ION4RAW: Improving metal recovery in Cu-Pb-Zn-(Au-Ag) ore deposits through inventory of by-products and critical raw materials

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Introduction

**H2020 European ION4RAW project**: Ionometallurgy of primary sources for an enhanced raw materials recovery

Improve recovery of by-products and CRM during ore treatment processes

> ➤ **Obtain reliable estimates of by-products and CRM**

> ➤ develop ionometallurgy processes

> ➤ 5 selected Cu-Ag-Au ore deposits through the world: Cononish Gold mine, Scotland; Cobre Las Cruces and El Valle Boinas, Spain; **El Porvenir** and Cerro Lindo, Peru
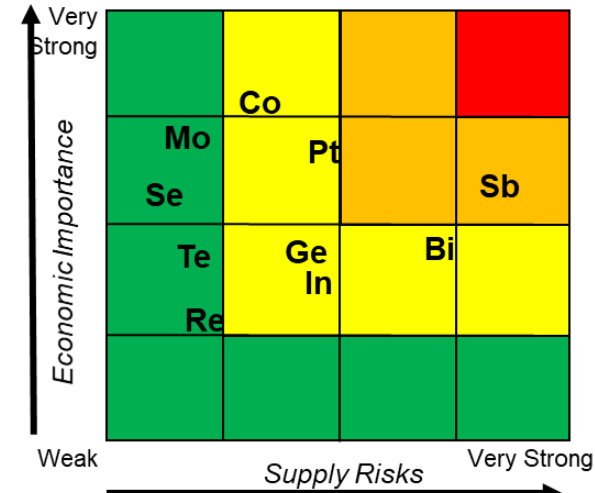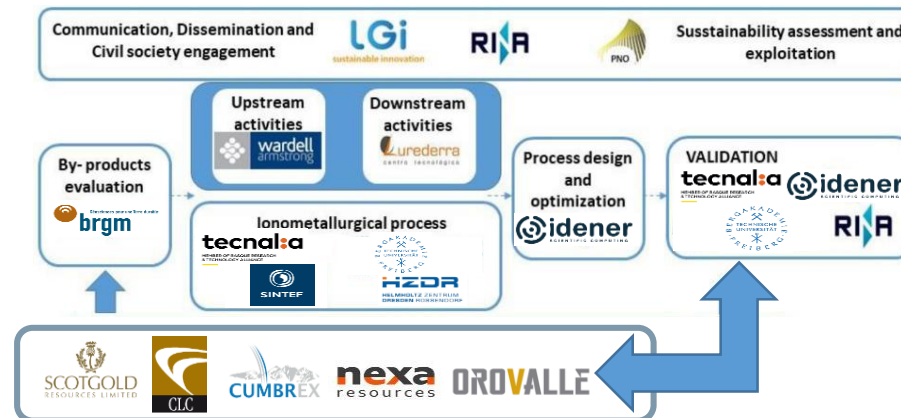
ION4RAW project organization

Workpackage 2 (BRGM leader): inventory of by-products and CRM

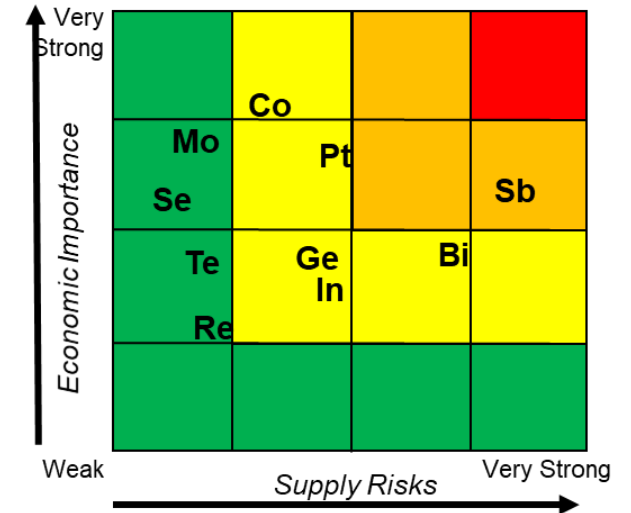➢ Characterization of ores and gangue, using a multi-technical approach

- XRD
- micro-XRF elemental mapping
- Optical and scanning electron microscope

➡ Identify carrier minerals of CRM and by-products, determine their distribution

- Electron microprobe (d.l. few 100 ppm)
- Laser-Ablation coupled with ICP-MS (d.l. 0.1 to few ppm)

➡ CRM and by-product quantification

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El Porvenir ore deposit (Mining operator: nexa Resources)

