

**MINING IN PORTUGAL**  
TECHNOLOGIES AND EXAMPLES

JOSÉ ANTÓNIO DE ALMEIDA (A@ECT.UINL.PT)  
(LOCAL COORDINATOR, BSc, PhD MINING ENGINEERING, MSc MINERALURGY AND MINE PLANNING)

1

### Outline

- Mine or quarry ?
- Mining Unitary Operations
- Mines in Portugal
- Neves-Corvo Mine (mining method)
- Sifucel Mine
- Panasqueira Mine
- Other Mines

2

### Mines and Quarries – what are the differences ?

**PUBLIC DOMAIN || Legislation (MINES)**

**Mineral deposits** - any mineral occurrences which by their rarity, high specific value or importance in the application in industrial processes due to the substances contained, are presented with special economic value. DL 88/90, of 16/03

**PRIVATE DOMAIN || Legislation (QUARRIES)**

**Mineral masses** - any rocks and other mineral occurrences that do not have the necessary characteristics to be qualified as mineral deposits DL 270/2001, of 6/10, revised by DL 340/2007, of 12/10

3

### Mining Unitary Operations

Underground unitary operations	Surface tasks
<ul style="list-style-type: none"> <li>• Production drilling (jumbos)</li> <li>• Charging and blasting</li> <li>• Loading and hauling to stock areas</li> </ul>	<ul style="list-style-type: none"> <li>• Comminution (secondary crushing and milling to liberation size)</li> <li>• Mineral processing for concentration of ores (gravity, magnetic, flotation)</li> </ul>
<ul style="list-style-type: none"> <li>• Comminution (primary crushing)</li> <li>• Transport to surface (conveyor, dumper, mine lift)</li> </ul>	

4

### Mining ore treatment chain

5

### Mining waste rock treatment chain

6

### Mines in Portugal

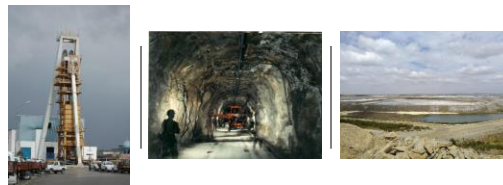
**Metallic mines** | | 3 WORLD CLASS mineral deposits (underground mines)

- Aljustrel (Cu, Zn)
- Neves Corvo (Cu, Zn, Pb, Sn, Au, Ag)
- Panasqueira (W, Sn, Cu)

**Industrial minerals** | | (open pit mines, Loulé underground)

- Clays
- Quartz, feldspars (pegmatites)
- Lithium minerals (for ceramics)
- Mineral salt (Loulé mines)

7



Neves Corvo mine

8

### Neves-Corvo Mine

**New mine:** first concentrate in 1989 (Bouguer anomaly in 1977)

**Owner:** Lundin Mining

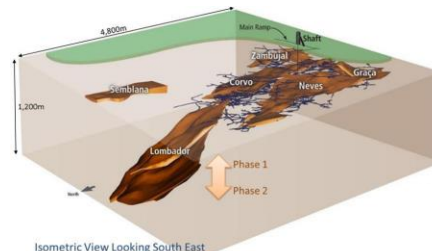
**Ore morphology:** massive sulphides and stockwork

**7 deposits:** Graça, Corvo, Neves, Zambujal, Lombador, Semblana e Monte Branco

**Object of exploration (mineral):** copper (chalcopyrite), zinc (sphalerite) and by-products lead (galena); indium, silver, gold

9

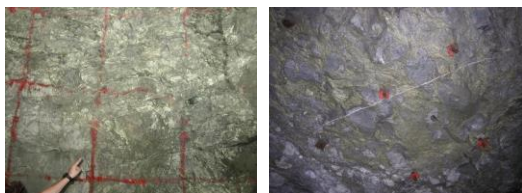
### Neves Corvo Mine



<https://www.lundinmining.com/site/assets/files/2791/2017-05-neves-corvo-cp.pdf>

10

### Neves-Corvo Mine

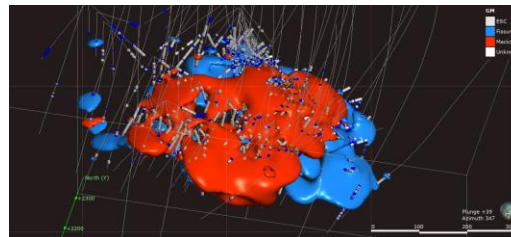


Massive sulphides

Stockwork ores

11

### Neves-Corvo Mine



**LEAPFROG MODELING EXAMPLE:** Zambujal is the smallest mineral deposit of Neves-Corvo mine. Maximum length about 600 m and maximum width 490 m, and average thickness 55 m (from 10 to 100 m).

