

Ore-forming fluids associated with Pb-Zn-Ag-sulfide mineralization of the Rogozna and South Kopaonik metallogenic belt

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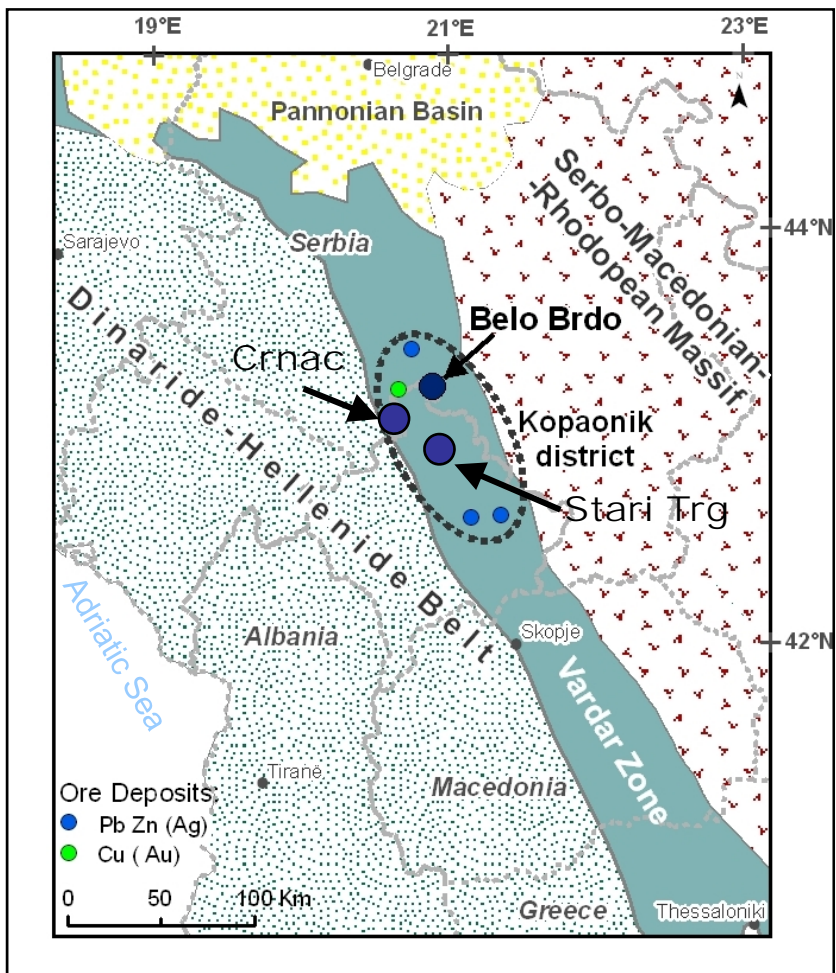
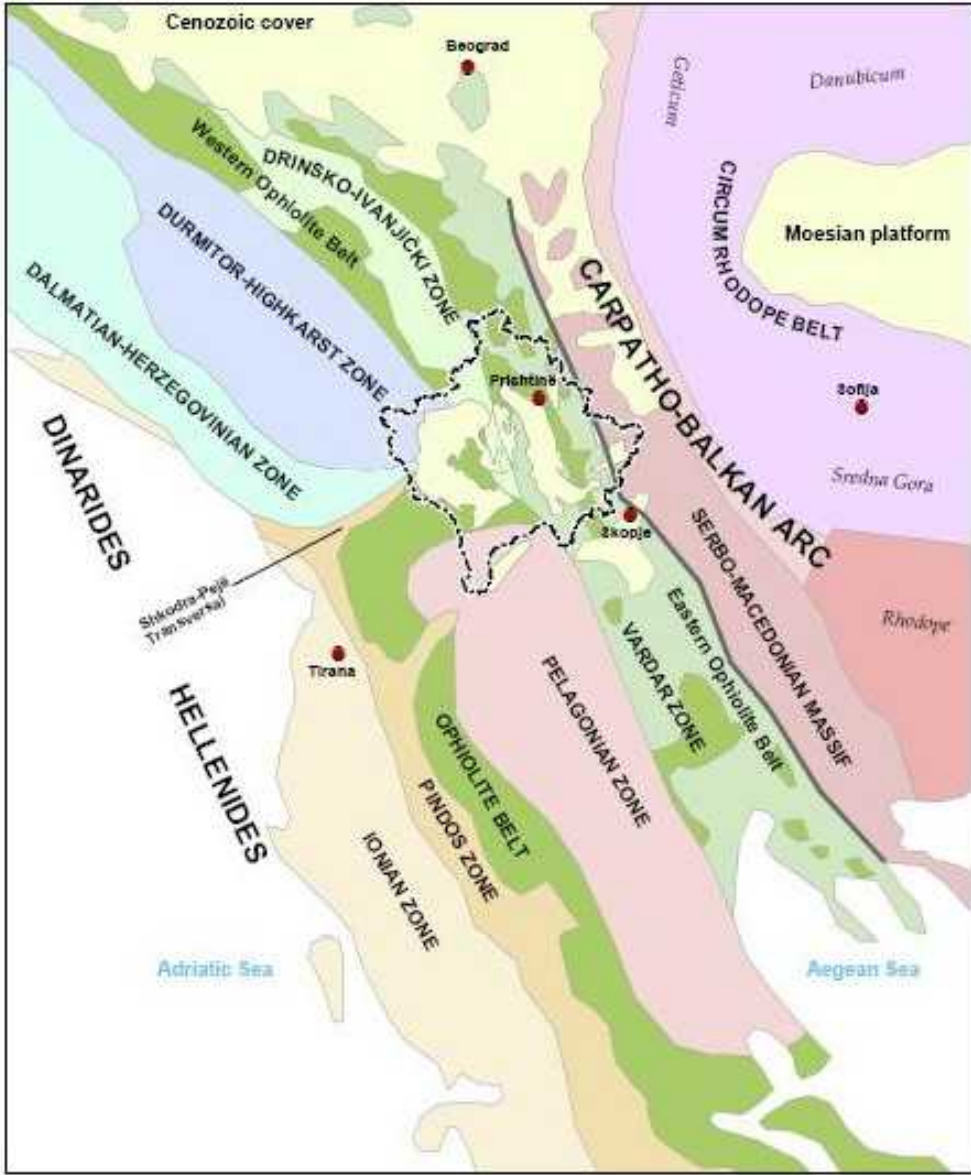
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Geological setting

