ROBOMINERS

Potential targets of small scale robotic mining

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ROBOMINERS - Project facts

- Title: Resilient Bio-inspired Modular Robotic Miners
- Call: “New solutions for sustainable production of raw materials” (RIA)
- Duration: 2019 June – 2023 November (54 months)
- Budget: 7,4 M€
- 14 partners from 11 European countries (universities, SMEs, governmental and non-governmental organisations), 16 LTPs (EFG member associations, covering 17 countries)
- Coordinator: UPM
- Website: www.robominers.eu

Objective

- Enable EU to access to strategic mineral raw materials from domestic resources
- Exploit mineral deposits which are not economic by traditional mining
  - Too small, too deep, difficult to access
- Develop a bio-inspired, modular and reconfigurable robot-miner
- Capable of navigating and performing selective mining – underground, in flooded environment

Specific objectives

Construct a fully functional modular robot miner prototype capable of performing selective mining

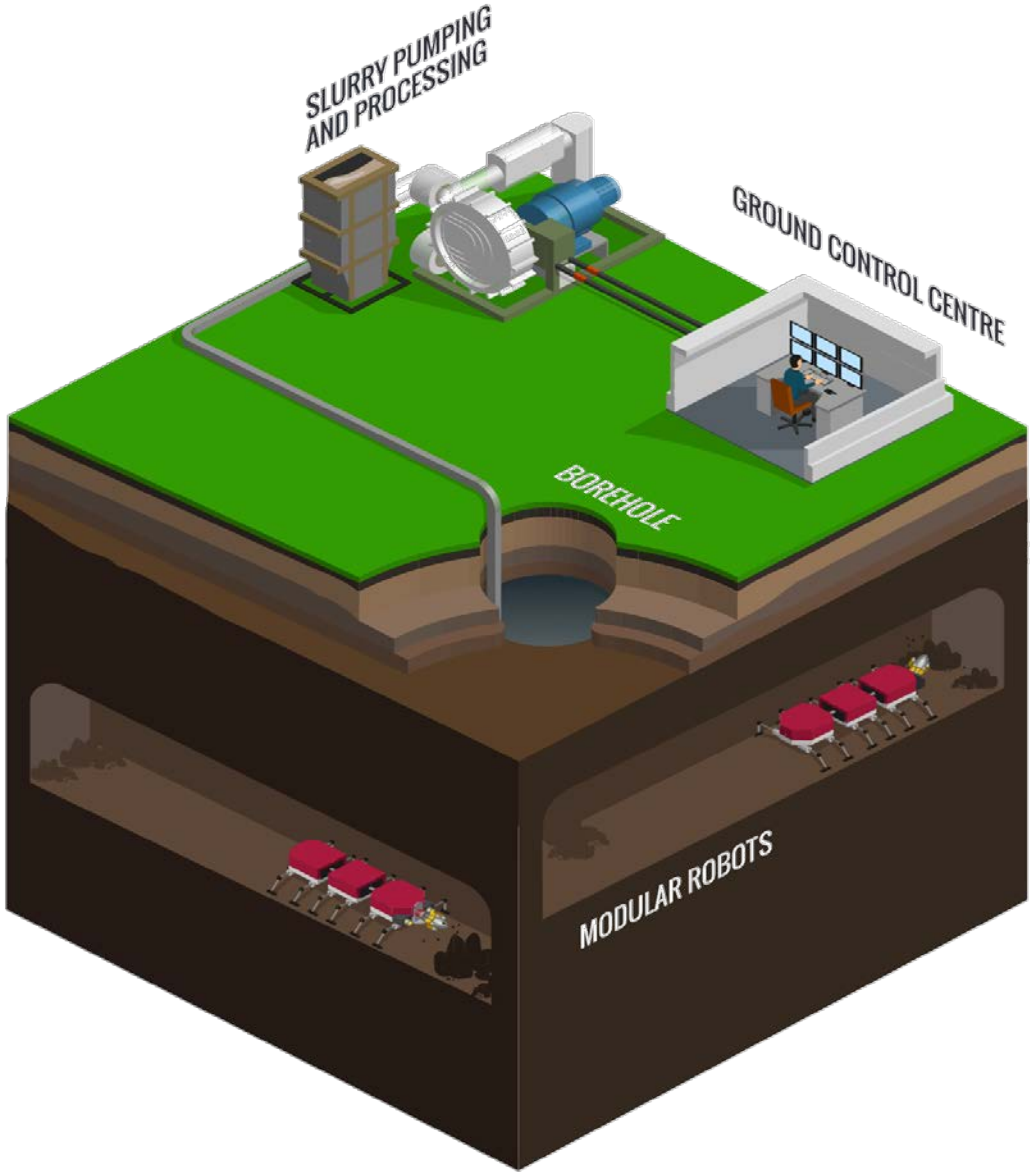
Validate all key functions of the robot-miner to a level of TRL-4.

Design a mining ecosystem of expected future upstream/downstream raw materials processes via simulations, modelling and virtual prototyping

Use the prototypes to study and advance future research challenges on

- scalability, resilience, re-configurability, self-repair, collective behavior, operation in harsh environments,
- selective mining,
- production methods, as well as for the
- necessary converging technologies on an overall mining ecosystem level.