12

### Neves-Corvo Mine

**Access to the mine:** one ramp (for people and equipment) and one shaft (ores and waste rock)

**Mining method:** bench-and-fill and drift-and-fill

**Concentration:** flotation

**Cut-off:** <1% Cu and <3,3% Zn

**Concentrates:** (1) copper ore with 23%-25% in Cu; (2) zinc ore with 45%-46% in Zn; (3) copper/lead ore with 30% of Cu and a minimum of 22% in lead

13

### Mining Methods

**Bench and fill** – Cemented & low cement Paste-fill, and uncemented Waste fill (rock fill). Length: 20 to 130m; width: 12m; height: 20m; Volume: 31000 m<sup>3</sup>

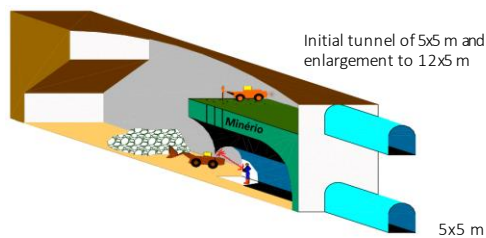
Constant ores, regular boundaries, large volumes

**Drift and fill** – Cemented Paste-Fill, Cemented Hydraulic Sand fill and uncemented waste Fill (rock fill).

Different ores, irregular boundaries, thickness lower than 10m.

