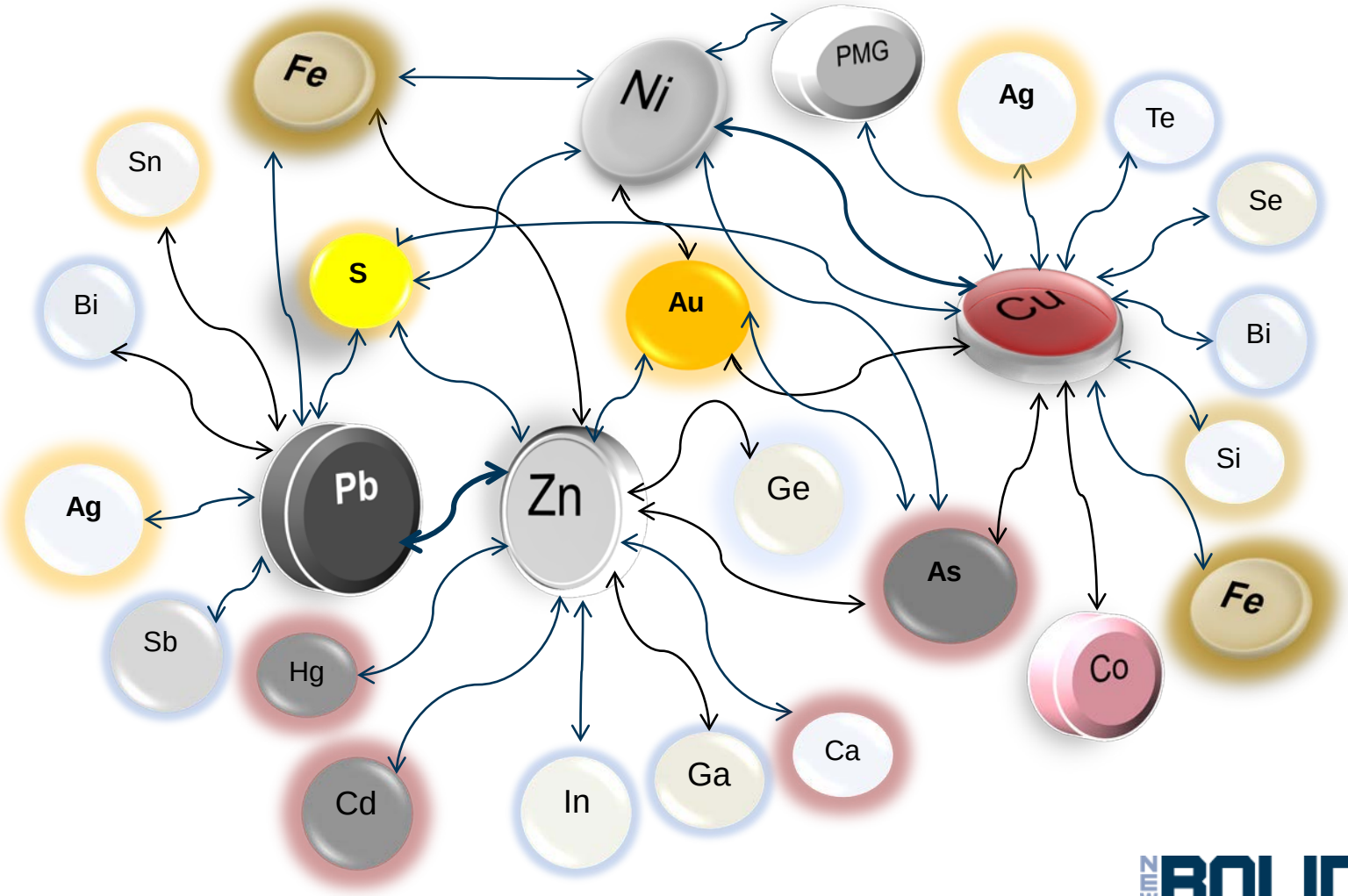
By-product metals are obtained within primary production

-Primary and secondary mineralogy differ

-Recycling cannot cover all needed elements but can avoid some unwanted species



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Zinc process produce of iron residue that is landfilled

- Precipitation of iron removes harmful impurities (As, Al, Ge, Pb, F, Hg…) from the process and is part of solution purification prior electrolytic recovery of 99,995 % pure zinc metal.