Concept



Robot parts (modules) are sent underground via a borehole

Self-assemble to form a fully funcional robot

Use specialised sensing devices to detect ore

Using ad-hoc production devices, they produce slurry that is pumped out

Geological background – review of relevant mineral deposits

- Ranking ore deposit types by their suitability for ROBOMINERS -

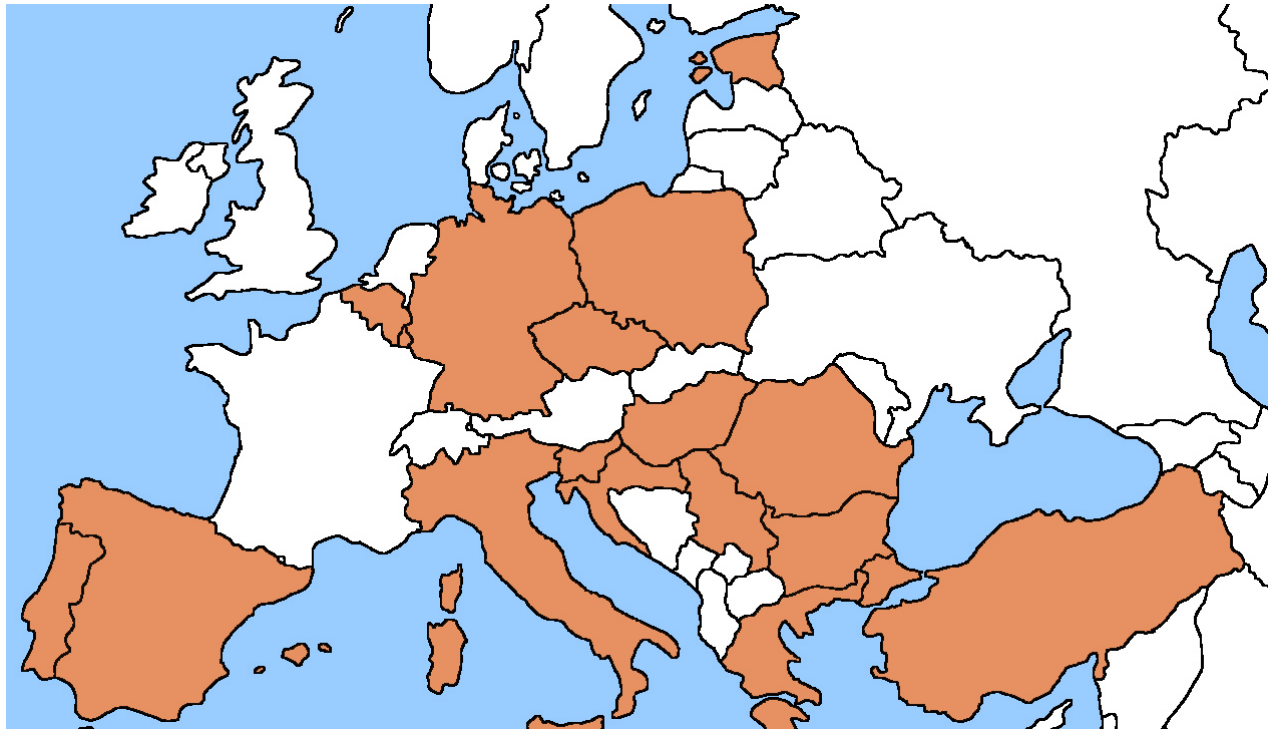
Ore type	Geometry	Rock mechanics - stability	Rock mechanics - extractability	Economics	Ranking ∑
SSC (Kupferschiefer-type)	5	4	4	4	17
Hydrothermal veins	4	3	4	4	15
Pegmatite	4	4	3	4	15
VMS	4	3	4	4	15
Carbonatite alkali REE	4	4	2	5	15
Cu-Ni-PGM sulphide	4	4	2	5	15
Epithermal (LS) vein type	4	3	4	4	15
Orogenic gold	4	3	3	5	15
Skarn	4	3	3	4	14
SEDEX	4	3	4	2	13
Layered chromite	4	4	2	2	12
Epithermal (HS)	3	2	3	4	12
IOCG	3	3	3	3	12
MVT	3	3	4	2	12
Bauxite deposit	4	2	4	2	12
Sedimentary manganese	4	2	4	2	12
Sandstone hosted uranium	2	3	3	3	11
Greisen	1	3	3	3	10
Podiform chromite	2	4	1	2	9
Carlin type ore	1	3	3	1	8
Porphyry copper	1	3	3	1	8

https://www.intechopen.com

https://hu.pinterest.com/pin/677932550128147138/

Database of deposits relevant for ROBOMINERS

- Data collection from 17 countries by EFG's LTPs
- Mining information, historic time range, geotechnical conditions, deposit type, commodities, magnitude, geographycal, geological information
- Number of sites: 1547
- Data will be visualised, available from the project website from July



