High-Pressure serpentinization and abiotic methanogenesis in metaperidotite from the Appalachian subduction (Northern Vermont)

Antoine Boutier[1,2], Alberto Vitale Brovarone[1,3], Isabelle Martinez[2], Olivier Sissmann[4], Sara Mana[5]

Picture credit to www.vermont.gov

1 Dipartimento di Scienze della Terra, Torino, Italia

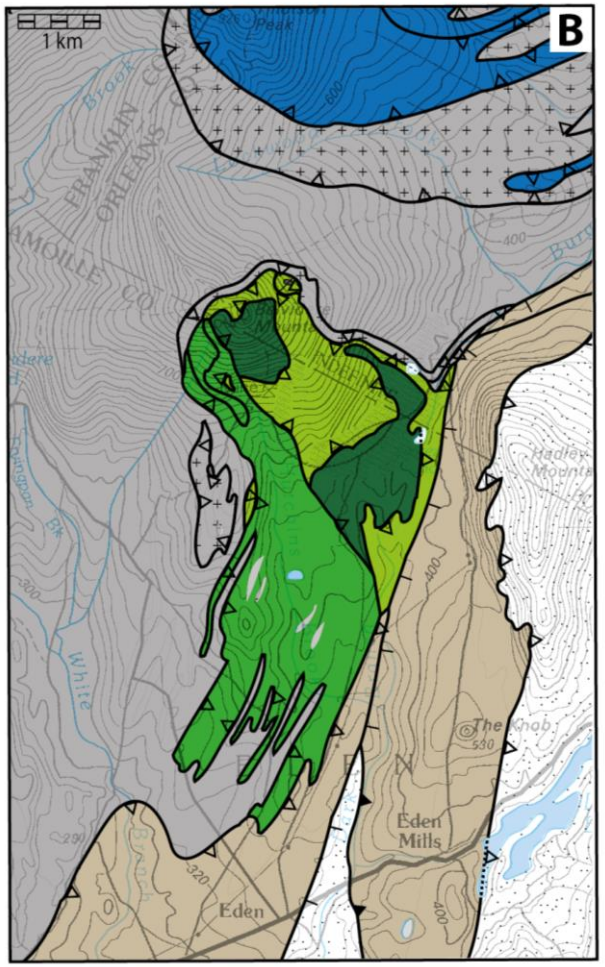
2 Institut de Physique du Globe de Paris, France

3 Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie (IMPMC), France

4 *IFP Energies Nouvelles, France*

5 Salem State University, Salem, USA

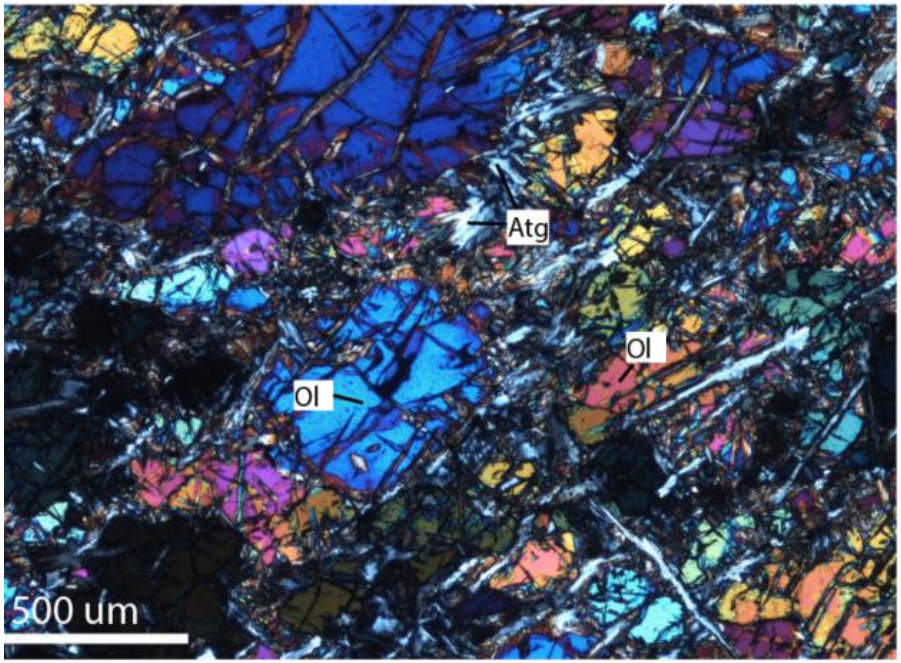
Field area: Belvidere Mountain Complex (BMC)