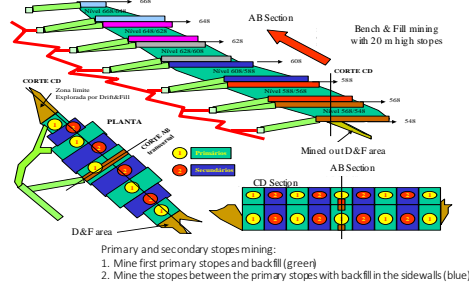
14

### Bench & Fill Mining Method – Neves-Corvo Mine



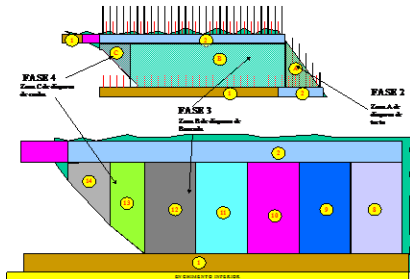
15

### Bench & Fill Mining Method – Neves-Corvo Mine



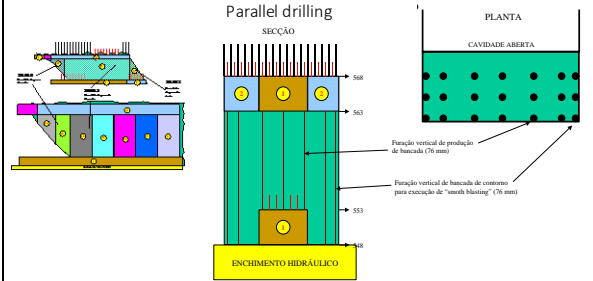
16

### Bench & Fill Mining Method – Neves-Corvo Mine

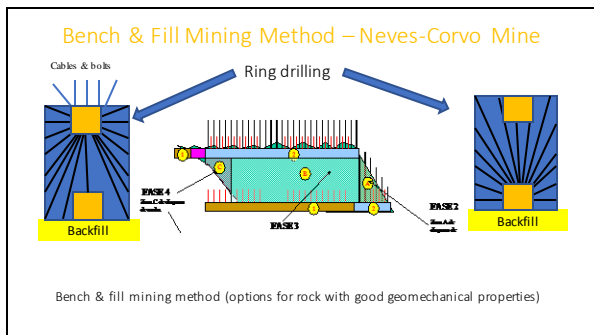


17

### Bench & Fill Mining Method – Neves-Corvo Mine



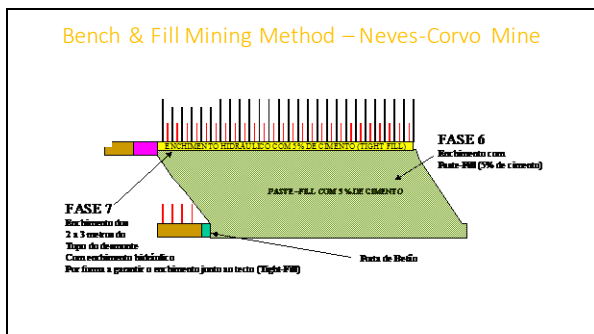
18



19



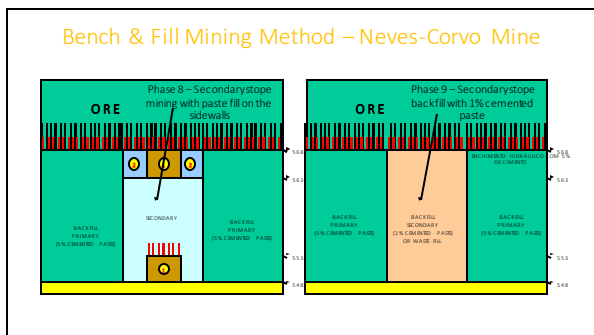
20



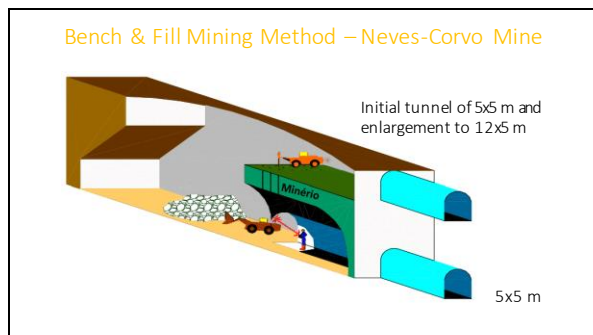
21



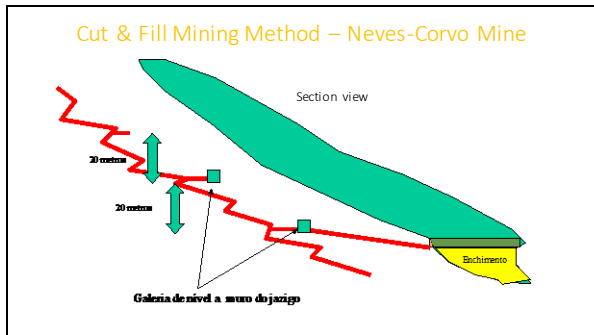
22



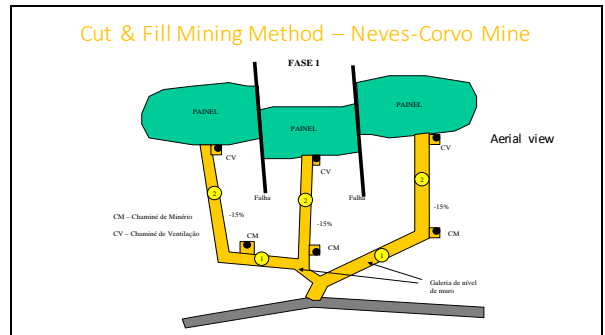
23



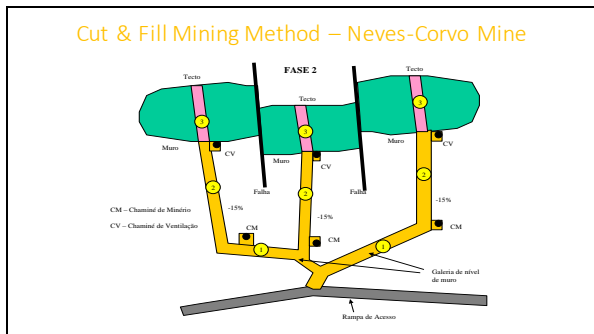
24



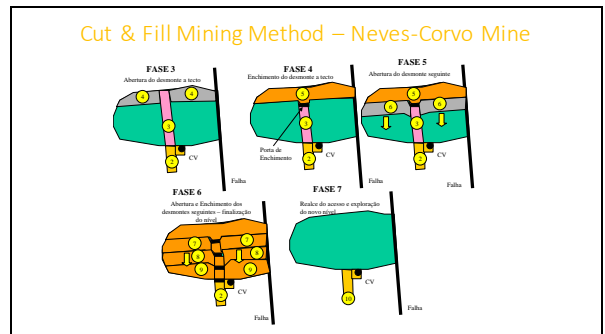
25



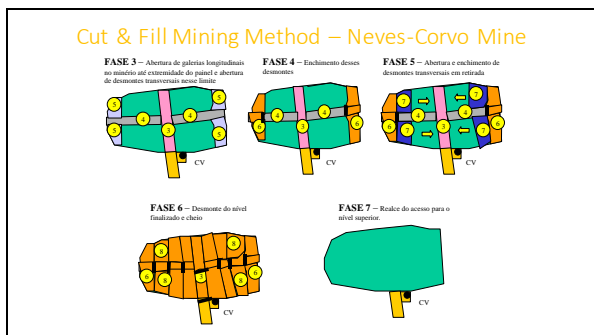
26



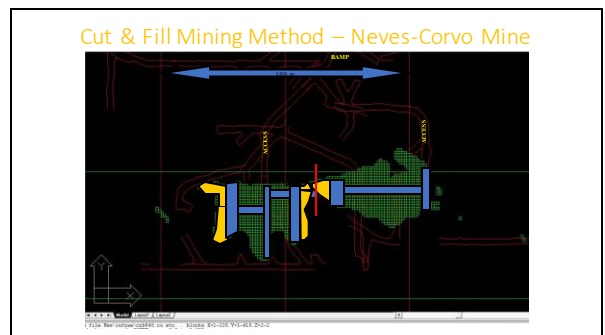
27



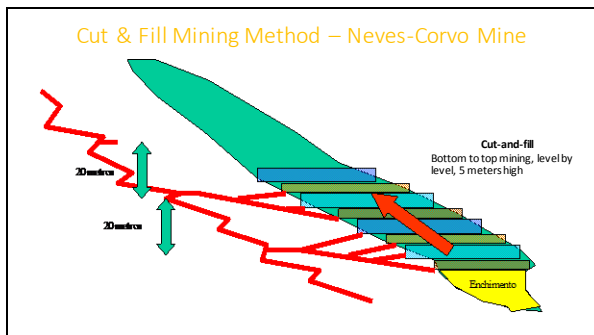
28



29



30



31

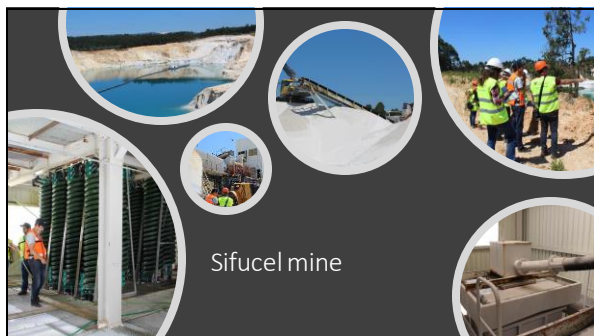