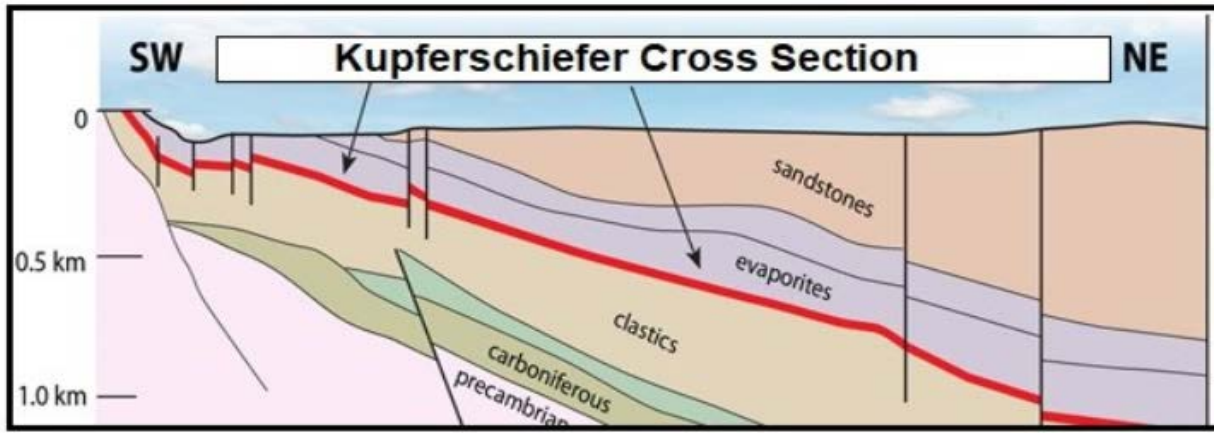
Mining scenarios

- Abandoned mines and operating mines with known remaining unfeasible sections (*no need for full recommissioning or dewatering of the mine.)*

- Ultra depth (in Europe deeper than 1500m). *A large diameter borehole will be drilled from the surface to the deep-seated deposit.*

- Small deposits uneconomic for traditional mining (*no need for development of any mine infrastructure)*

https://investingnews.com

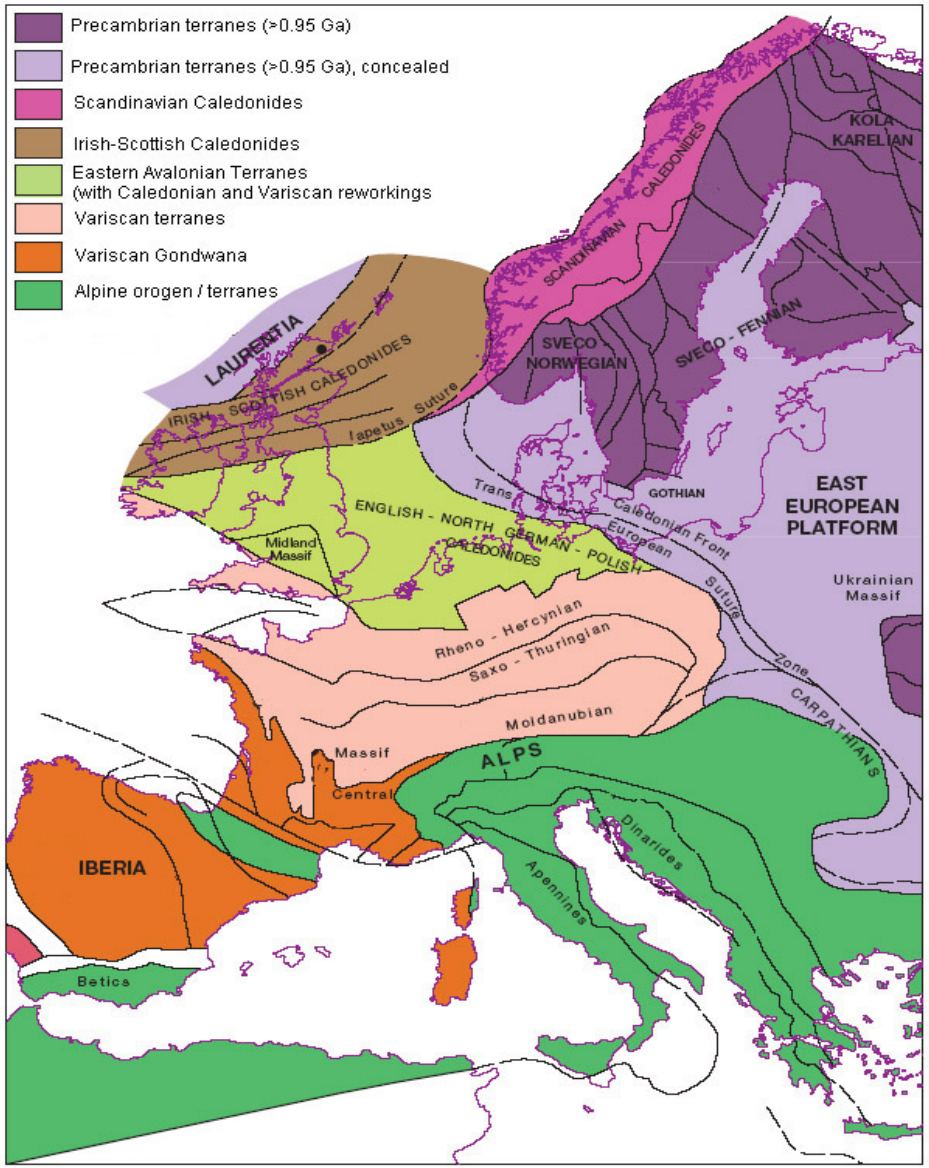


https://www.juniorminingnetwork.com

European outlook: potential targets in the European metallogenic belts

European metallogenic belts:

- East European Craton (Fennoscandian Shield)
- Caledonides (Scandinavia, British Isles)
- Variscides (Iberia – SW-England – France – Germany – Czech Republic – Poland)
- Alps - Carpathians – Balkans – Dinarids