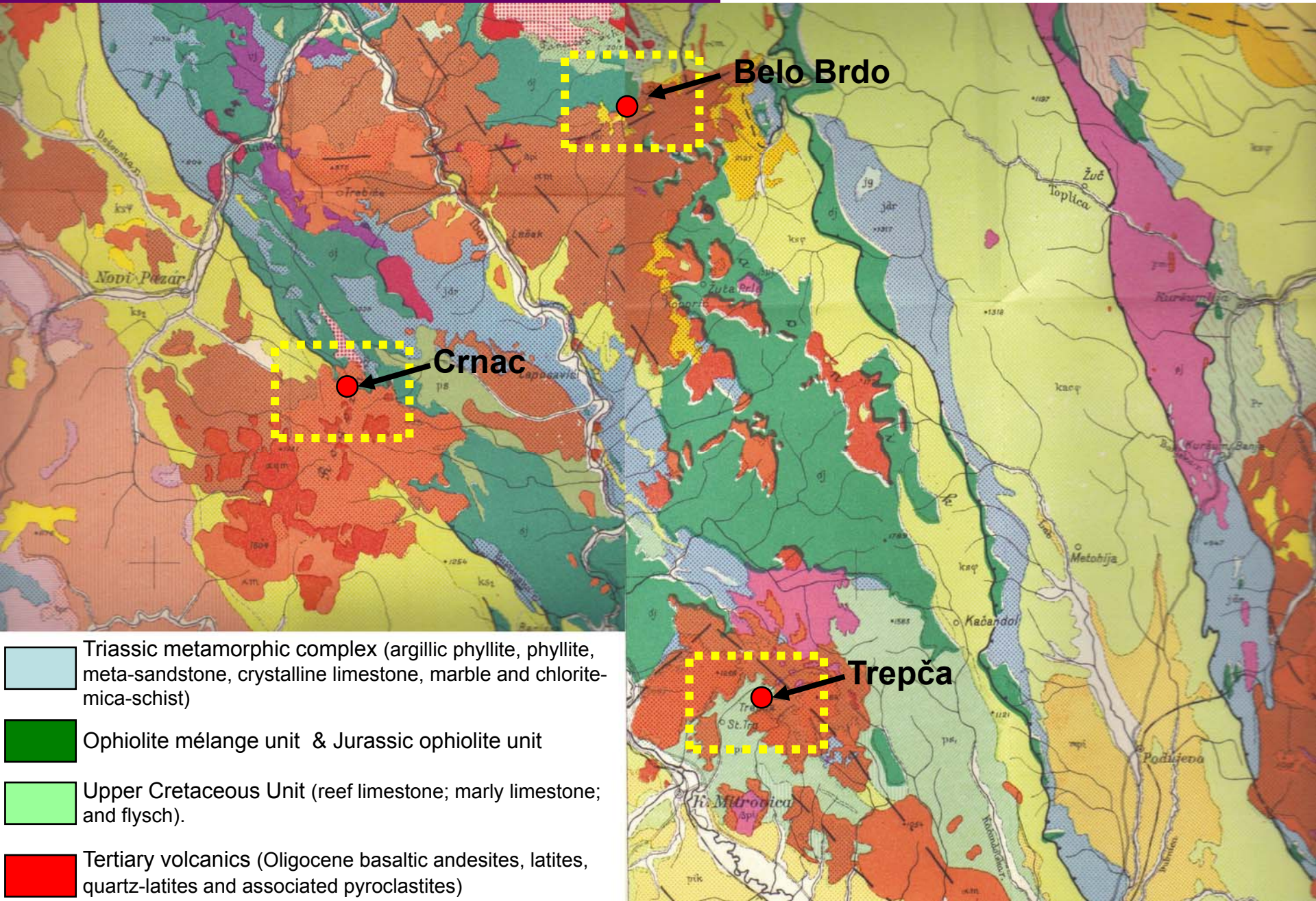
Geotectonic Units of Central Balkan

Scale approx. 1 : 3,500,000

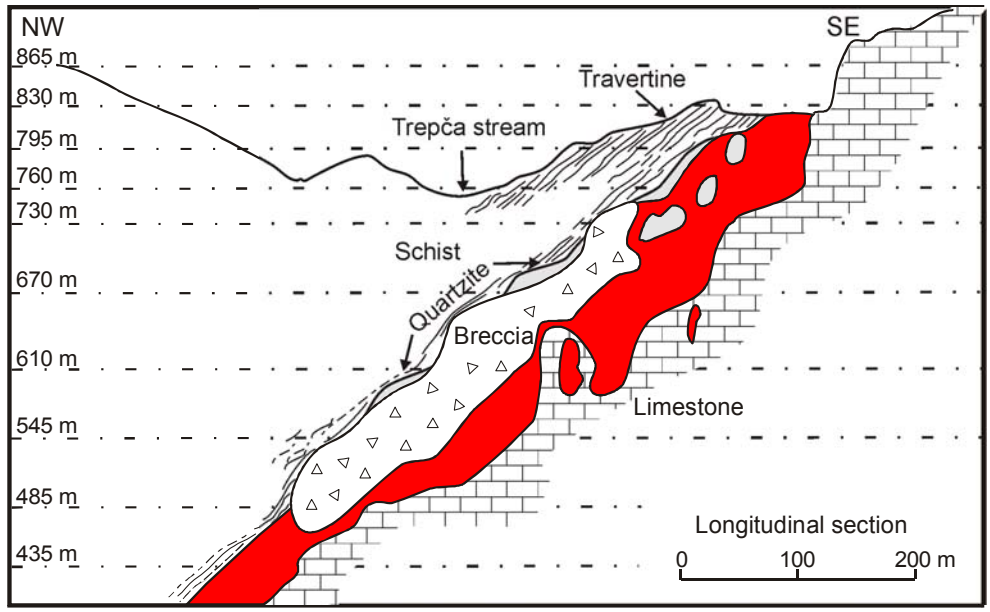


modified after SCHÖNENBERG & NEUGEBAUER, 1997; DIMITRIJEVIĆ, 1999; MEÇO & ALIAJ 2000 et al.

Geological setting



Stari Trg mine/Trepča – host rocks



Host limestones (Triassic) with sulfide mineralization, surface (+850m)

Host limestones with developed palaeokarst (Triassic), level X. (+75m)

Stari Trg mine – volcanic rocks

The deposit is related to intensive Neogene magmatism within the Western ophiolitic Vardar zone, in the easternmost part of Dinarides.



Contact quartz latite-breccia



Quartz latite

Stari Trg mine – volcanic rocks



Caldera



Caldera – satellite photo image



Travertine

Stari Trg mine – breccia



Milled breccia within limestone
Level X.



Breccia with fragments of schist and marble...

