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# オマーンと西アルプスオフィオライトのオフィカーボネート中の多世代流体包有物 Multi-generation Fluid Inclusions in Ophicarbonates in Oman and Western Alps Ophiolite

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## 1. Mantle Carbonation in Fast and Slow Spreading Ridges

**Carbonation of serpentinite is important because of** Global carbon cycle (Alt + 2013, Lithos), Slow earthquakes (Okamoto + 2021, Comm Earth Environ, Uno + PNAS 2022), Carbon capture and storage (Kelemen + 2011, Ann Rev Earth Planet Sci).

**Ophicarbonates: Carbonates in serpentinites**  
Common in serpentinized mantle in ophiolites and in oceanic core complex, where the mantle is exhumed on the seafloor.

**Our fluid inclusion analysis**  
Clarifies fluid compositions and PT conditions recorded in fluid inclusions of carbonates formed in Oman and Western Alps, which are formed at fast and slow spreading ridges, respectively.

## 2. Ophicarbonates in Oman and Western Alps Ophiolites

**Oman ophiolite** represents an oceanic lithosphere originally formed at **fast-spreading ridges** and then exhumed in subduction zone. Serpentine in Wadi Tayin massif is characterized by type 1 carbonate veins at suboceanic stage and type 2 carbonate veins during exhumation (Noel +, 2018 Lithos).

**Piemont Zone of western Alps** is an oceanic unit containing a paleo oceanic core complex formed at **slow-spreading ridge** (Manatschal + 2010, Lithos). We studied from the lowest metamorphose ophiolites: Chenaillet (free of subduction metamorphism, Lafay + 2017, Lithos) and Lago nero (metamorphosed at green-schist facies).

## 3. Methods

**Raman microscopy**  
Chemical species in fluid inclusions and crystals.

**Microthermometry**  
Salinity and homogenization temperature (density) of fluid inclusions.

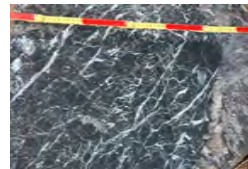
## 4. Variations of Ophicarbonates



**Oman carbonated serpentinite**  
Multi-generated carbonate veins are observed as a time sequence. Type 1 (Noel +, 2018 Lithos) is <0.2 mm thick and composed of calcite and formed at suboceanic stage. Type 2 veins are 1-10 mm thick and of large calcite and small calcite and dolomite and formed at exhumation stage. Type 3 is composed of 0.01 mm calcite and dolomite at the last stage.



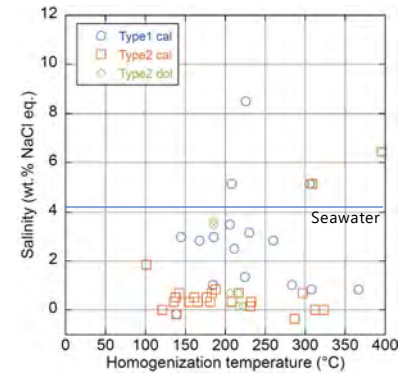
**Chenaillet ophicarbonates in Western Alps**  
Serpentine is veined by primary calcite (PCV, Lafay + 2017, Lithos) and serpentine is locally replaced by calcite cores (CC). Serpentine breccias are filled with calcite matrix (MxC).



**Lago nero ophicarbonates in Western Alps**  
Branching calcite veins are developed in the serpentinite (BCV).



## 5. Seawater-like or Slightly Salty Fluids



### Oman carbonated serpentinite

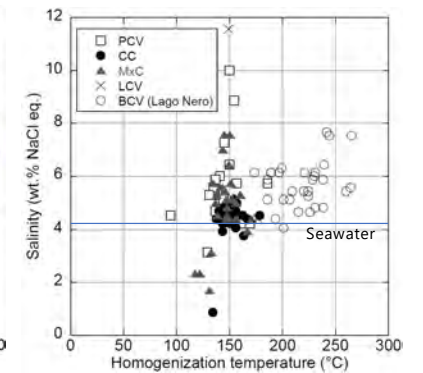
Type 1 has salinity similar to seawater and can be formed in suboceanic mantle.

Type 2 calcite has almost fresh water and can be formed on land.

Type 2 small dolomite have a range of salinity and some of them can be formed in subduction stage.

No inclusion is observed in Type 3 due to its small size (<0.01mm).

Followed classification by Noel + (2018 Lithos)



### Chenaillet and Lago nero (Western Alps) ophicarbonates

No difference in salinity (5%) and homogenization temperature (145°C) among primary calcite vein (PCV), calcite cores (CC), calcite matrix (MxC), and last calcite vein (LCV).

Classification by Lafay + (2017 Lithos)

Lago nero (BCV) show higher salinity (6%), and higher homogenization temperature (220°C), possibly formed in subduction processes.

## 6. Concluding Remarks

Fluid inclusions suggest that ophicarbonates are formed during seawater interaction beneath the oceanic crust (in Oman) and on the seafloor (Chenaillet) and during subduction processes (in Lago nero). Further analysis of ophicarbonates associated with higher-grade metamorphism is in progress.