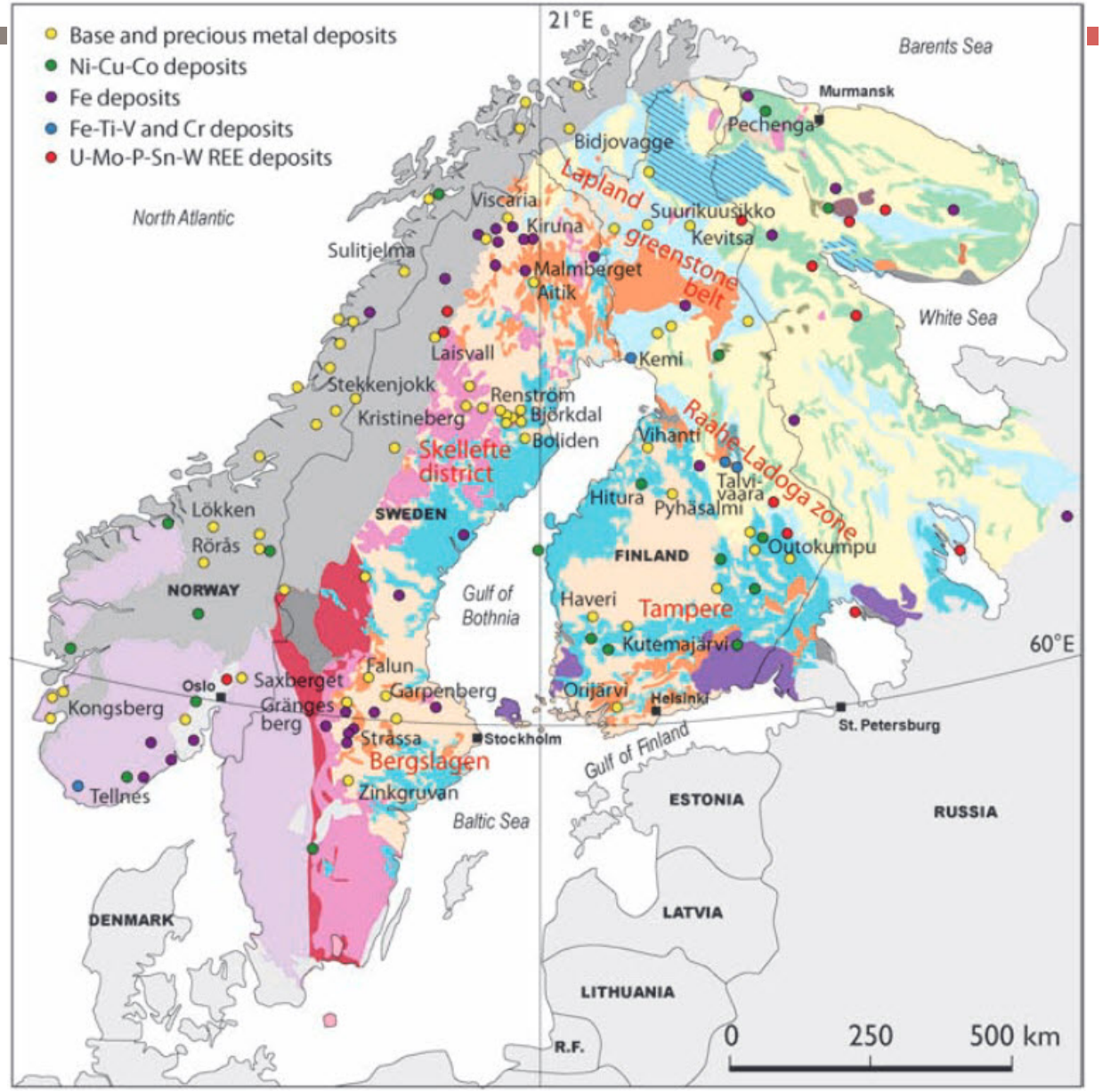


Plant et al. 2005

East European Craton - Fennoscandian Shield

Abandoned mines and operating mines with unfeasible sections:

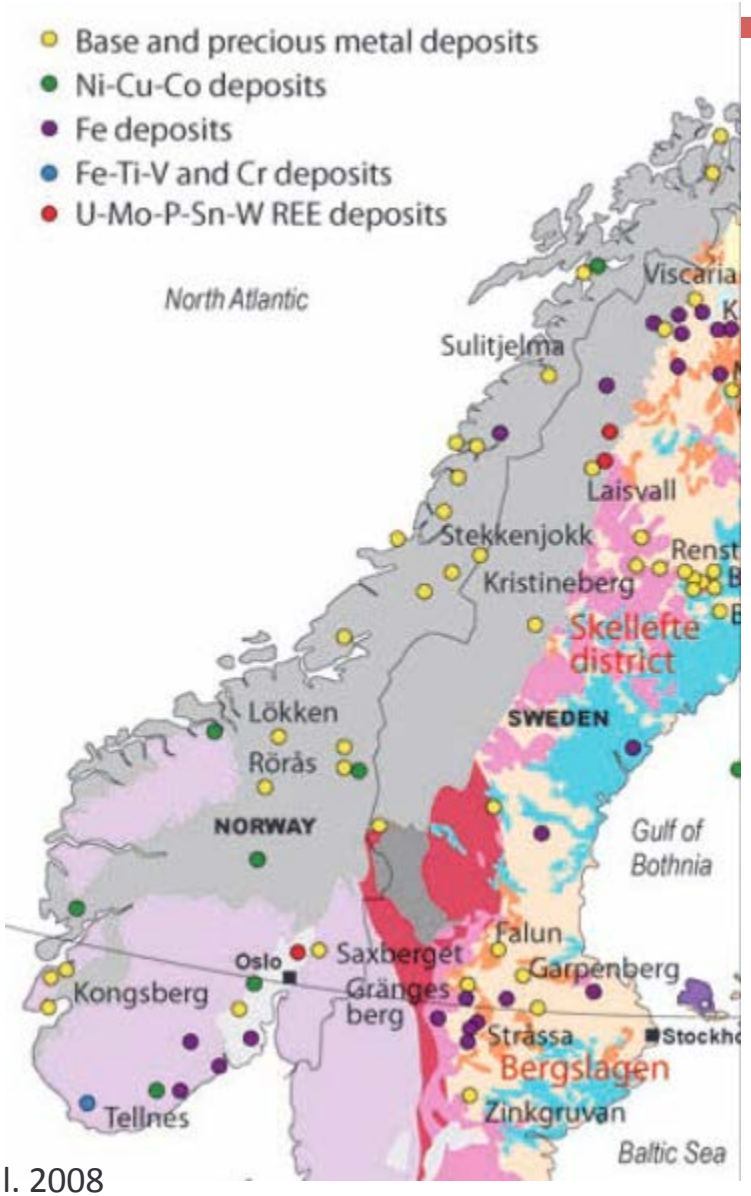
- Skellefte and Bergslagen regions, Pyhasalmi: Cu, Zn, Pb, Co, Ni, Ag, Au
- Kittilä: Au
- Norrbotten, Bergslagen: REE
- Outokumpu: Cu, Zn, Co, Ni, Cr, Ag, Au
- Kemi deposit: Cr (dipping to NW -> ultra deep?)