### Mineral Processing Plants – Neves-Corvo Mine

**Underground:** primary crushing

**Surface facilities:** screening, secondary crushing, grinding, flotation and dewatering tanks

Primary crushing      Grinding (rod mills | ball mills)      Flotation cells plant

32



33

### Sifucel Mine – Quartz Sand Exploitation

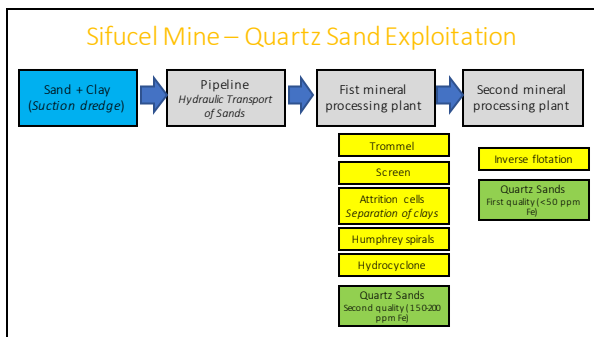
**Mine size:** Medium

**Owner:** Parapedra Group

**Ore morphology:** sub-horizontal layer of sands, thickness above 50 m, several hundreds of meters in horizontal development

**Object of exploration (mineral):** quartz for glass and solar panel industry

34



35



36

### Modal Analysis of Minerals

**Main Minerals**

- Quartz | | SiO<sub>2</sub>
- Ilmenite | | FeTiO<sub>3</sub>
- Rutile | | TiO<sub>2</sub>
- Pyrope | | Mg<sub>3</sub>Al<sub>2</sub>(SiO<sub>4</sub>)<sub>3</sub>
- Staurolite | | Fe<sup>2+</sup>; Al<sub>6</sub>O<sub>4</sub>(SiO<sub>4</sub>)<sub>4</sub>(OH)<sub>2</sub>
- Schorl | | (Na(Mg,Fe,Li,MnAl)<sub>3</sub>Al<sub>3</sub>(BO<sub>3</sub>)<sub>3</sub> 5xO<sub>10</sub>(OH,F)<sub>4</sub>)