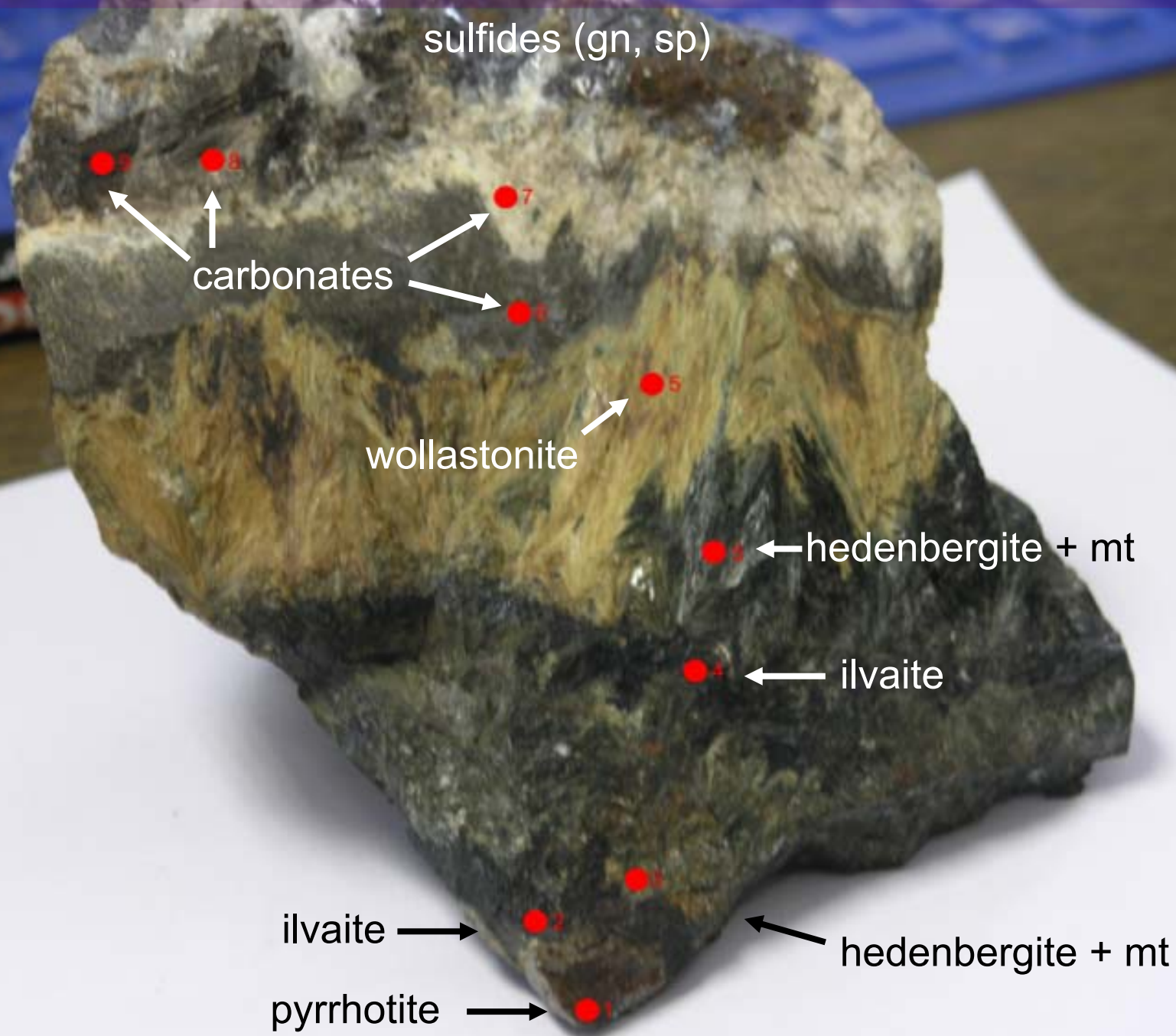


Mineralized fragment within breccia
Level X.



...and with fragments of sulfides (Po, Py)

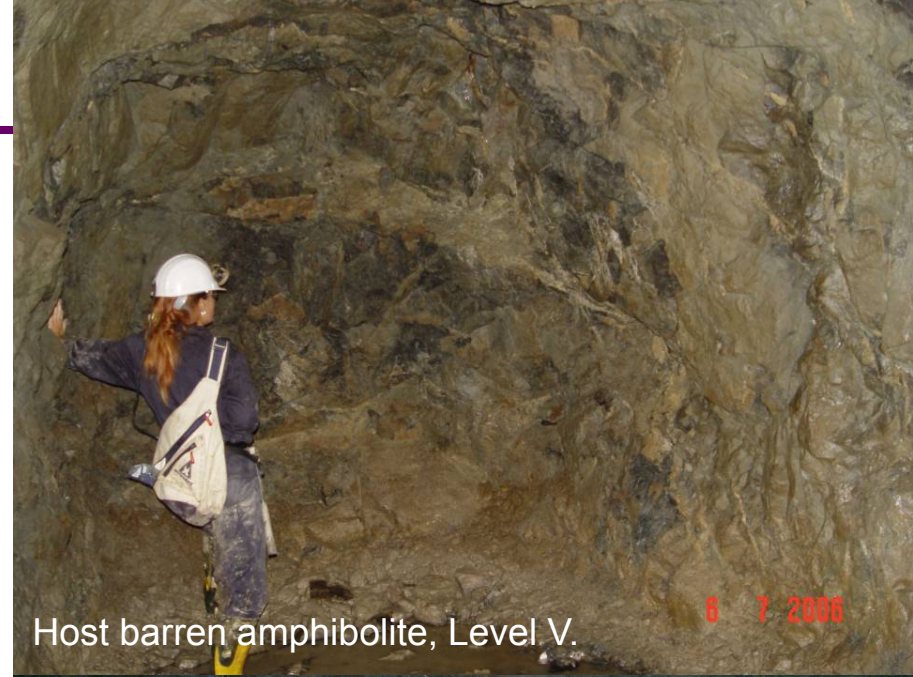
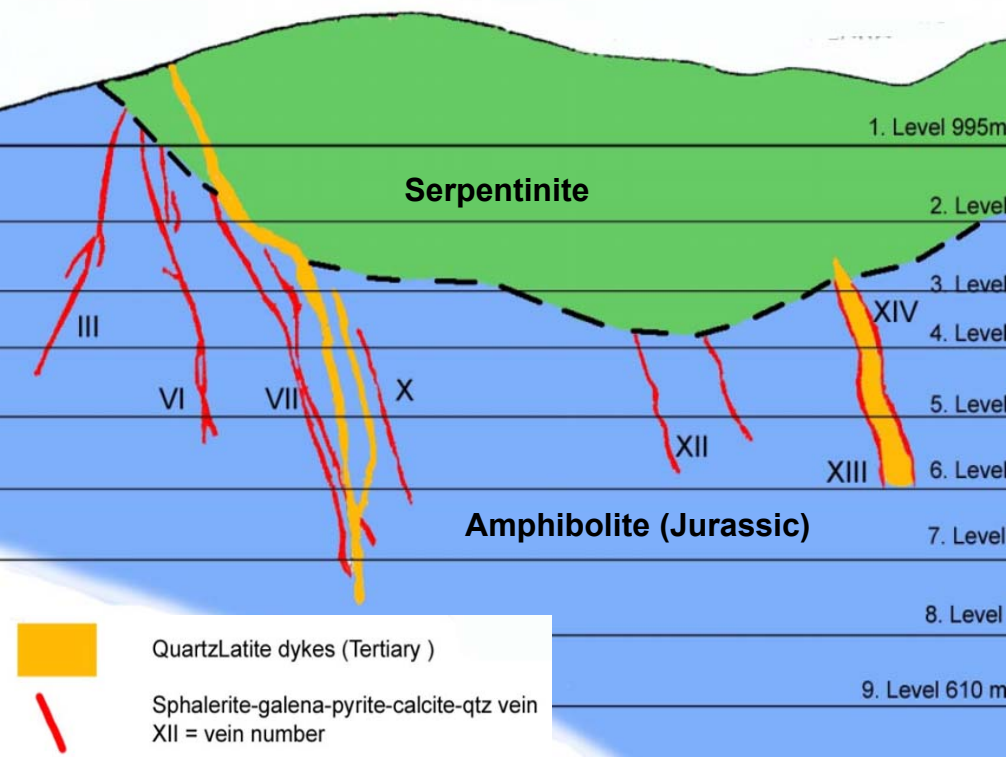
Stari Trg mine – Skarn mineralization