Weihed et al. 2008

Caledonides - Scandinavia

- Mostly base and precious metal deposits Pb-Zn-Cu-Ag-Ag-As-Sb (abandoned and operating mines)
- Abandoned mines: Kongsberg silver district, Ag-Hg-Sb vein mineralisation. 80 mining sites, 1623-1958
- Ultra depth: Alum Shale: U, Mo, Ni, V, As, Zn, Cd, Pb, REE; at 7 km depth in Denmark!
- Fen Complex: Fe-Nb-REE, Ni-Cu-PGE – only exploration



Weihed et al. 2008

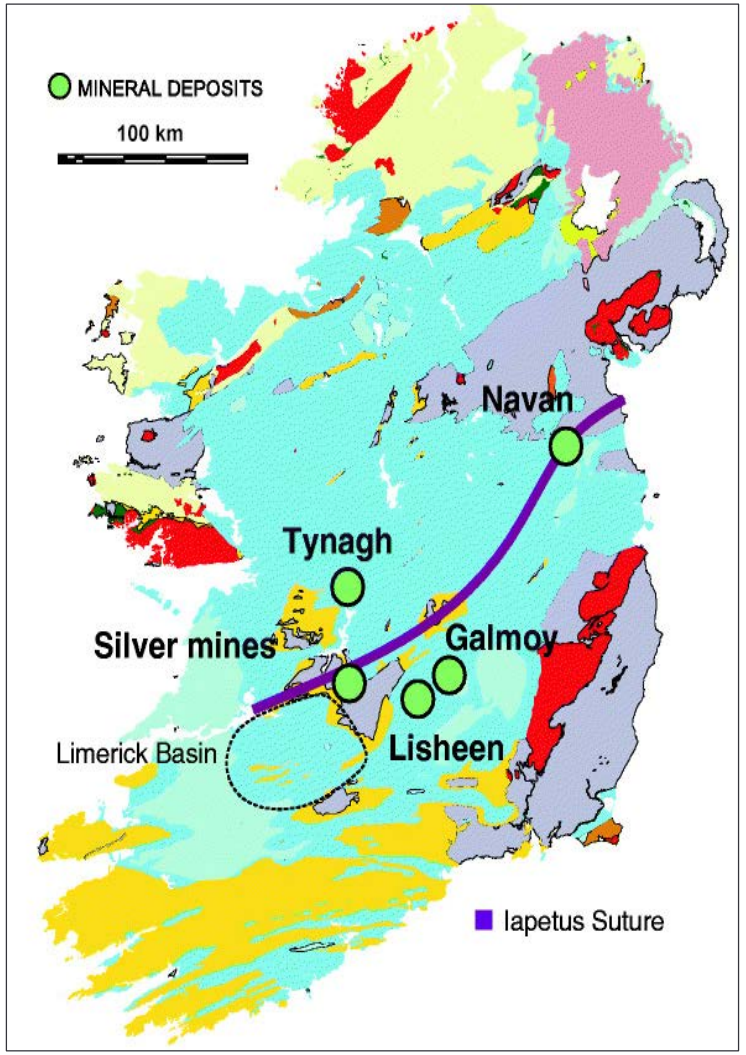
Caledonides – British Isles

<u>Abandoned mines, operating mines, small deposits</u>:

Ireland – Zn-Pb-Ag, numerous vein-type deposits

Scotland – minor importance.
Au, Ag: Tyndrum (reopening an old mine)

