

# Characterization and valorization of tailings from the Tharsis mine, through hybrid separation techniques.

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Tharsis mine is located in the Andévalo region (Huelva, Spain), in a geological area known as the Iberian pyrite belt, the mine is considered a massive sulfide deposit. Most of the massive sulfides are monotonous fine-grained pyrite and with some siderite-rich facies. (Tornos et al., 2008). This mine had been active for several centuries, passing through different civilizations, up until the 20th century when the mine cess its production after decades of exploitation by the British company Tharsis, Sulfur and Copper. Recently, some studies suggested that this mine has a great potential for the recovery of critical and strategic raw materials, highlighting several elements with possibilities of being recovered through secondary mining, especially Ag, Zn and Pb and, to a lesser extent, Sb, Cd, Bi and As. (Rosario-Beltré et al., 2023)

The aim of this study is the characterization and the valorization of metals present in the tailings of the Tharsis mine, mainly focusing on Mn-Co for the production of batteries, through hybrid separation techniques. Different tailings samples of the Tharsis mine were mixed, homogenized and quartered for different analyses and processes. To determine the chemical composition of the samples different techniques were used such as X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS), the particle size distribution was determined by wet sieving up 0,1 mm and with a laser scattering particle size distribution analyzer (LA350) under 0,1mm. Then, the chemical composition of the mixture and the different size fractions. The XRF results were analyzed with the t-student distribution at a confidence level of 99,75%. (Table 1). Co concentration it's about 0,11%, which represent a reasonable content for a future concentration process, if the metal is totally or partially liberated whereas the Mn content is not very high and will need a flow sheet to generate a concentrate with reasonable content values.

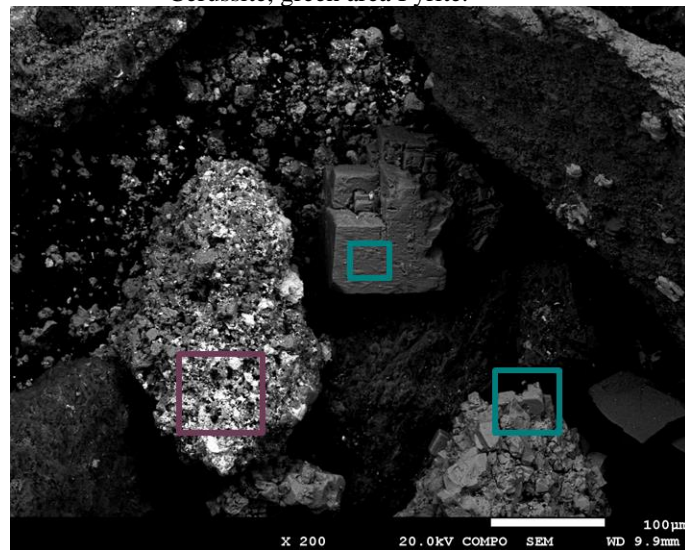
Table 1. Chemical composition and size distribution of the Tharsis tailing samples.

Size range (mm)	<0.1	0.1-1,25	>1.25	Weighted sum	MIX	ε r (%)
Mass (%)	35,41	40,22	24,3			
%						
SiO <sub>2</sub>	12,62	8,61	11,88	10,83	11,17	3,05
Al <sub>2</sub> O <sub>3</sub>	2,07	1,50	1,63	1,73	1,95	11,24
Fe <sub>2</sub> O <sub>3</sub>	30,53	34,00	30,40	31,89	29,97	-6,40
MgO	0,49	0,55	0,51	0,52	0,86	39,31
CaO	0,48	0,37	0,59	0,46	0,40	-15,17
P <sub>2</sub> O <sub>5</sub>	0,34	0,21	0,49	0,33	0,36	8,92
SO <sub>3</sub>	51,30	51,61	52,60	51,74	53,26	2,86
K <sub>2</sub> O	0,34	0,24	0,19	0,26	0,26	-1,02
Co	0,10	0,12	0,10	0,11	0,10	-8,70
Cu	0,18	0,19	0,20	0,19	0,19	-0,69
Zn	0,56	0,47	0,60	0,53	0,49	-8,69
As	0,14	0,13	0,12	0,13	0,12	-10,04
Pb	0,57	0,80	0,44	0,63	0,60	-5,17
Ni	34,60	32,70	34,65	34	34	1%
ppm						
Ti	694	654	361	597	589	-1,34
Mn	447	437	550	468	426	-9,80
Sn	159	173	129	157	151	-4,02
Sb	367	478	249	383	364	-5,25
Ag	838	883	745	833	801	-4,07
Cr	74	75	94	79	70	-13,55
Te	54	50	45	50	51	1,82
Ba	61	72	46	62	57	-7,69

In order to determine the mineralogical composition, different techniques were used such as Scanning Electron Microscopy - Energy Dispersive X-ray spectroscopy (SEM-EDS), X-ray diffraction (XRD) and Mineral liberation analysis (MLA). XRF confirmed the presence of pyrite, which is the major mineral phase in the area, as well as other species such as Quartz, Sphalerite, Magnetite, Gupéite, Chalcopyrite and Pyrrhotite. Moreover, the presence of Cerussite was also confirmed by SEM-EDS. (Figure 1).

Finally, Flotation and gravity concentration tests based on particle MLA were performed in order to valorize the tailings samples of the Tharsis mine.

Figure 1. SEM-EDS of a Tharsis sample from 0,1-1,25 mm size fraction, purple area Cerussite, green area Pyrite.



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