Location
Western Cordillera of the Andes mountain range in central Peru

Ore type
- Intrusive-related skarn
- Andradite-type garnet (Grt) and diopside-type clinopyroxene (CPX) exoskarns → calcic skarn group

Main ore
- **Zn-Ag-Pb- (Au-Cu) polymetallic mineralization**
- **hosted by the andradite exoskarn**
- associated with the retrograde hydrothermal stage: **Mn-calcite**, quartz
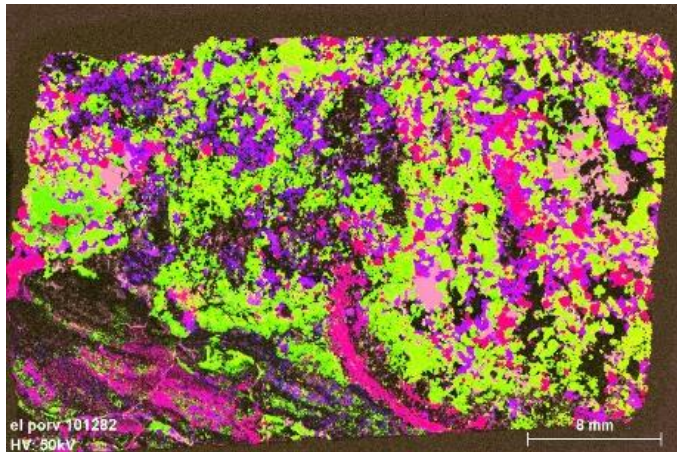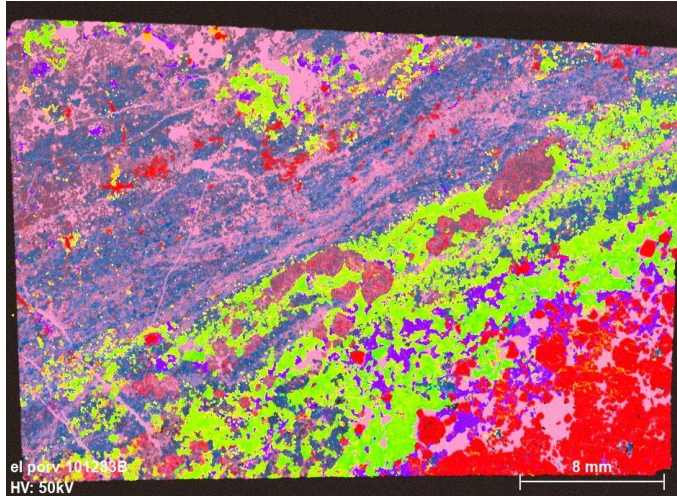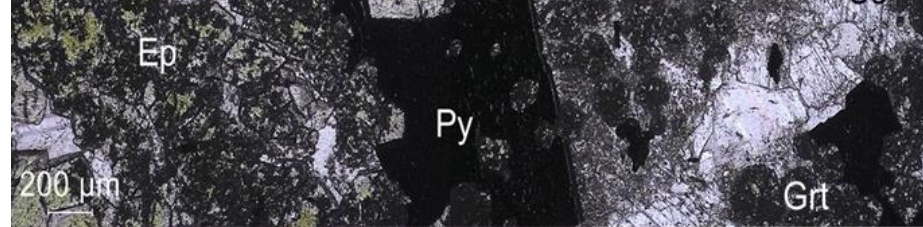
Minor ore
- **Cu-Mo porphyry style**