https://www.geograph.org.uk/photo/3439597

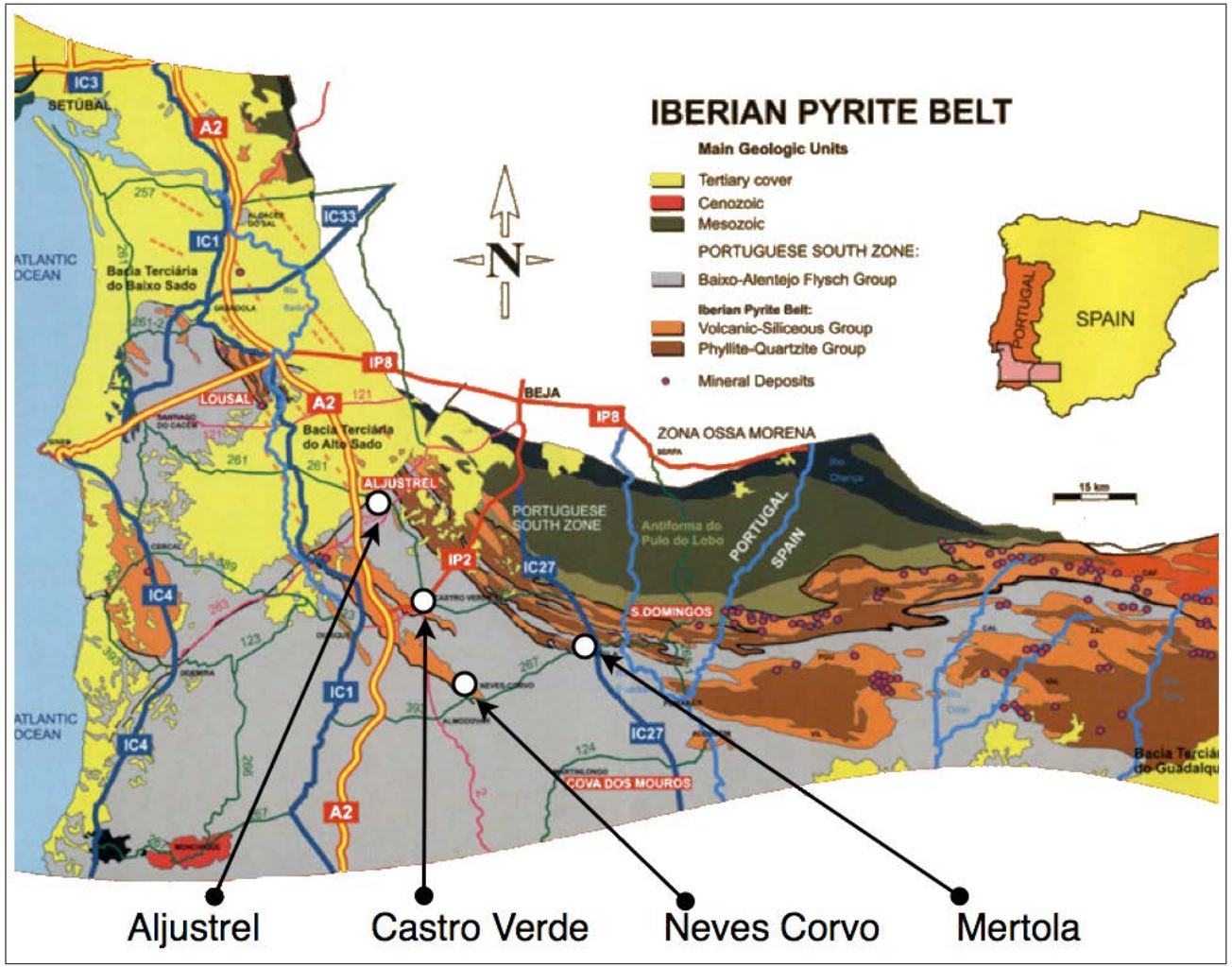


Davidheiser-Kroll et al. 2014

Variscides – Iberian Peninsula

Abandoned mines and operating mines with unfeasible sections

- Iberian Pyrite Belt: 240×70km
- VMS type deposits
- Mined from 8th century BC
- Cu, Pb, Zn, Ag, Au (Sb, Bi, Co)
- Originally 2000 Mt ore, still has 400 Mt left to exploit



https://en.wikipedia.org/wiki/Iberian_Pyrite_Belt

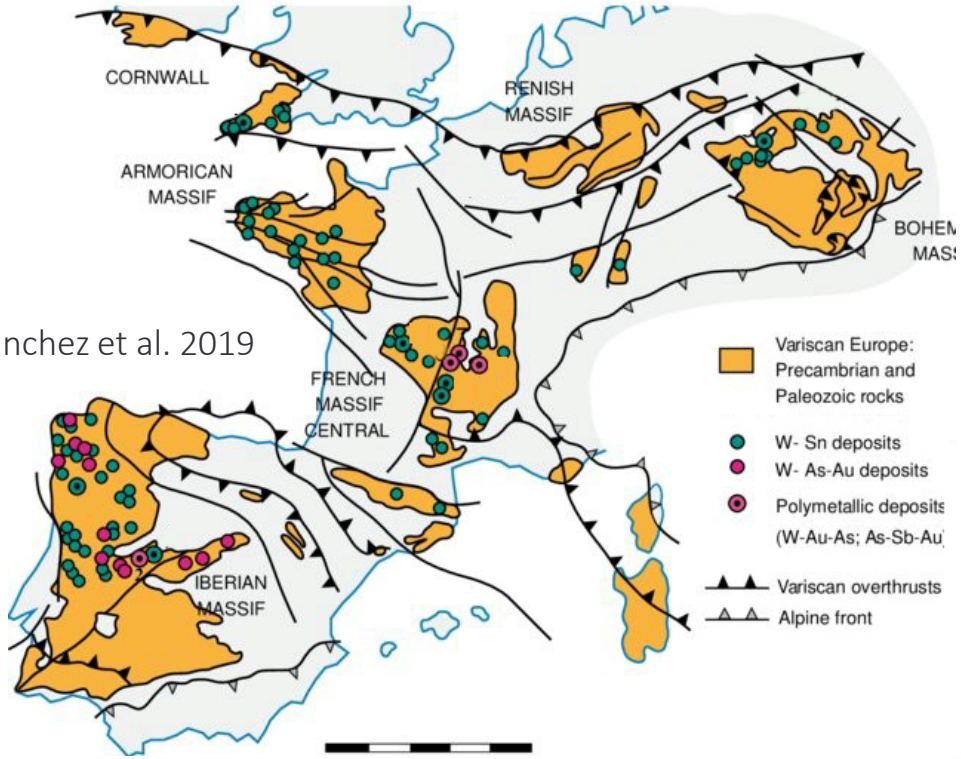
Variscides – from SW-England to Poland

Abandoned mines, small deposits:

