

Identification and determination of factors encountered in marine minerals processing, influencing world metal markets

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INTEROCEANMETAL



Interoceanmetal

- **Pioneer contractor**, Zone Clarion - Clipperton, in 2016 the exploration contract was extended for five years
- **International Organization**; the member of Interoceanmetal, **IOM**: Poland, Bulgaria, the Russian Federation, Cuba, the Czech Republic and Slovakia

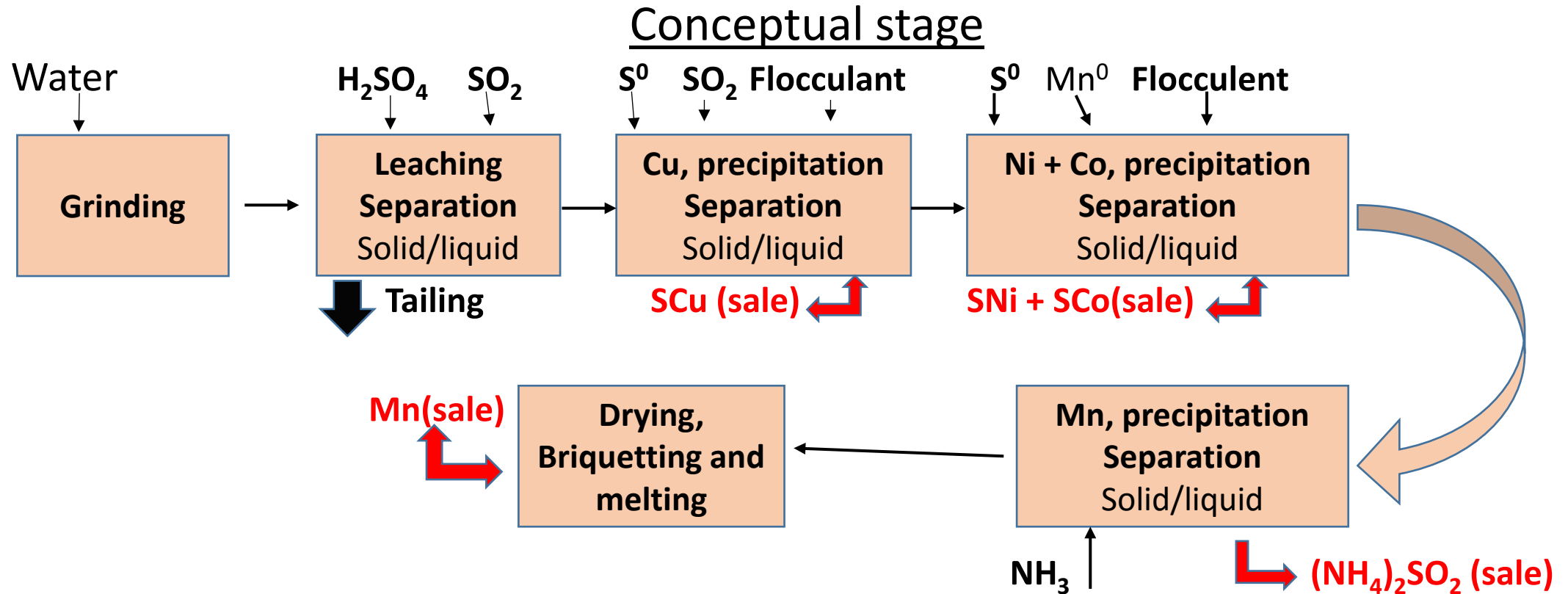


Currently IOM develops the optimization of three technologies for the metallurgical processing of polymetallic nodules:

- **Hydrometallurgical Process** of Acid Leaching using sulfur dioxide as a reducer
- **Pyro - hydrometallurgical processing;** obtaining Mn-rich slag and subsequent hydrometallurgical treatment of Ni, Co and Cu alloys
- **Hydrometallurgical;** HPAL process according to the technology of the Moa Bay plant, Cuba, using pyrite as a reducer and the extraction of Ni, Co, Cu and Zn with the "Resin in Pulp"