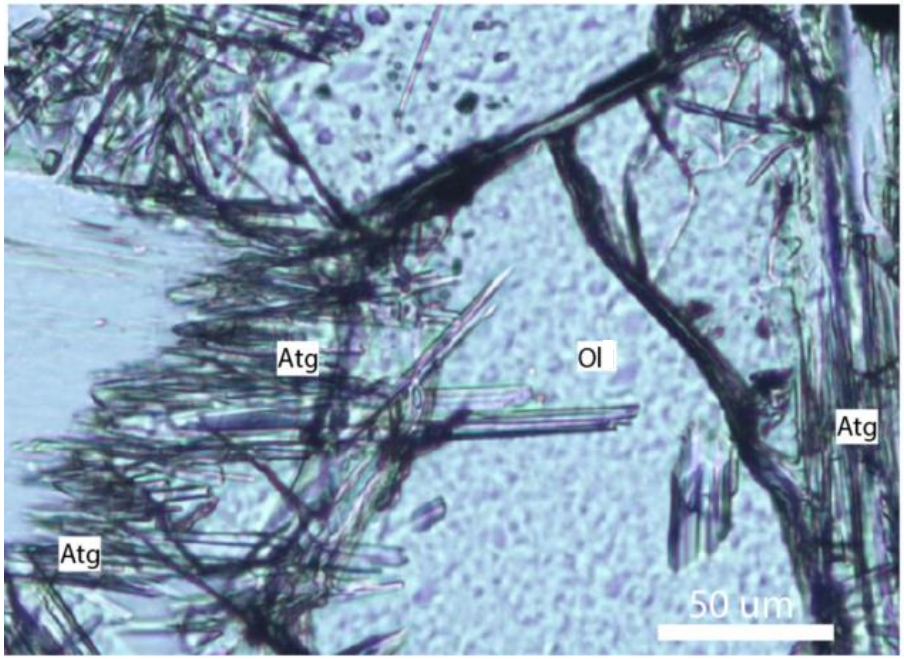


modified from Hibbard et al., 2006

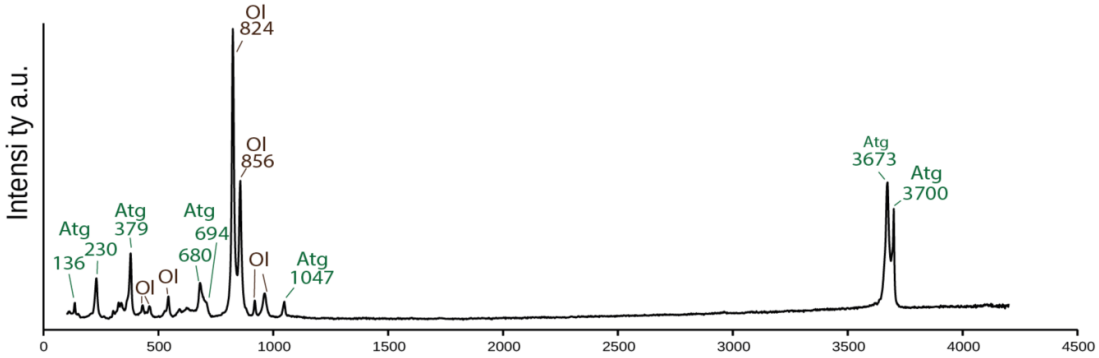
- Appalachian subduction, to ~450°C and ~ 1.2 Gpa
- Ultramafic body embedded in metasediments
- Serpentinites and fresh peridotites