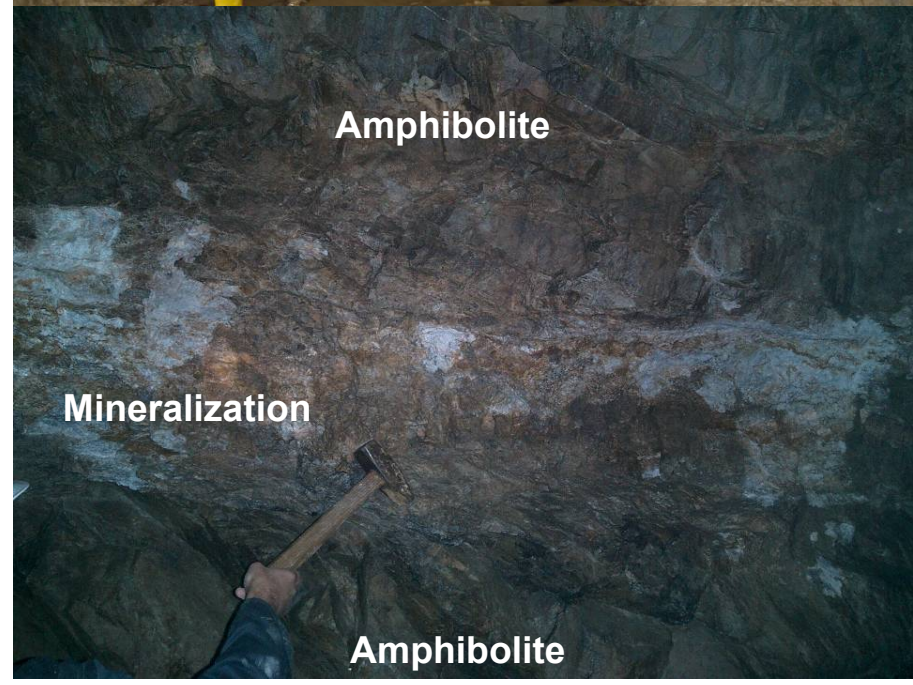
Stari Trg mine – Hydrothermal mineralization



Crnac mine – host rocks



Host barren amphibolite, Level V.



Host amphibolite with sulfide mineralization, Level V.



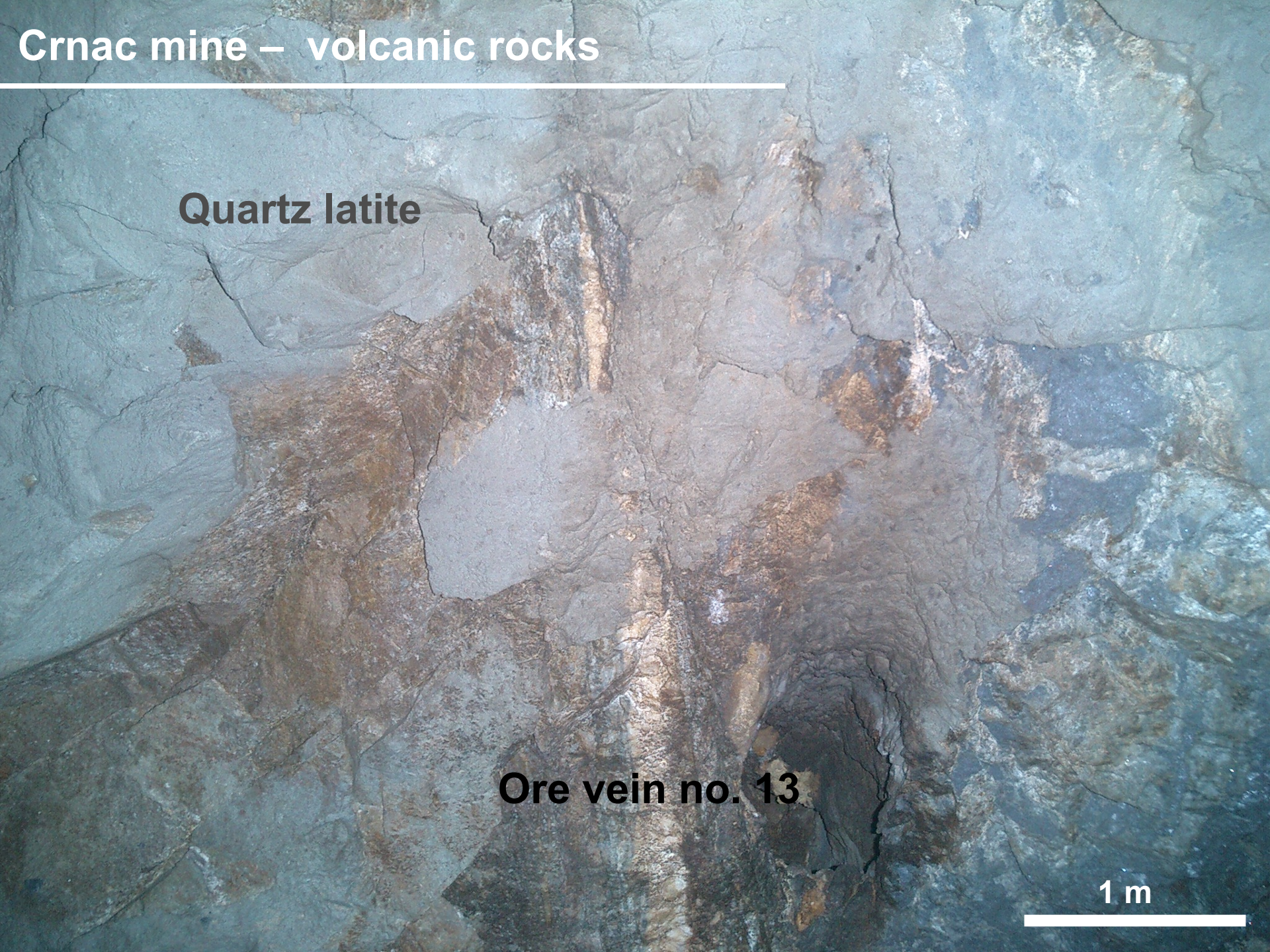
Listwaenite, Level IV.

Crnac mine – volcanic rocks

Quartz latite

Ore vein no. 13

1 m



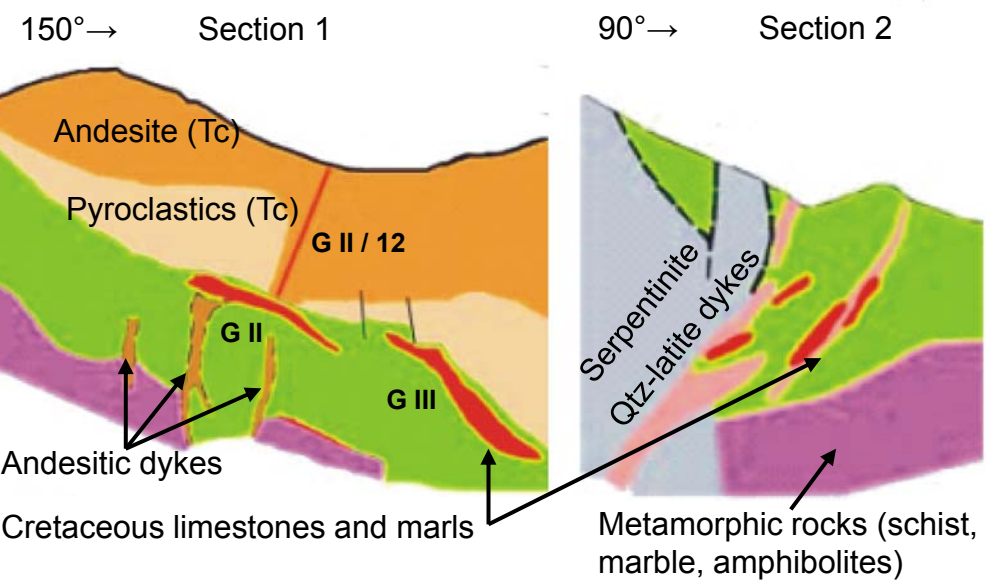
Crnac mine –mineralization



Listwaenite mineralization

Vein mineralization

Belo Brdo mine – host rocks



Disseminated pyrite and galena in mm-sized quartz veins which are cutting hydrothermally altered volcanic host



Chloritised andesitic host with intense stockwork quartz-calcite veins.