Hydrometallurgical Processing

Central Institute of geological studies of non-ferrous and precious metals, Moscow, RF



Hydrometallurgical Processing

Lab tests; basic results

Extraction; %

Mn - 70

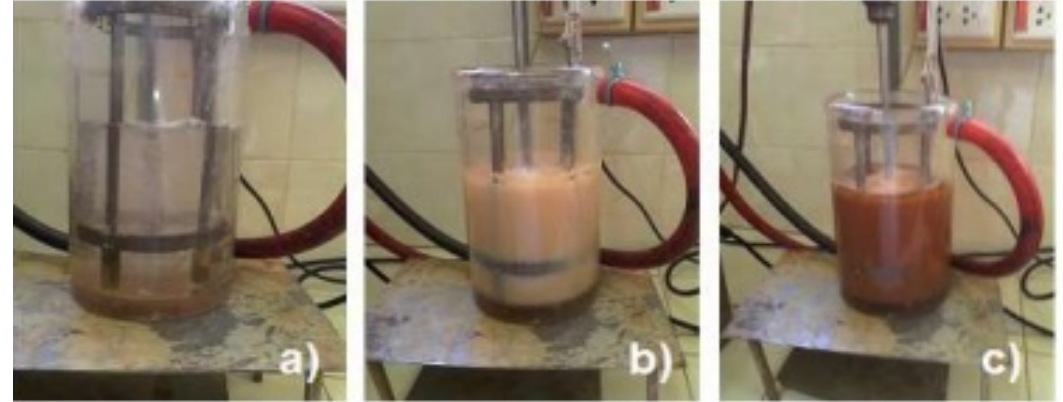
Ni – 97,5

Co – 92,5

Cu – 92,5

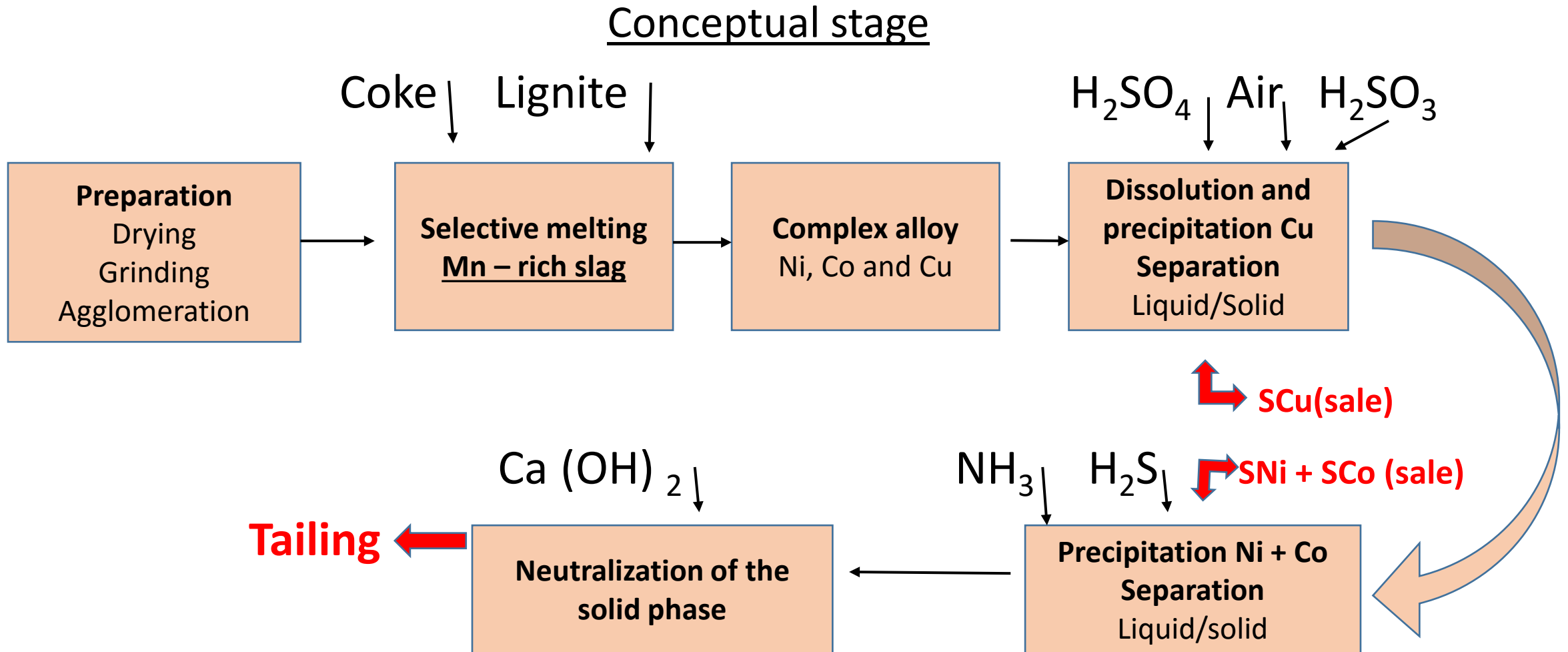
Sulfuric acid consumption

290 - 310 Kg / ton. PN



Pyro - Hydrometallurgical Processing

University of chemical and metallurgical technologies, Sofia, Bulgaria



Pyro - Hydrometallurgical Processing

Lab tests; basic results

Extraction, %

In the slag

Mn – 90

In the complex alloy

Ni – 92,0

Co – 93.6

Cu – 92,8

Consumption of electric power

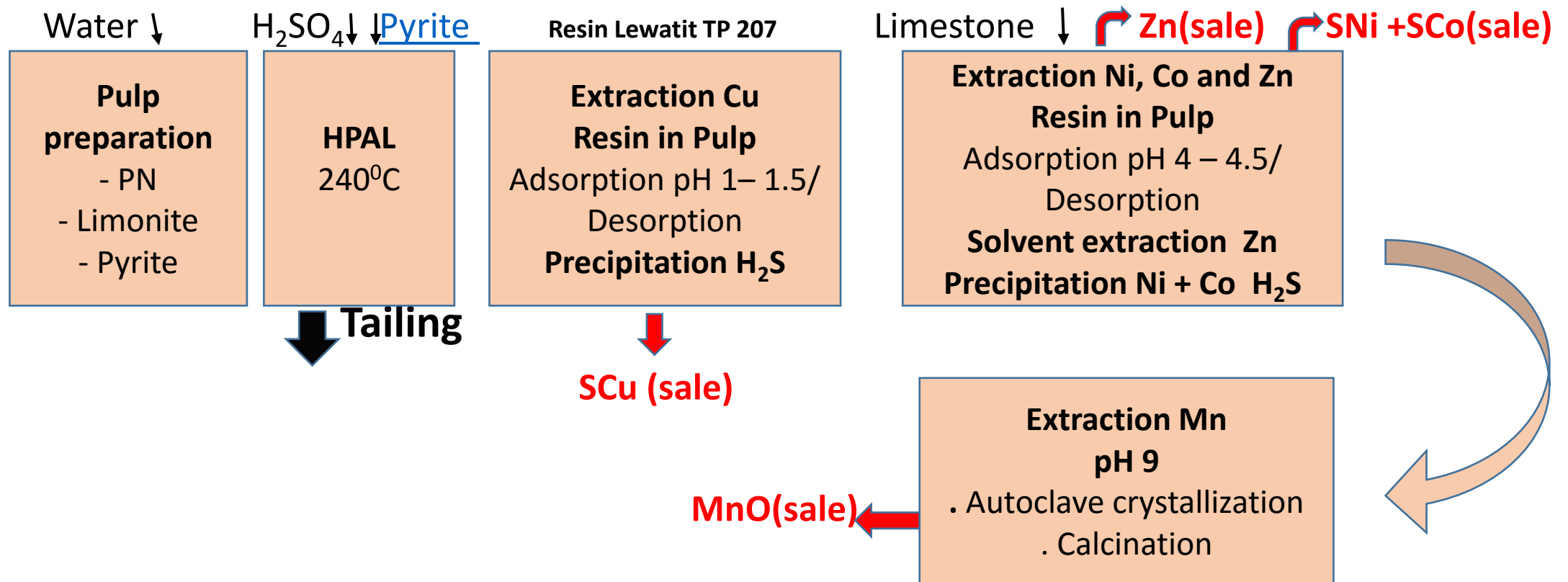
520 - 530 KWh / ton. slag



High Pressure Acid Leaching Process (PN+limonite)

Research center for the mining – metallurgical industry, Havana, Cuba

Conceptual stage



HPAL process

Lab tests; basic results

Extraction, %

Ni – 95,5

Co – 92, 8

Cu – 90,5

Zn – 92

Sulfuric acid consumption;

320 - 350 Kg / ton of ore + PN





