Metamorphic Evolution of Ophicarbonates (Zermatt-Saas-Unit)

Trace Element Composition of HP Ophicarbonate as Monitor of Subduction Fluids

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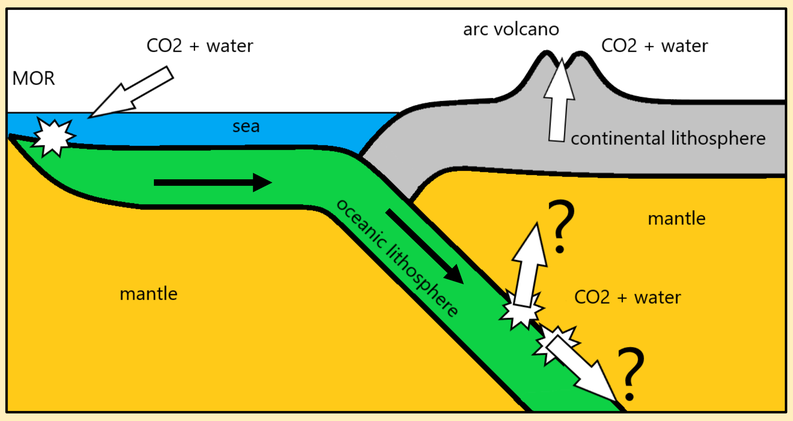
Introduction



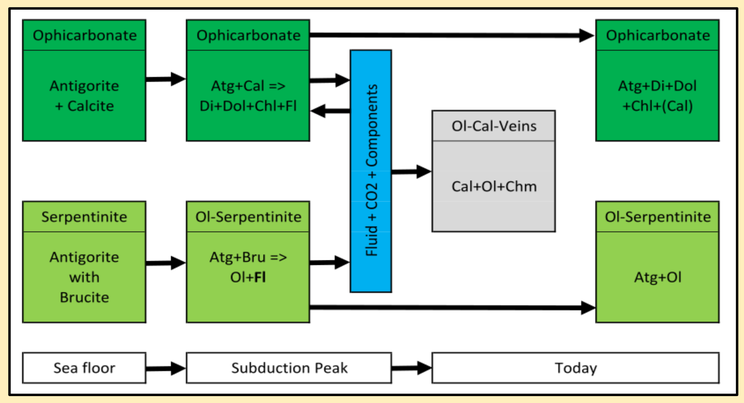
The processes linked to the **deep carbon cycle** are not entirely understood and therefore highly debated. It is unclear how much of carbon or CO_2 gets remobilised during subduction and how much carbon could get buried into deep earth to remain in the mantle for large geological periods. Because **ophicarbonates can be far more stable to elevated P and T** than other carbonate bearing rock types they can be seen as the most important **"CO_2 input-lithology" for earth's mantle**. In this study we investigate the metamorphic history of the Zermatt-Saas-ophicarbonates to check how CO_2 could be preserved in the rock at 80 km depth and temperatures about 550° C.

Questions

Aims of this study:

- Investigate the **metamorphic reactions** which lead to the observed mineral assembly
- Reconstruct the fluid behavior during metamorphic mineral reactions (**open** vs **closed** system)
- Evaluate the CO_2 behavior in the fluid and rock in the meta-morphic processes (**CO_2 gain or loss** through heat induced fluid release)