Mineral/grupo	ANÁLISIS		
	MOYEN	MOYEL	MOYER
Quartzio	10.02	10.99	10.02
Ilmenite	1.00	1.00	1.00
Rutile	1.70	1.13	<0.01
Ilmenite_yTio	0.00	0.01	<0.01
Ilmenite	0.00	1.12	<0.01
Quartzite	0.01	0.00	<0.01
Cassiterite	<0.01	0.00	<0.01
Columbite (Sn)	<0.01	0.00	---
Estaurite	0.00	0.07	---
Zinco	1.00	0.00	0.00
Staurolite	0.00	<0.01	<0.01
Pyrope	1.70	10.00	<0.01
Chalcocite	0.00	10.00	10.00
Calcite	<0.01	0.01	<0.01
Cromite	---	0.00	---
Epistola cymifera	0.01	0.10	---
Gabrite	---	0.00	---
Zinco	1.00	0.00	<0.01
Schort	1.00	10.00	---
Mineralite (Al)	0.00	0.10	<0.01
Mineralite (Ti)	<0.01	0.01	<0.01
Ilmenite	<0.01	<0.01	<0.01
Staurolite	<0.01	0.01	<0.01
Columbite	<0.01	0.10	<0.01
Pyrite	<0.01	<0.01	<0.01
Estaurite	<0.01	<0.01	<0.01
Mineralite	<0.01	<0.01	---
TOTAL	100.00	100.00	100.00

37



38

### Panasqueira Mine

**Old mine:** the official mining license was dated from May 24, 1896

**Owner:** Almonty group since 2016

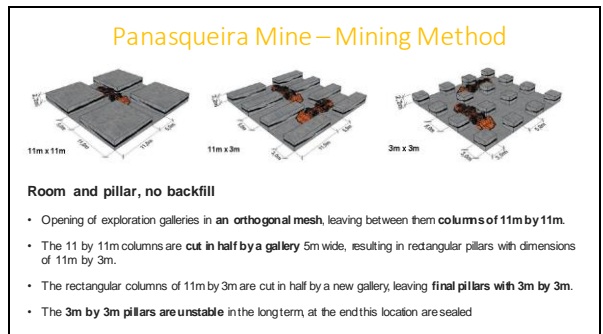
**Ore morphology:** Sequence of sub-horizontal quartz veins developed in schist rocks

**Object of exploration (mineral):** tungsten (wolframite); tin (cassiterite) and copper (chalcocopyrite) are by-products of the exploration

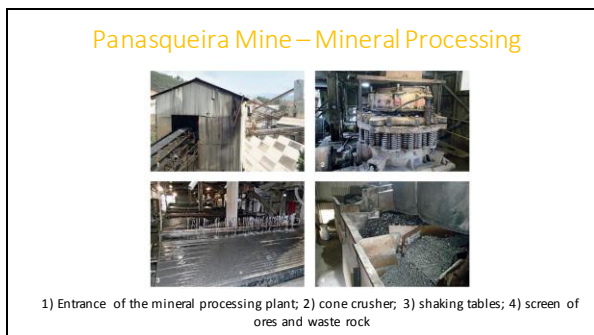
**Mining method:** room and pillar (without filling)

**Mineral concentration:** gravity and magnetic

39



40



41



42

### Panasqueira Mine waste rock deposit and tailings dam at the top



43

### Other Portuguese mines || industrial minerals



Mining clay minerals- centre of Portugal <http://www.ldeirmao.pt/>



Mining of rock salt – Loulé Algarve <https://rock-salt-mine-visite-minad-sal.gema-de-loule.net/pt/site/>



Mining lithium minerals for ceramics - centre of Portugal

44

### Issues to be addressed during the field trip:

- Mining industry is very complex and unpredictable
- Underground Mine Works are Complex
- How important is the 3D space
- High-tech Equipment's
- Comminution of Ores and Liberation size
- Mine Facilities are Unfriendly – Be always safe

45

### Links:

<https://www.lundinmining.com/operations/neves-corvo/>

<https://www.911metallurgist.com/equipment/rod-mills/>

46