- Direct Leaching in Kokkola makes jarosite and sulphur residue that is landfilled as combined waste = Jarosite, [NaFe3(SO4)2(OH)6] + sulphur.

- Boliden Kokkola has invested in double filtration process making the residue mechanically more stable and reduces the volume required.

Landfill outlook globally for iron residue

No landfilling allowed at the site

- Some sites in Europe and Asia – Increasing trend. No landfilling in China.
- In many cases iron rich sludge or leach products must be transported elsewhere for treatment or processed at the site.

Landfilling allowed with stabilization

- Jarofix stabilization for non sulphur containing iron residue.
- Metals stabilization by sulphidation.

Pyrometallurgical treatment of zinc or non-ferrous residues

- Pyrometallurgical methods (Ausmelt, ISASmelt, Plasma..) used for making ***cleaner stable slag*** that can be used for urban development. Limits given for Pb and Zn.
- Simultaneous metals recovery from oxide dust (Zn, Pb, Cd, Ag, As, Hg, In, Ga, Ge).
- Different pyrometallurgical concepts in operation in China, South Korea, India, Europe, and Australia.

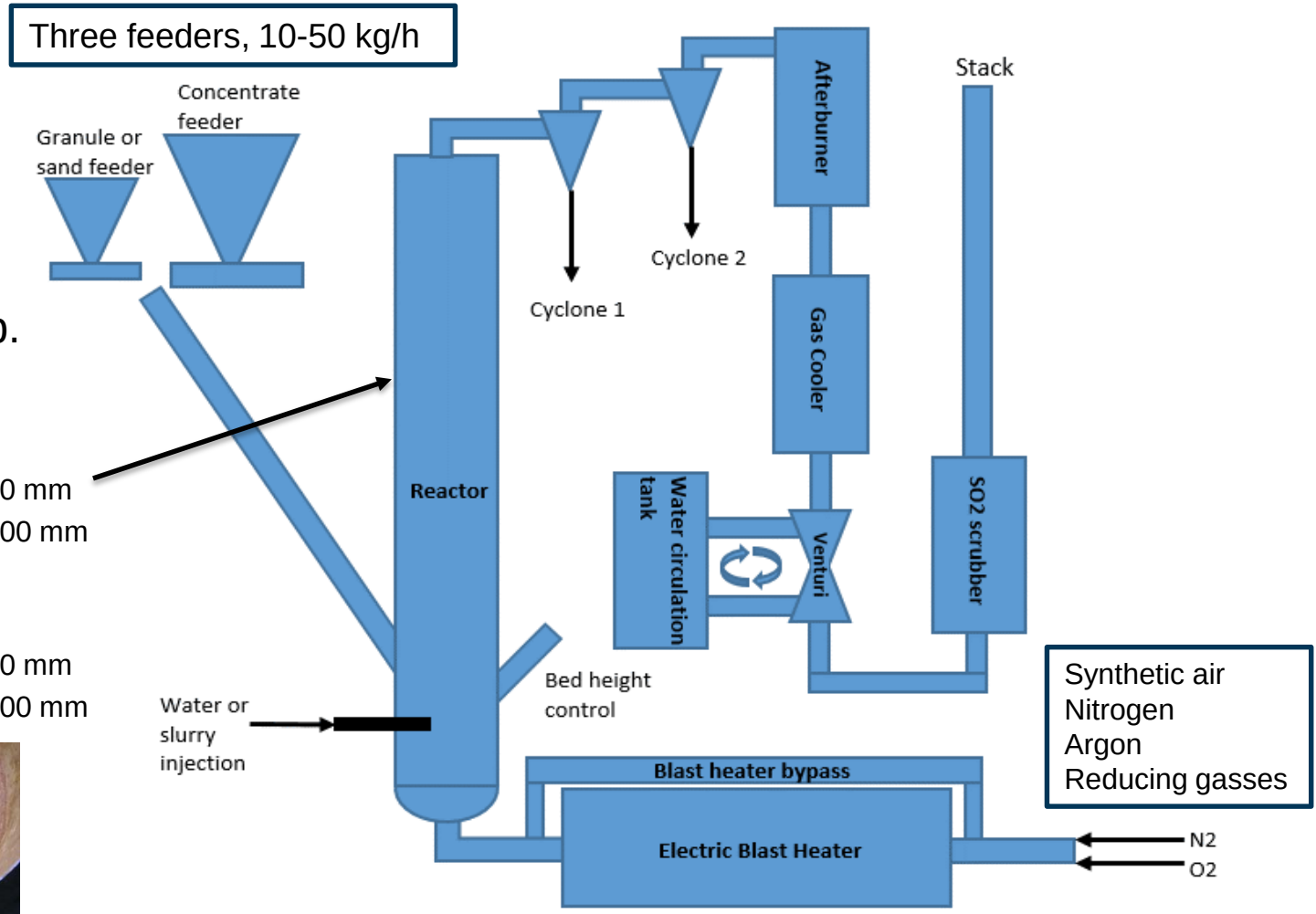
Boliden Kokkola pond area sections

Zn residue treatment – Sulphur residue

- Boliden Kokkola produces 100 000 t of sulphur residue annually. Sulphur content circa 80 wt-%.
- Sulphur is currently mixed with jarosite as combined waste and landfilled.
- The amount of sulphur residue in separate historical pond is currently
  828 000 t (332 000 t dry).
- Sulphur residue is roasted in fludized bed reactor and also making suitable SO2 for sulphuric acid production.
- After roasting valuable metals in calcine (Zn, Ag, Cu, Pb) can be recovered and elements of concern (As, Hg, Cd…) safely disposed .

Fluidized bed pilot tests (FBR) carried out successfully with different feeding strategies. Test work at MEFOS Luleå.

- 970°C max temp.
- Dimensions
  - Freeboard
    - Diameter 300 mm
    - Height 6000 mm
  - Bed
    - Diameter 200 mm
    - Height 2000 mm



Lindbäck, T.; Sjöström, U.; Magnusson, M.; Sjöström, J.; Salminen, J; Rytioja, A; Nyberg, J. (2017). *Treatment Of A Sulphur Rich Sludge And Mixture With Zinc Concentrate - Using A Fluidised Bed Reactor In Pilot Scale*. In W. Nowak (Ed.), Proceedings of the 12th International Conference of Fluidized Bed Technology (pp. 691-698). Krakow

Sulphur residue can be used to produce marketable sulphuric acid and the metal value from the obtained calcine can be recovered.