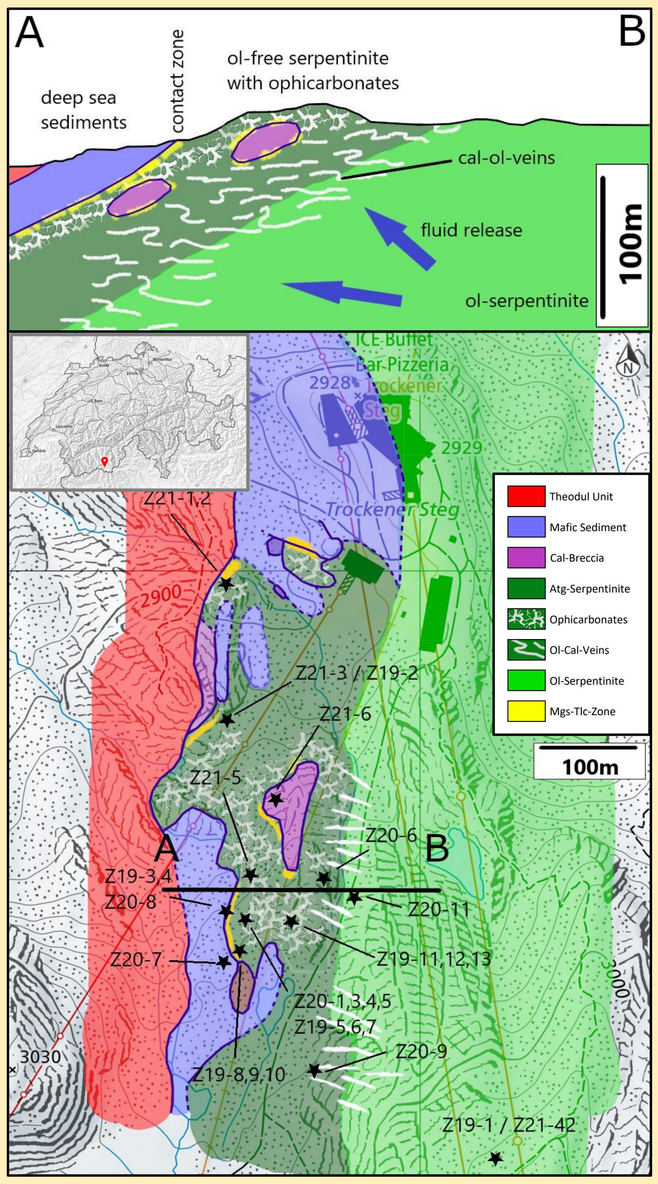
Ophicarbonate Evolution



This sketch shows the 3 rock types of interest: Ophicarbonate / olivine-serpentinite and olivine-calcite-veins.

- **The ophicarbonate** may have lost only very little carbonate minerals during fluid release. The metamorphic dolomite is abundant in the ophicarbonate.
- **The olivine-calcite-veins** were precipitated by a CO_2 bearing fluid. Their textural properties exclude a formation at the sea floor.
- **The olivine serpentinite** originates from a brucite bearing serpentinite, however the brucite reacted completely with antigorite during subduction. This reaction released quite **large amounts of fluid**.

Geological Situation

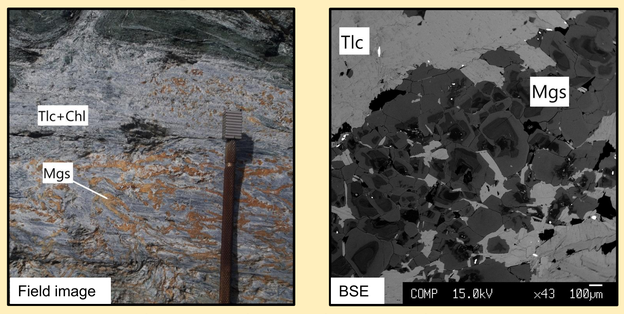


Profile and map show an overview to the geological situation of the Trockener Steg (3000 m above sea level)

- The contact zone (profile) between metasediments and ophicarbonates →former sea floor.
- Below ophicarbonate slow transition into olivine-serpentinite with occasional olivine-calcite-veins
- Fluid release (profile) was below the ophicarbonate

Samples

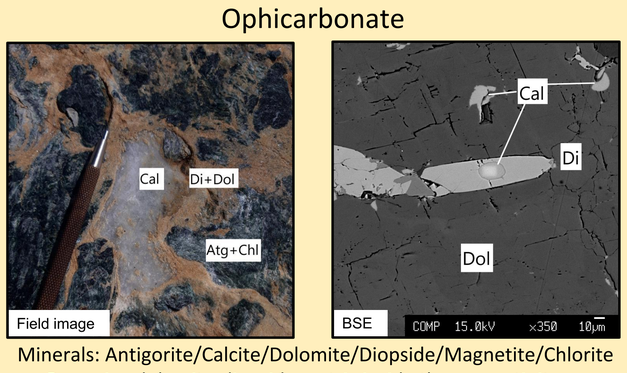
Magnesite-Talc Contact Zone



Minerals: Talc/Magnesite/Chlorite/Magnetite/Dolomite

- talc-chlorite-matrix with large magnesite-aggregates
- Paragenesis explained by a slight CO_2 influx along the contact

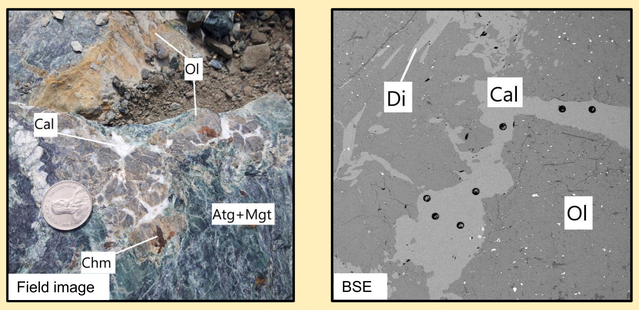
Ophicarbonate



Minerals: Antigorite/Calcite/Dolomite/Diopside/Magnetite/Chlorite

- Pervasive dolomite-diopside matrix inside the serpentinite
- Calcite is a relic ->Always isolated from antigorite or as inclusion
- Antigorite builds up matrix with magnetite and chlorite