**Moa Bay;
leaching area**

Facilities of the Moa Bay port to receive the polymetallic nodules



Moa Bay metallurgical plant, HPAL process



Other technologies in evaluation process

FeMn production

Mineral mixture + PN

Collaboration with the Company Orava Ferroalloy Works Istebné, **OFZ**,
Slovak Republic.

Other technologies in evaluation process
Production; high purity powders Co, Ni, Zn and Cu

Technology "Carbonyl"

Collaboration with the Canadian Company Chemical Vapor Metal Recovery (**CVMR**)

Carbonyl technology

Laboratory-scale tests were carried out

Now bench-scale tests are carried out



Economic model

“Order of Magnitude”

- ✓ In the process of elaboration the first economic model
 - ✓ They will be developed for the five technologies
- ✓ An internal tool as a first step for economic analysis

Technologies vs. Market

There are many ways to extract metals from Polymetallic Nodules, **but what is the production cost?**

Metals Market

Future increase of metals consumption; general causes

World population growth(billions)

| 2011 | 2017 | ... | 2050 |
|------|------|-----|----------------|
| 7 | 7.3 | ... | 9.9 (1) |

World urbanization increase (%)

| 1957 | 1967 | 2014 | ... | 2050 |
|------|-------|------|-----|---------------|
| 21 | 50/50 | 54 | ... | 62 (2) |

Development of emerging economies;

China, India, Russia, Brazil...

(1) [Web PopulationMatters](#) & [Web PopulationAction.org](#)

(2) [World Urbanization Prospect, 2014, UN – Dep. of Economic and Social Affairs](#)

Co and Ni

Batteries

Ni : Co: Mn 8:1:1

2015 – 12.2 GWh ... 2025 – 36.8 GWh

Since 2016 more energy accumulated in the batteries of the EV than in other types of batteries

New electric vehicles

Sold 2018 – 3.1 million in use. ... 2030 ~ 125 – 150 millions (3)

Combustion engines; in a long process of extinction

Cobalt; critical case

Metal sparse, deficit in 2017, 2018, ... (5)

Risk; ~ 60% occurs in a single country, not very stable

EU; Regulation 2017/821 - Due Diligence towards supplier countries at risks or in conflicts (including child labor)