- Suitable quality SO2 gas obtained from both pilot tests for sulphuric acid production.
- Range for the main process parameters preliminary determined.
- Sulphur residue and its mixtures with zinc concentrates can be granulated.
- Calcine that is suitable for leaching process was obtained.
- (~50 % Zn and Ag, Pb, Cu, Cd, As, Fe..)

Both pyrometallurgy and hydrometallurgy both needed in an integrated process

- Zinc concentrate was concentrated *hydrometallurgically*.
- Sulphur residue was formed in direct leaching *hydrometallurgically*.
- Sulphur residue was roasted *pyrometallugically*.
- The metals from calcine can be recovered *hydrometallurgically*.
- In solution purification iron is removed *hydrometallurgically.*
- Iron residue landfilled (*hydrometallurgy*, very slow heap leaching…) or processed industrially with *pyrometallurgical* methods (Ausmelt, ISASmelt, Plasma, Box fumer, combinations, other….).
- Obtained metal oxide dust will be leached and metals recovered *hydrometallurgically…*

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Conclusions

- Waste treatment methods in nonferrous industries are increasingly studied and in use.
- Possibility to recover more by-product metals and minimize waste generation.
- This trend is both driven by tightening legislation especially in Asia but also zero waste targets and better overall metals recovery (better resource efficiency).
- Applying advanced pyrometallurgical methods for residue treatment enables better recovery on by-product metal.
- Has effect on energy demand and CO2 emissions.
- Full beneficiation of treating residues from non-ferrous industries require combined hydro/pyro separation processes for recovery of by-product metals.

  -Outlet for As, Cd, Hg, Se, Sb, F, Cl and other elements of concern.

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Safety first - always

- Everyone of us is responsible of his / her own safety
- Everyone of us is helping our collegues to work safely


Martin wants to get the job done.
He couldn't without metals.
Means of communication are essential for growing communities. They bring people and jobs closer together and make it possible for people to move forward in life. Trains, buses and tablets all depend on copper and zinc, that are used in everything from electrical wires to steel bodies. Martin is ready to do his best, and so are our metals.
Zn
Cu
Ag
Au
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Metals for modern life