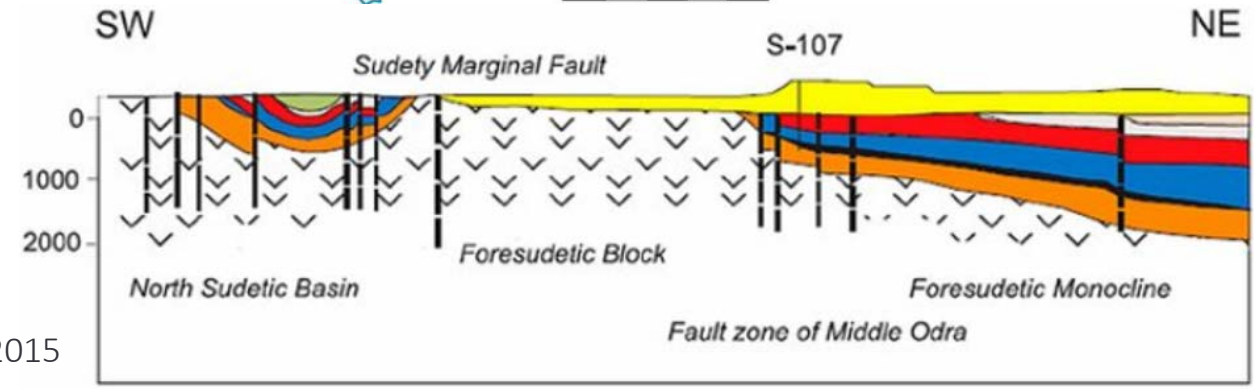
- Cornwall: Sn, Cu (W, Zn, Ag, As), mining from 2000 BC
- Erzgebirge: Sn, Ag, Li, W, U; 800 years of mining. Cinovec: Li
- Many abandoned base metal mines from Spain to Poland (Rammelsberg)

Ultra deep:

- Kupferschiefer: from England to Silesia
  Cu, Pb, Zn (V, Mo, U, Ag, As, Sb, Hg, Bi, Se, Cd, Tl, Au, PGE)
  Known from 2km depth in SW Poland
  The Cu-rich shale is <2m thick