Deep Sea mining; could be solution for shortage of Co

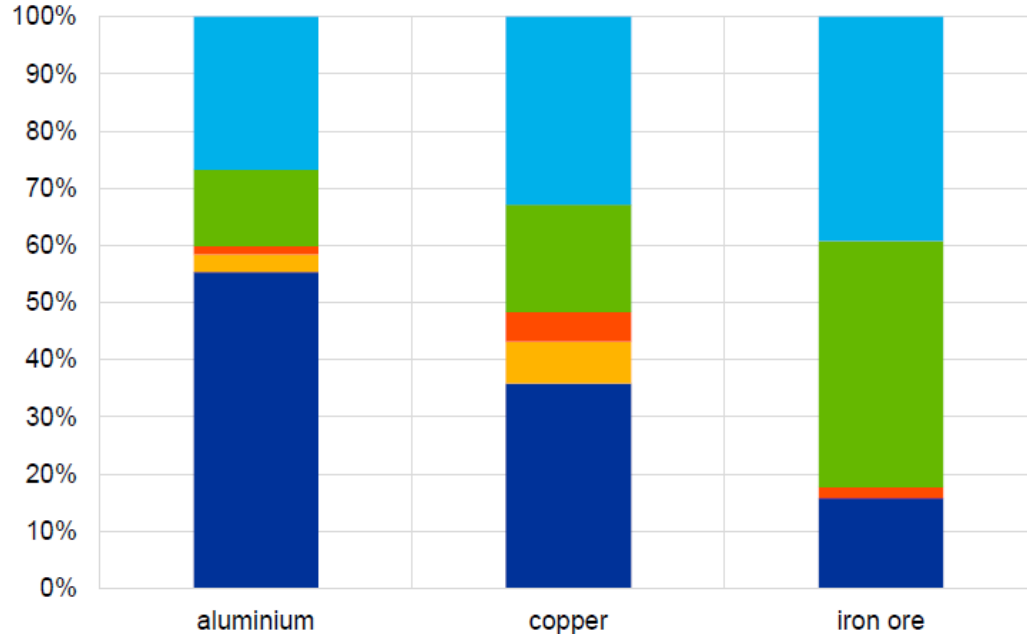
Geographical composition of metal production and consumption

Geographical composition of metal production and consumption

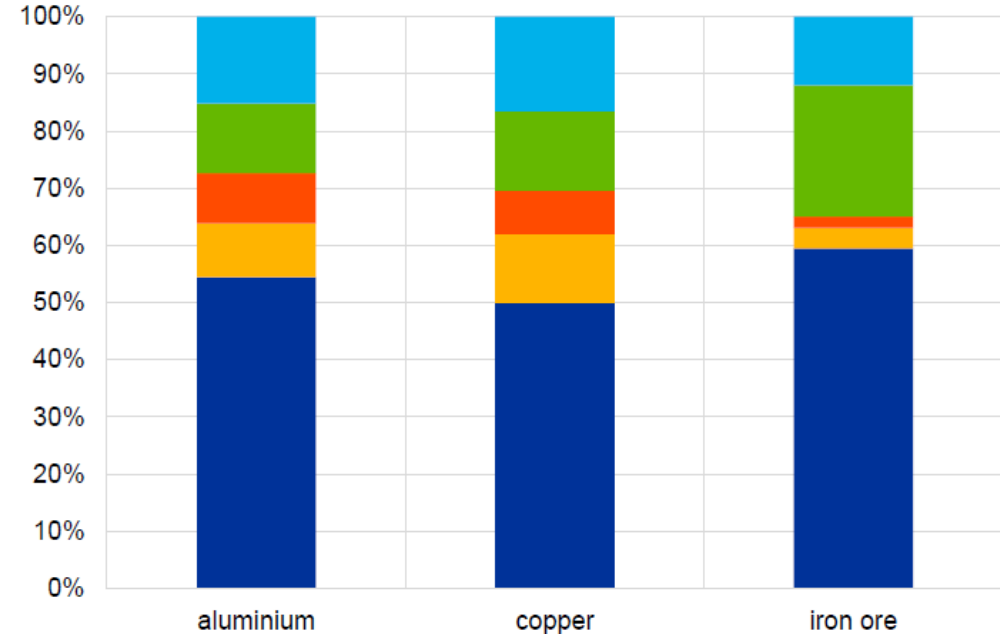
(global percentage shares in 2016)



a) Production



b) Consumption



In the middle of the way

- ✓ Questions to be answered in our Project
- ✓ Cooperation with Universities, Research Centers and Production Companies

Interoceanmetal focuses on 2021!

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... in the middle of difficulty lies the opportunity...
(A. Einstein 1879 – 1955)



Thank you!