Belo Brdo mine – volcanic rocks

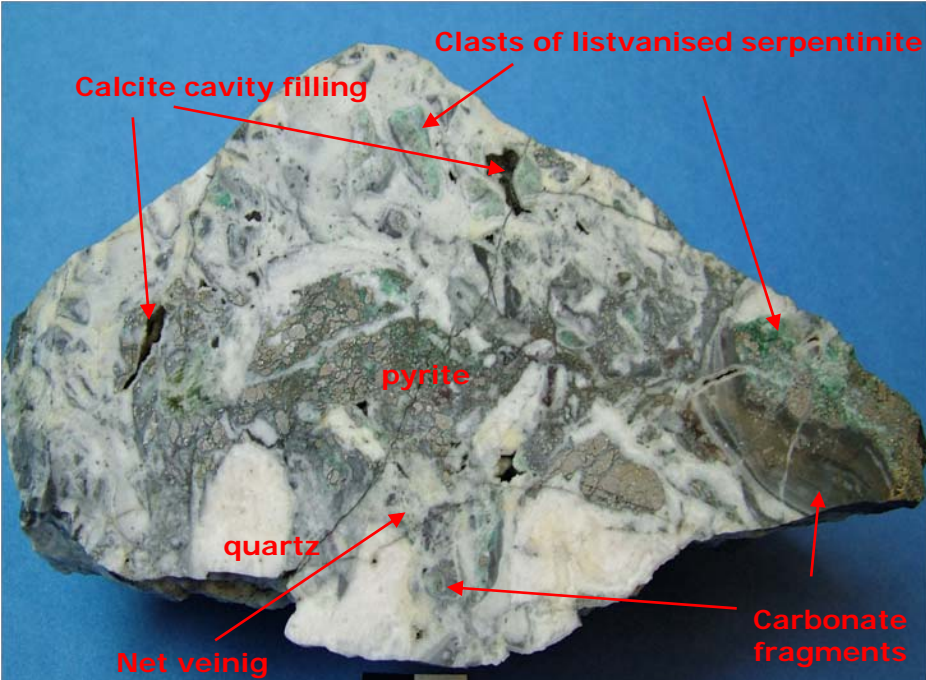


Phase I volcanism: Andesites



Phase II volcanism: stockwork of pyrite veins in contact of quartz-lattice dyke and ophiolitic melange

Belo Brdo mine – mineralization



Hydrothermal breccia developed within a quartz-carbonate stockwork structure at serpentinite and carbonate contact.



“Rhythmically” banded mineralization from vein ore body. Pyrite-sulphides-pyrite-quartz.

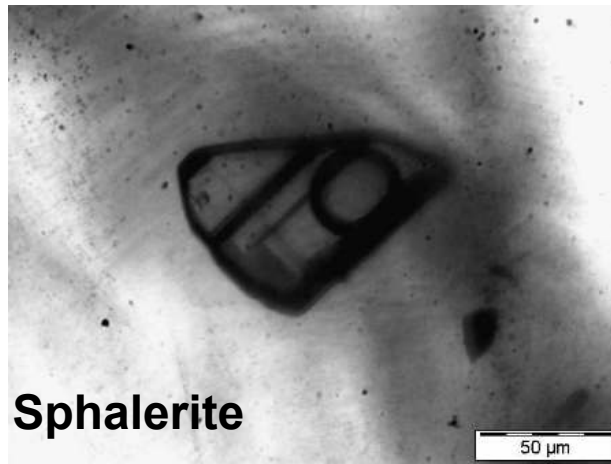
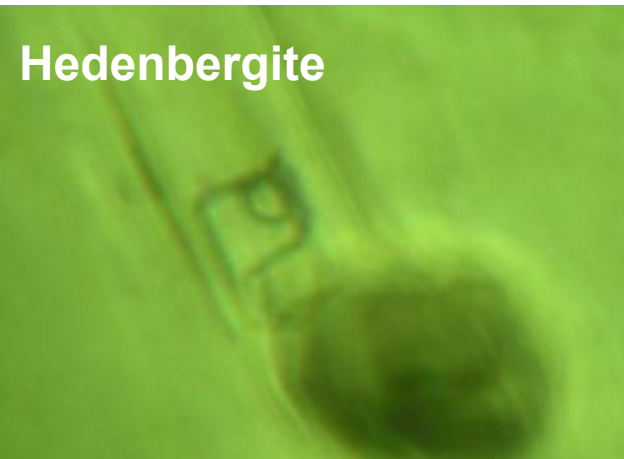


Replacement texture. Fine-grained and coarse-grained granulated pyrite (brass yellow) replaced by galena (grey). Also quartz and calcite vugs