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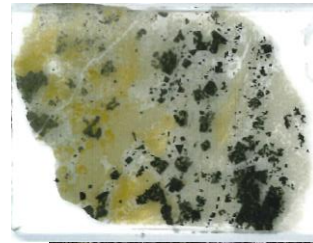Ionometallurgy of primary sources for
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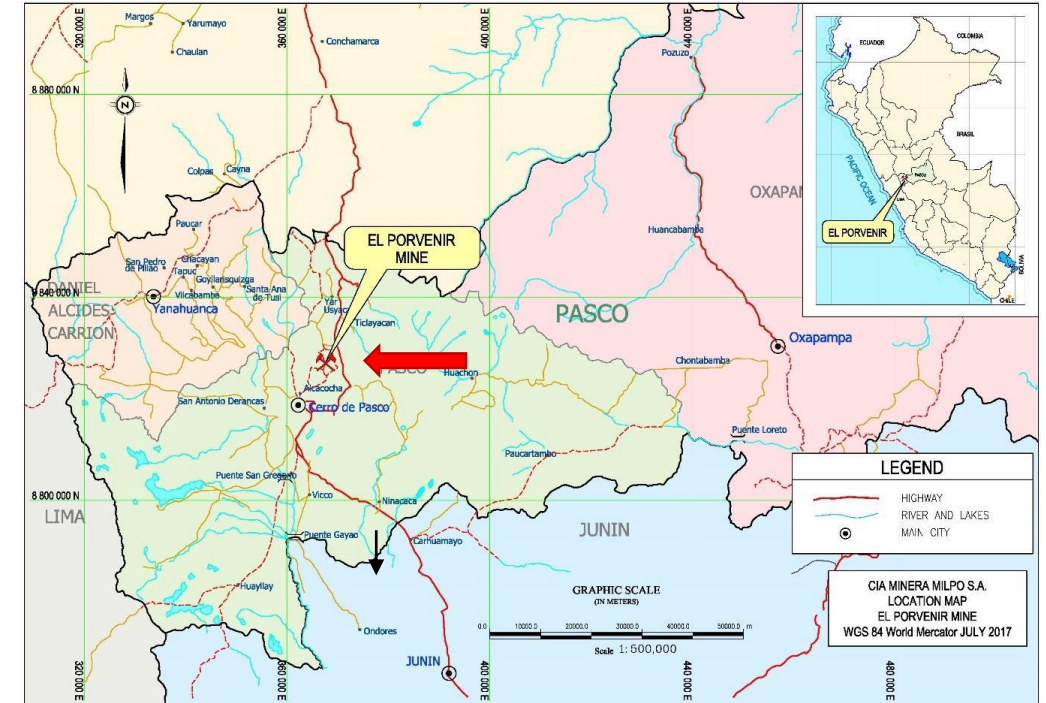
El Porvenir ore characterization: Metal carrier minerals and their distribution

µXRF mapping (resolution 40 µm)

Sph
Gn
Py/ Py
Mn-Cc
Cpy
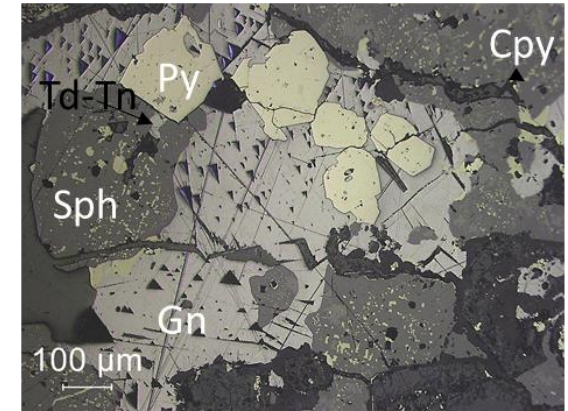
Andradite exoskarn

Natural transmitted light

Ore minerals

Reflected light

Sphalerite: **Zn,** Cu, *Ag, Co, In (257 ppm), Se*
Galena: **Pb**, Ag$_{(0.3-1.5\%)}$-Bi$_{(0.1-3.5\%)}$, Sb (1325 ppm), Se (234 ppm), Te (876 ppm), *Rh*

Chalcopyrite: **Cu**, *Ag, Bi, In (115 ppm), Ni, Pb, Pd, Rh, Sb, Se*
Tetrahedrite-tennantite   **Sb (1-21%)**, **Cu**, **Ag** (0.3-12.7%), Bi (0.5%), *Se*
Pyrite   *Au, Co, Ni, Pb, Sb, Se, Te, Zn*
Aleksite   Bi$_2$**Pb**Te$_2$S$_2$
Saddlebackite   Bi$_2$**Pb$_2$**Te$_2$S$_3$

Bold: main metal
Bold : > 1 %
Normal: > few 100 ppm (EPMA)
Italic: > 1 ppm (LA-ICPMS)

Abbreviations: Py pyrite, Ep epidote, Cc calcite, Qz quartz, Sph sphalerite, Cpy chalcopyrite, Gn galena, Td tetrahedrite, Tn tennantite

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ION4RAW WP2 - Conclusion and perspectives

➢ Optimize the multi-disciplinary approach of ore characterization to obtain reliable estimates of by-products and CRM, and apply it on the 5 ore deposits

➢ This presentation: El Porvenir ore deposit:

- Zn-Ag-Pb-(Au-Cu) with low Au in pyrite
- Galena main carrier of Ag but also Bi, Se, Sb, Te
- low Mo associated with Cu-Mo porphyry mineralization

➢ monitore the by-products identified in ore to improve their recovery by ionometallurgy processes in the different concentrates

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