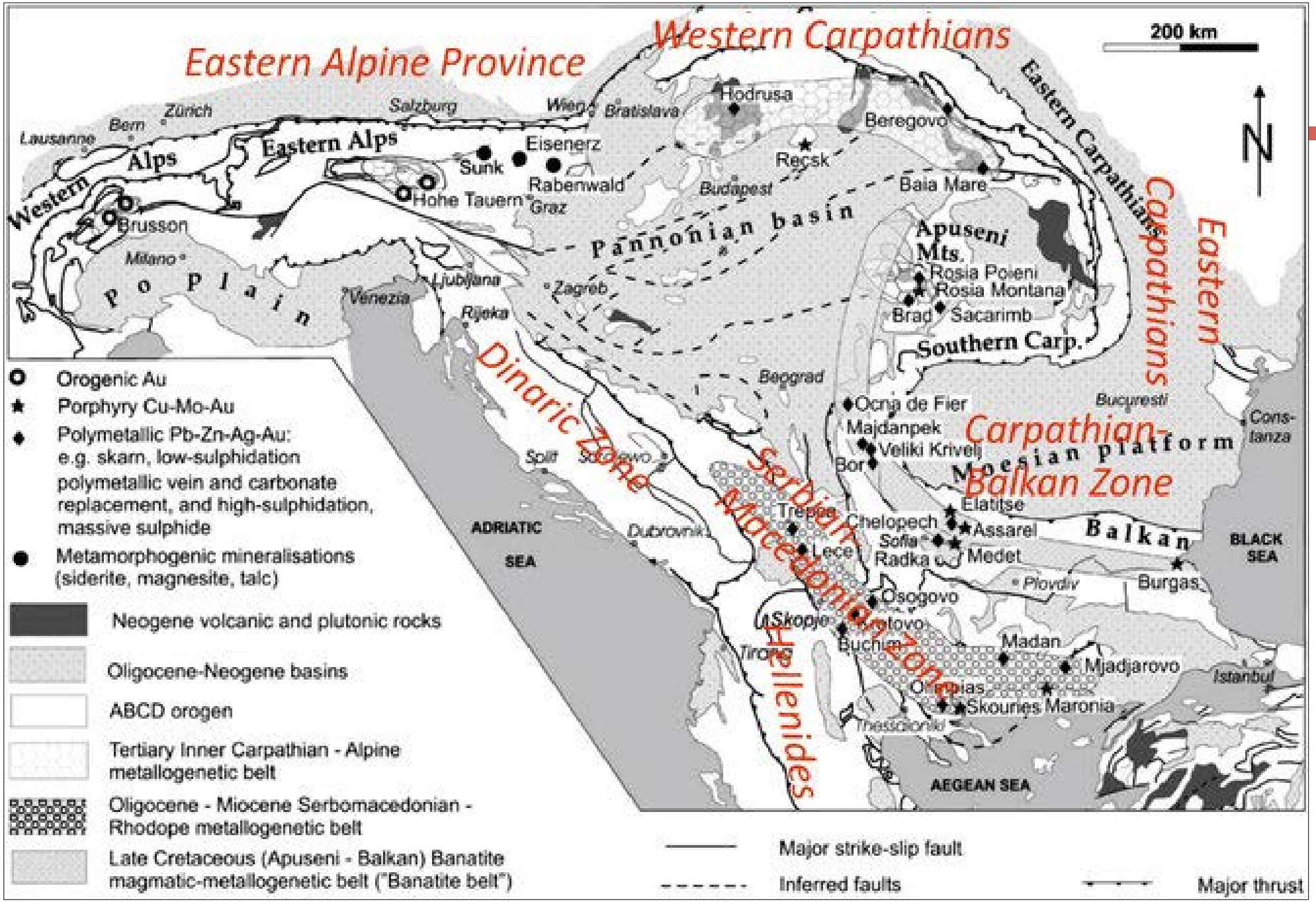


Timón-Sánchez et al. 2019



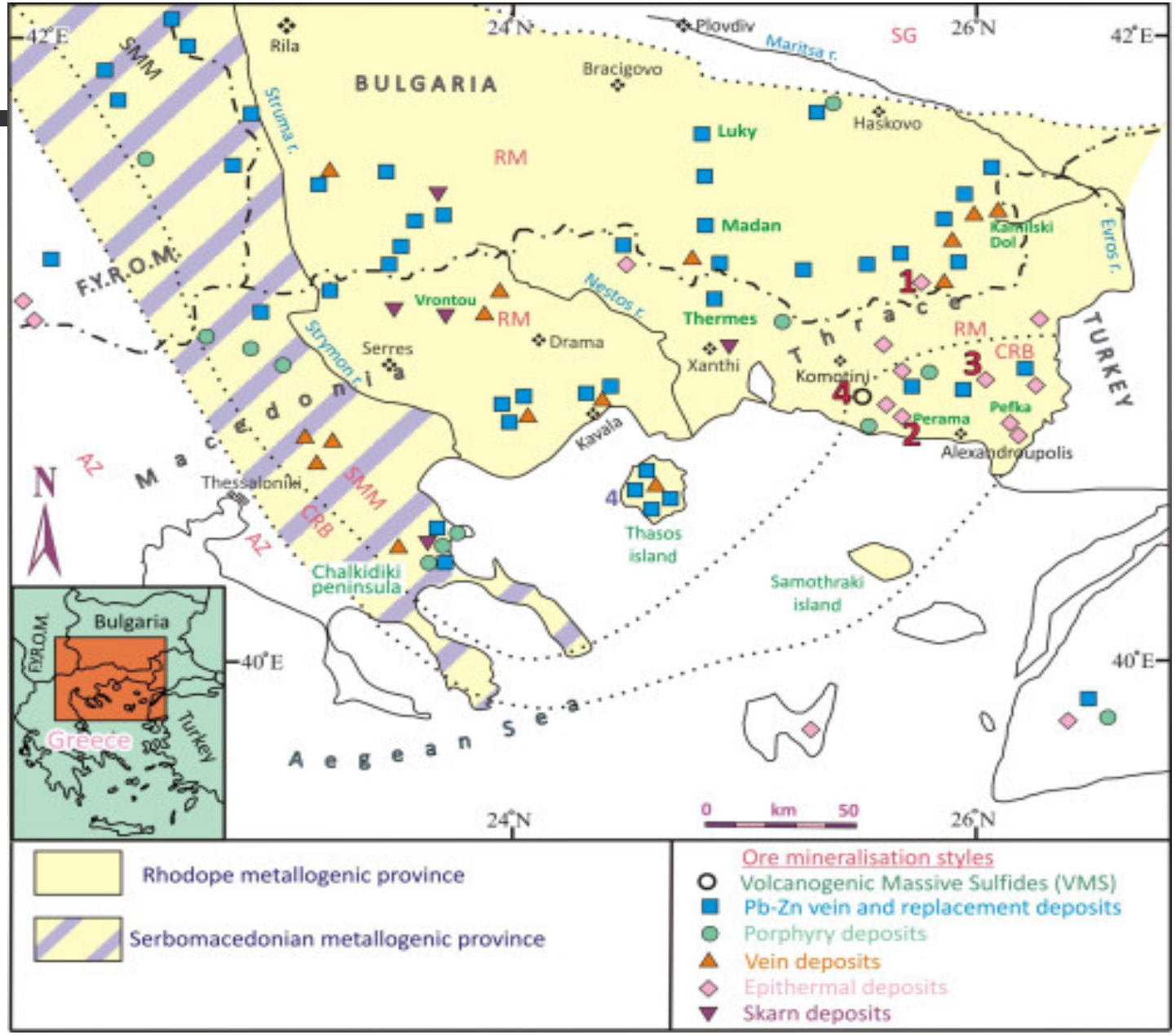
Bauer et al., 2015

Alpine Belt



Melcher & Reichl, 2017

Balkan Peninsula



<u>Abandoned mines and operating mines with unfeasible sections:</u>

Chelopek, Bulgaria: 40 Mt 1.1% Cu and 3.1 ppm Au ore since 1959

Albania: PGE bearing podiform chromite

https://authseg.wordpress.com/2016/12/18/293/

Thank you for your attention!

https://robominers.eu/