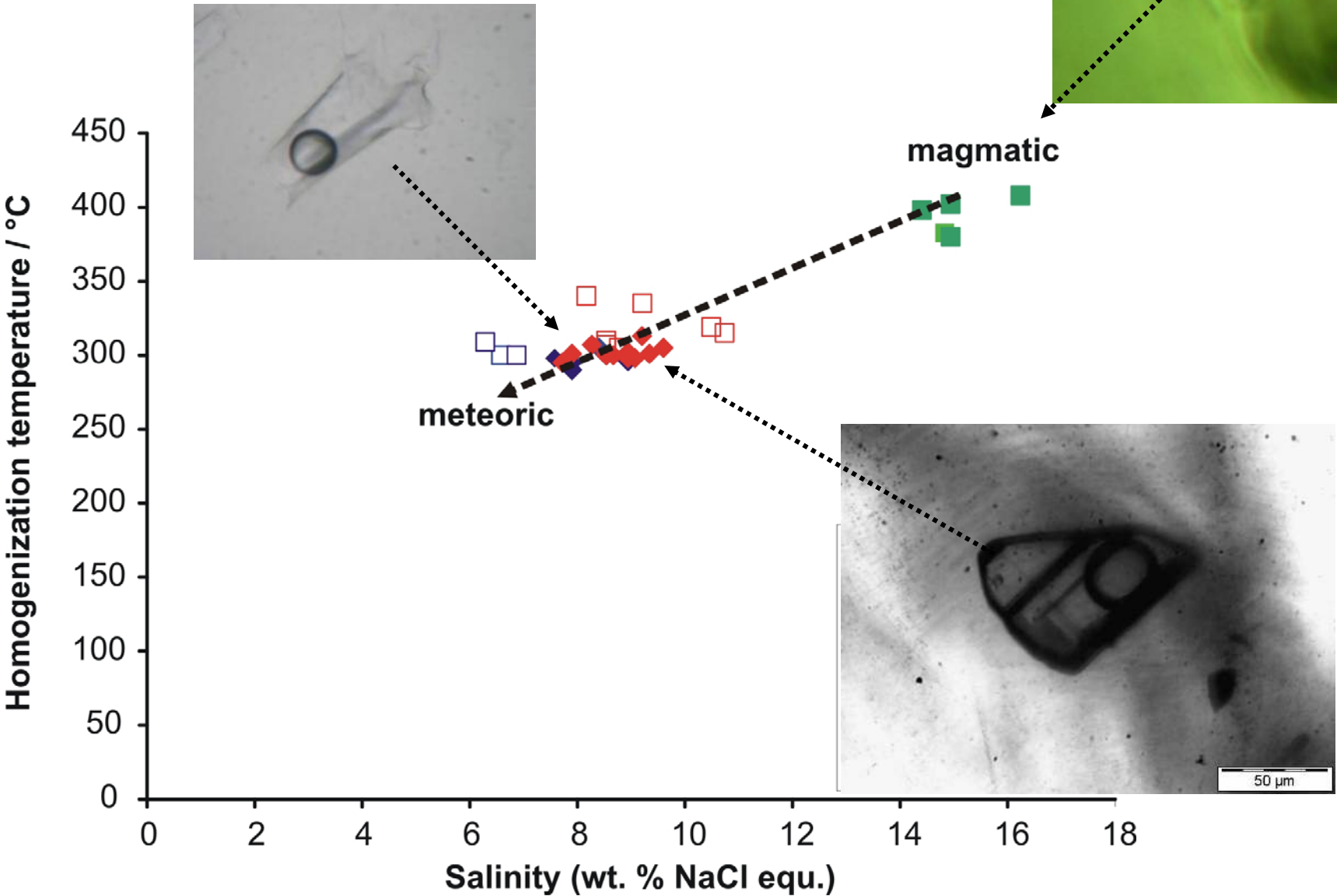
Stari Trg mine – fluid inclusion data

Mineral	Composition	Th (°C)	Salinity (wt. % NaCl eq.)
Hedenbergite (skarn)	NaCl-KCl-H ₂ O	385 - 410	14.8 - 16.5
Sphalerite (skarn)	NaCl-H ₂ O	295 - 315	7.6 – 9.6
Sphalerite (hydroth.)	NaCl-H ₂ O	240 - 300 *	7.6 - 14.8
Quartz (skarn)	CaCl ₂ -NaCl±KCl-H ₂ O	305 - 350	8.1 – 12.0
Quartz (hydroth.)	CaCl ₂ -NaCl±KCl-H ₂ O	295 - 310	4.5 – 7.5
Carbonate (breccia)	CaCl ₂ -NaCl-H ₂ O	235 - 262	22.2 – 32.4
Carbonate (skarn)	CaCl ₂ -NaCl±KCl-H ₂ O	>T _{decrip.}	9.9 – 11.1
Carbonate (hydroth.)	CaCl ₂ -NaCl±KCl-H ₂ O	>T _{decrip}	4.5 – 7.5

* Negative thermal gradient of approximately of 20° /m between level X. (+75m) and V. (+375m) is estimated according to FIs data from sphalerite.