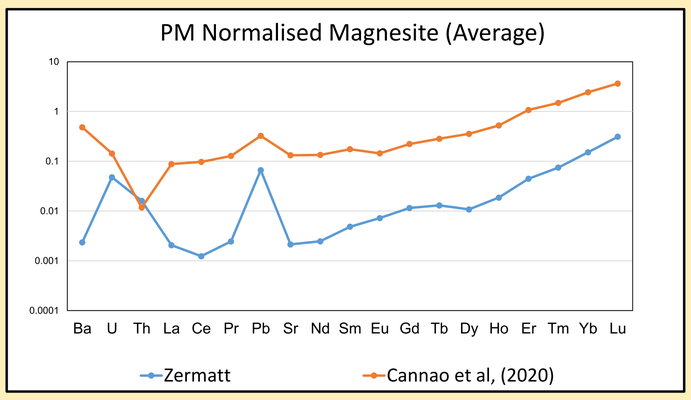
Olivine-Calcite Veins



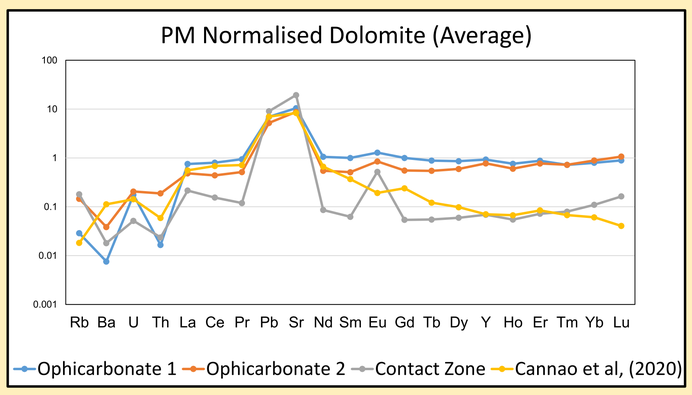
Minerals: Antigorite/Calcite/Olivine/Magnetite/(Diopside)

- Well shaped olivine crystals , sometimes diopside
- Clinohumite shows presence of water

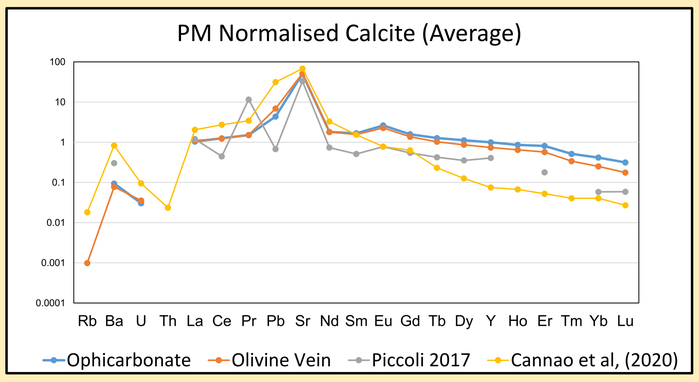
Trace Element Data



Eu-anomaly is likely present but invisible due data below detection



Eu-anomaly is not changed by the slight fluid influx in the contact zone



Piccoli/Cannao: reference ophicarbonate data (Corsica/Liguria)

Summary / Conclusions

- Only minor amounts of CO_2 escaped out of the system (ophicarbonates + olivine serpentinite)
- Trace element signatures show little composition change from initial calcite to dolomite/magnesite
- Beside the reaction zone, the ophicarbonate rock was not influenced by sedimentary-liberated fluid
- The calcite-olivine veins indicate a short distance (<100m) transport of dissolved CO_2 in aqueous fluids
- Down to 80 km depth and 550°C and back up, the rocks and fluids remained near closed system

Trace Element Discussion

- All calcite signatures are very similar: same source/origin!
- Eu2+ -anomaly is always positive → reduced conditions
- U is not mobile → reduced conditions
- Sr and Pb-anomalies fit calcite precipitation on sea floor →not as high to consider an additional sedimentary influence (if so only little in magnesite)

References

- Kempf, E. D., Hermann, J., Reusser, E., Baumgartner, L. P., & Lanari, P. (2020). The role of the antigorite+ brucite to olivine reaction in subducted serpentinites (Zermatt, Switzerland). *Swiss journal of geosciences*, *113*(1), 1-36.
- Cannaò, E., Scambelluri, M., Bebout, G. E., Agostini, S., Pettke, T., Godard, M., & Crispini, L. (2020). Ophicarbonate evolution from seafloor to subduction and implications for deep-Earth C cycling. *Chemical geology*, *546*, 119626.
- Map: Swisstopo (map.geo.admin.ch)
- Corsica calcite trace element data of Francesca Piccoli (2017)

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