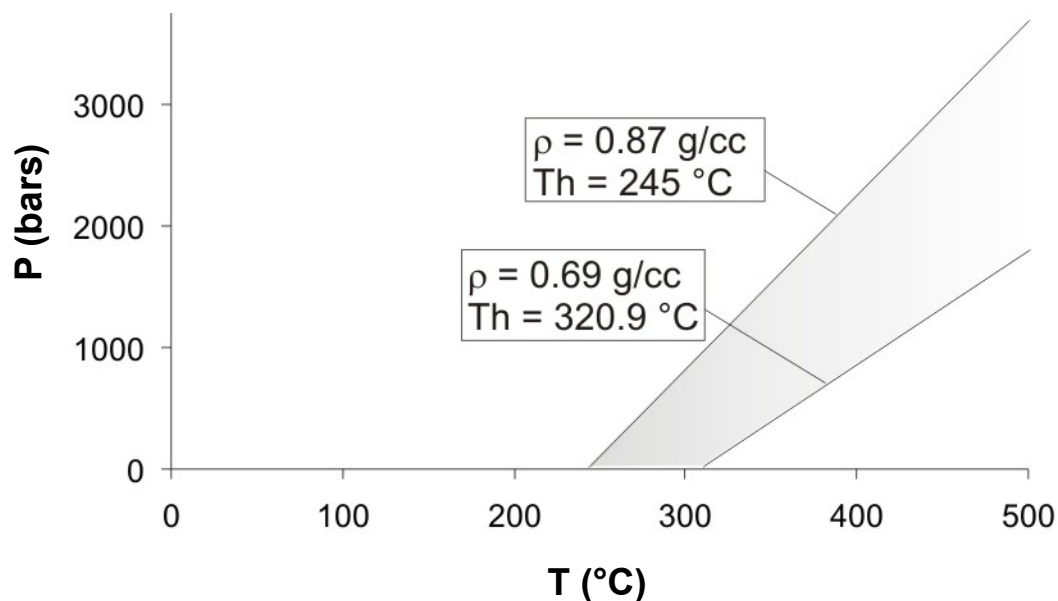


Stari Trg mine – fluid inclusion data

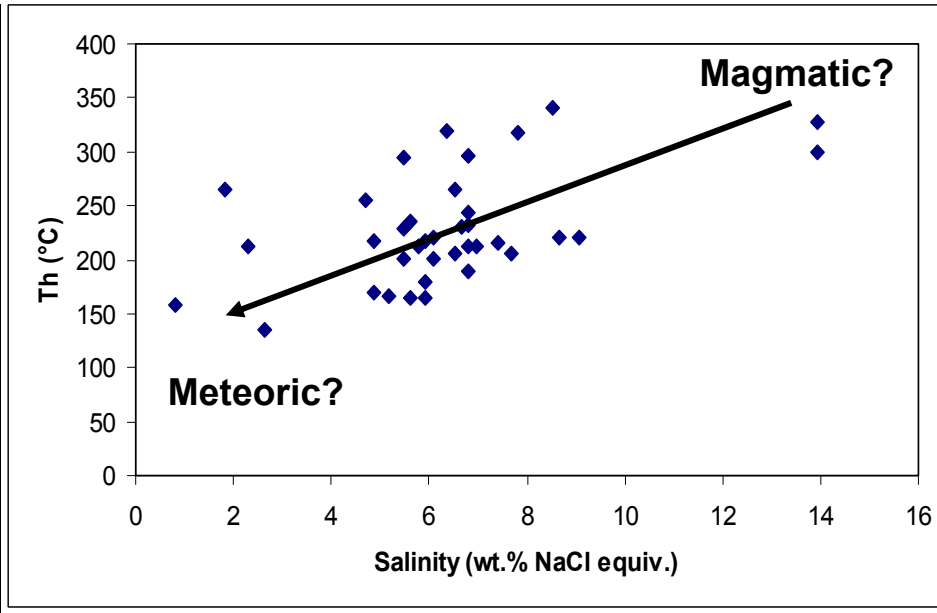
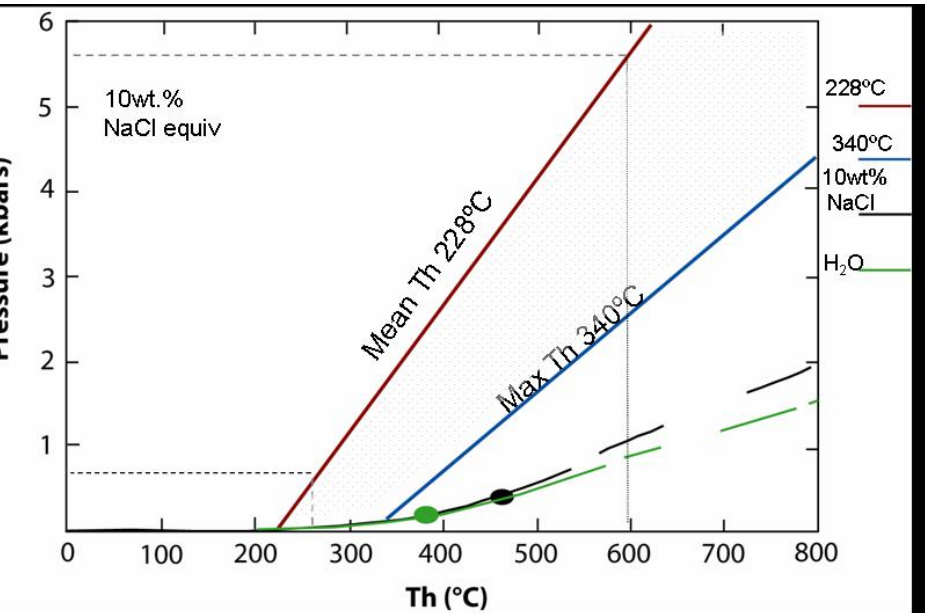
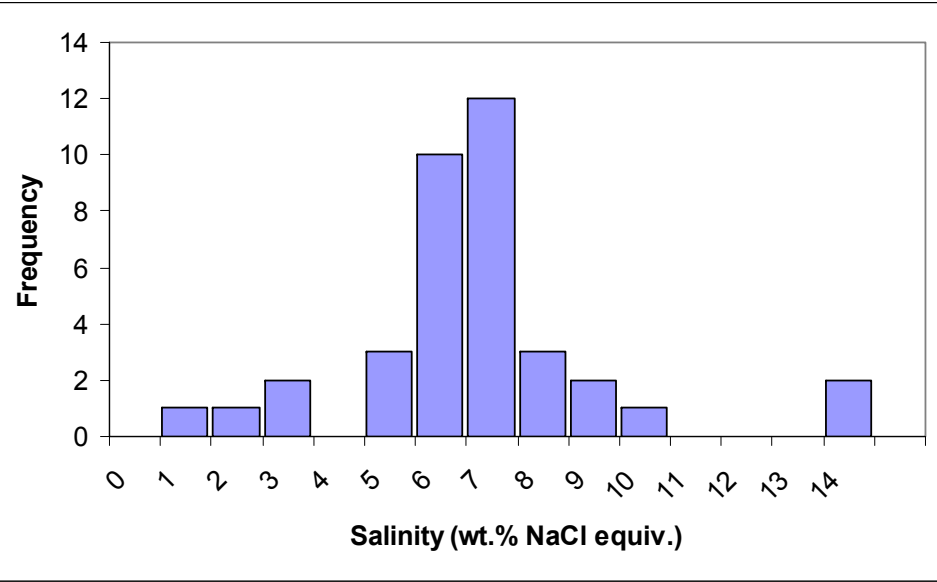
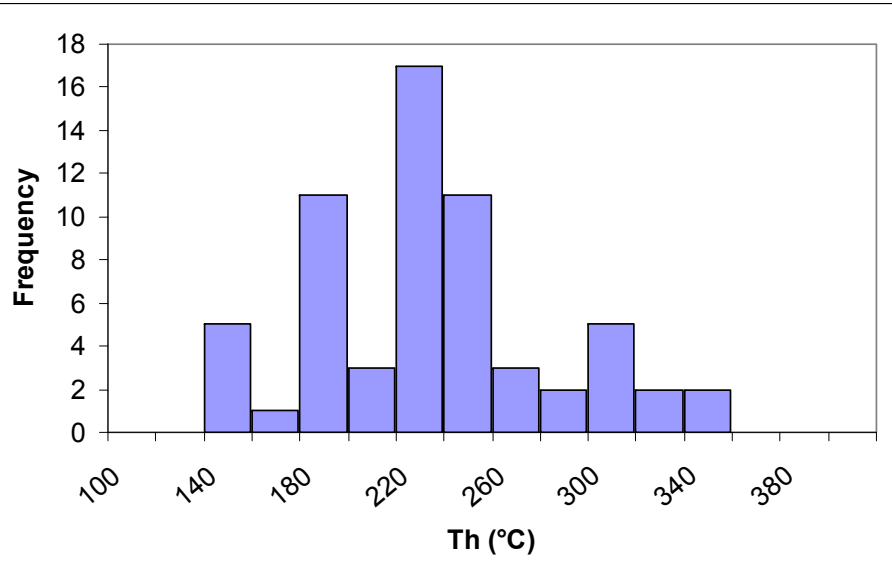


Crnac mine – fluid inclusion data

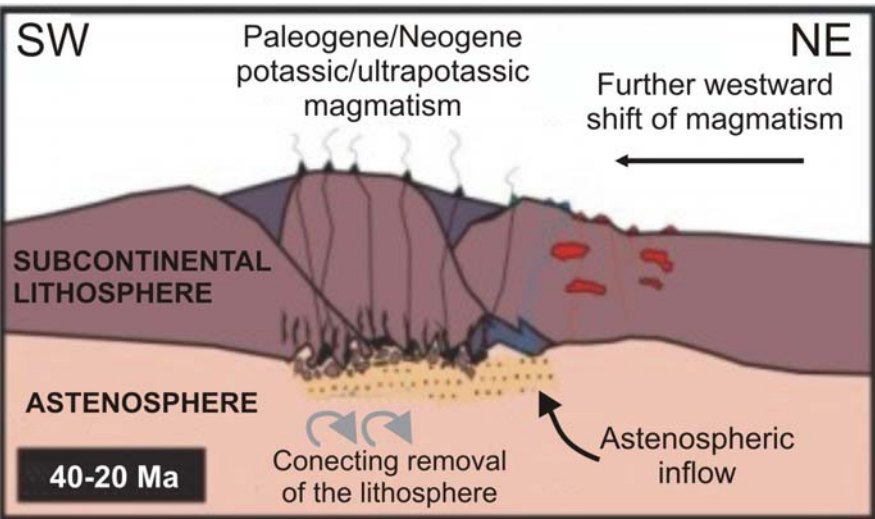
Mineral	Inclusion generation	Composition	Th (°C)	Salinity (wt. % NaCl eq.)
Quartz (listwaenite)	P	NaCl-H ₂ O	249 - 324	2.9 – 6.7
Carbonate (listwaenite)	P	CaCl ₂ -NaCl±KCl-H ₂ O	247 - 325	5.1 – 7.0
Carbonate (listwaenite)	PS	CaCl ₂ -NaCl-H ₂ O	219 - 250	4.3 – 4.9
Carbonate (listwaenite)	PS	NaCl-CO ₂ -H ₂ O	268	11.7



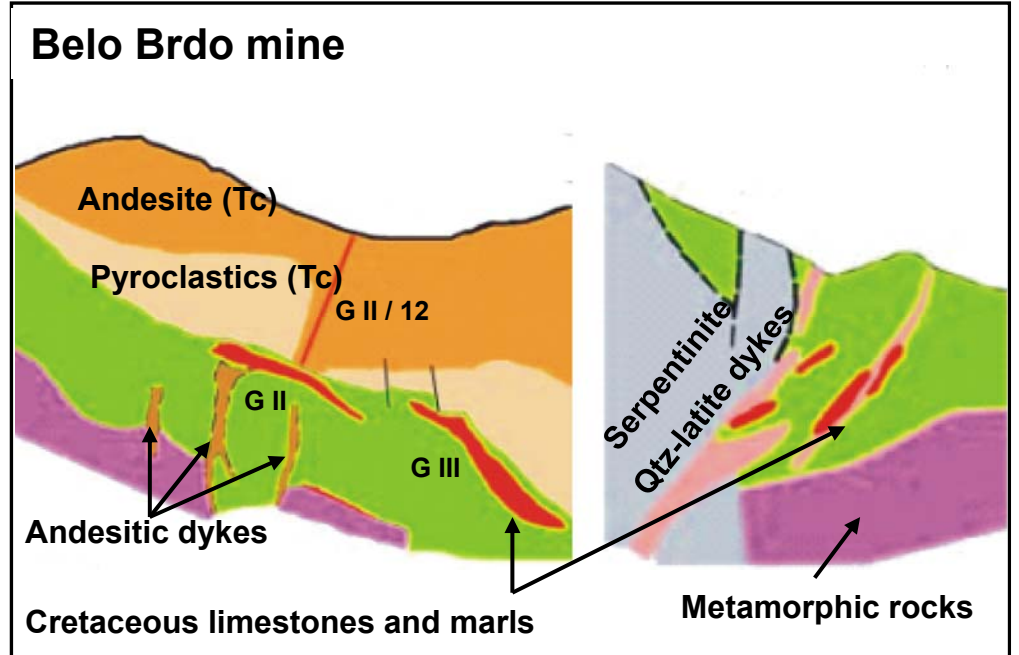
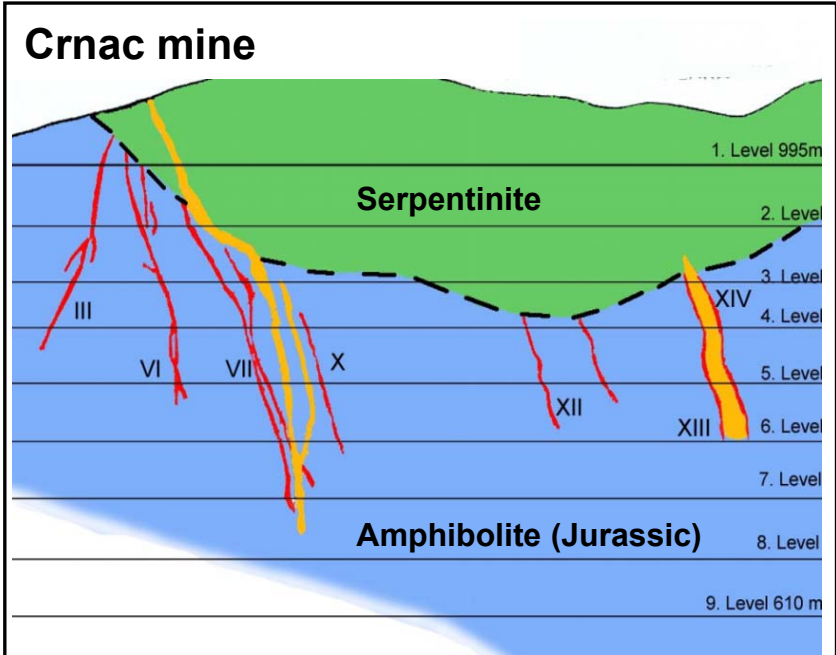
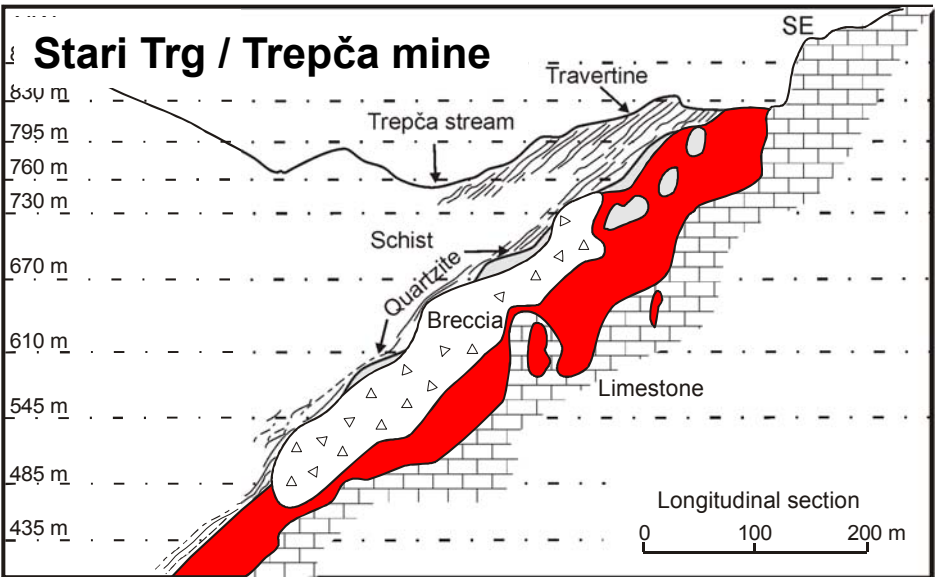
Belo Brdo mine – fluid inclusion data



Conclusion



Cvetković et al., 2004



Applied methods

Host rocks

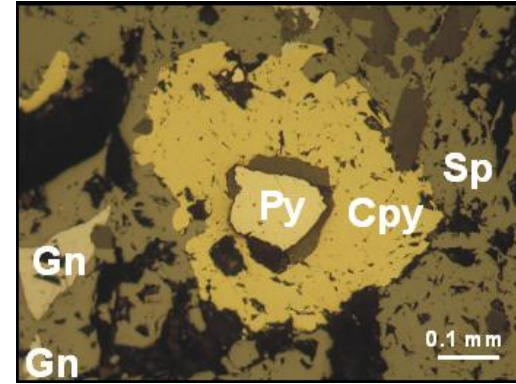
- carbonates
- $\delta^{18}\text{O}$ vs. $\delta^{13}\text{C}$
- $^{87}\text{Sr}/^{86}\text{Sr}$
- geochemistry

- amphibolites
- geochemistry
- Ar/Ar dating



Ore minerals

- Ore microscopy
- Microprobe
- SEM/EDX & SEM/WDS
- $\delta^{34}\text{S}$
- fluid inclusions within sphalerite



Gangue minerals

- fluid inclusions
- $\delta^{18}\text{O}$ (silicates)
- geochemistry
- $\delta^{18}\text{O}$ vs. $\delta^{13}\text{C}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ (carbonates)



Volcanic rocks

- K/Ar dating
- Ar/Ar dating
- geochemistry



Fluid inclusions studies

- microthermometry
- chemistry of leachates
- LA-ICP/MS
- δD vs. $\delta^{18}\text{O}$