Petrography and microstructures



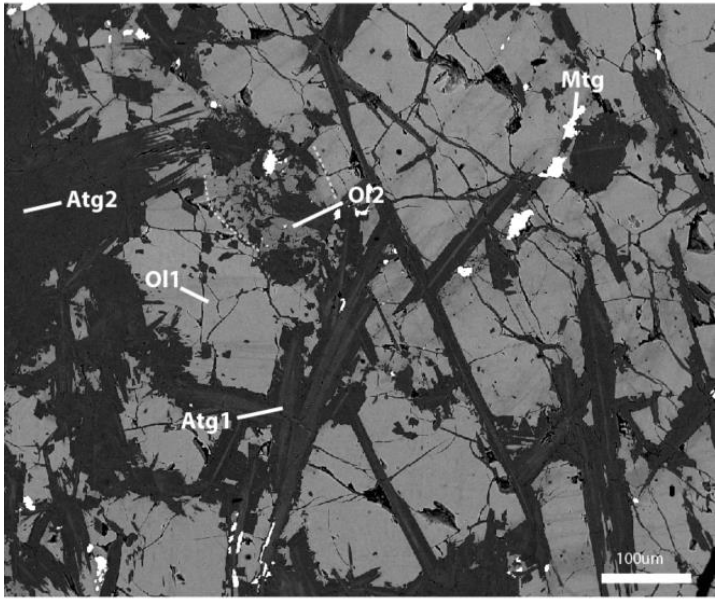


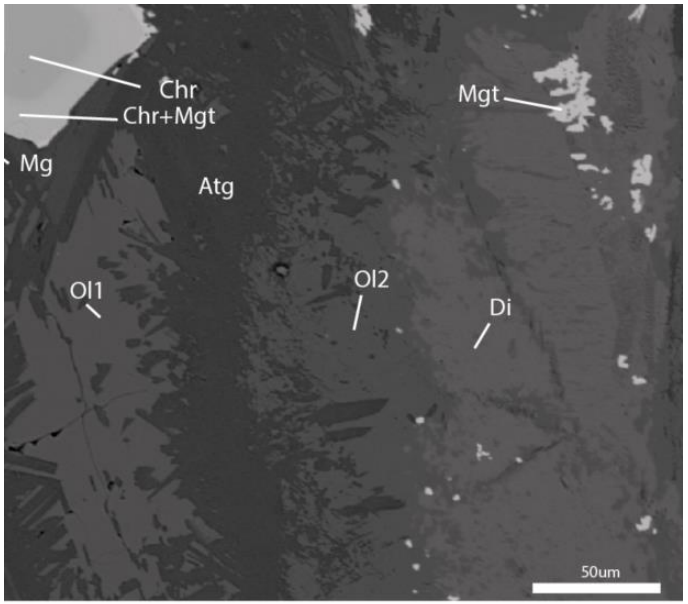
Ol:Olivine Atg:Antigorite

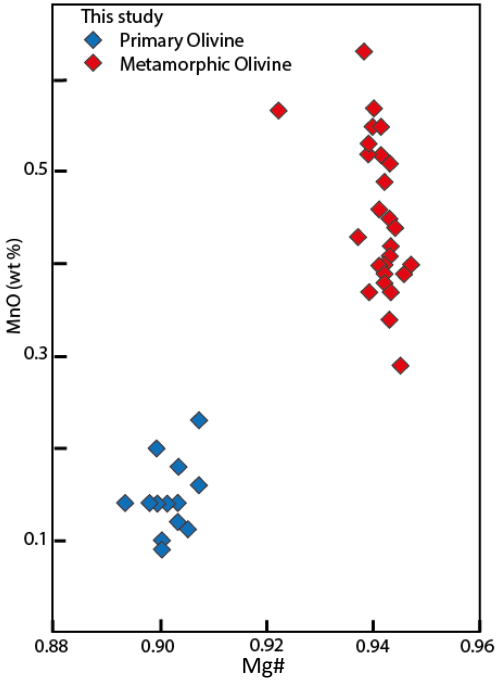


- Static serpentinization
- Mantle olivine preserved
- Antigorite (T> 400°C)
- Overgrowth of antigorite on olivine

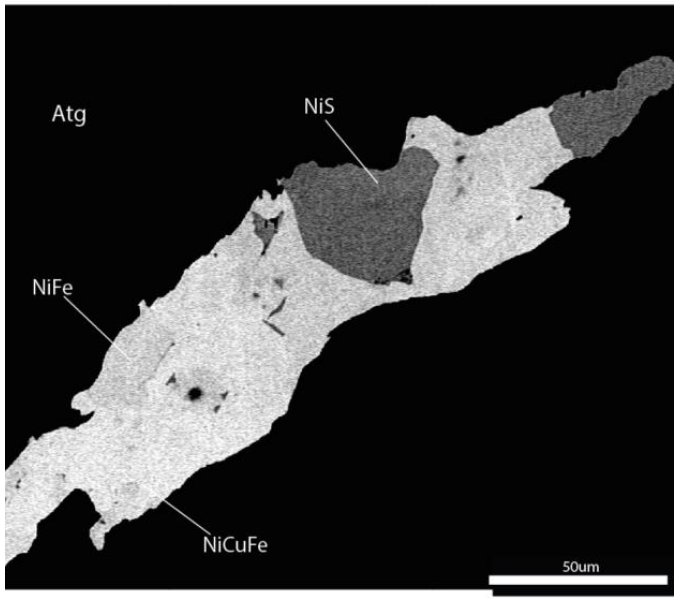
SEM Observations





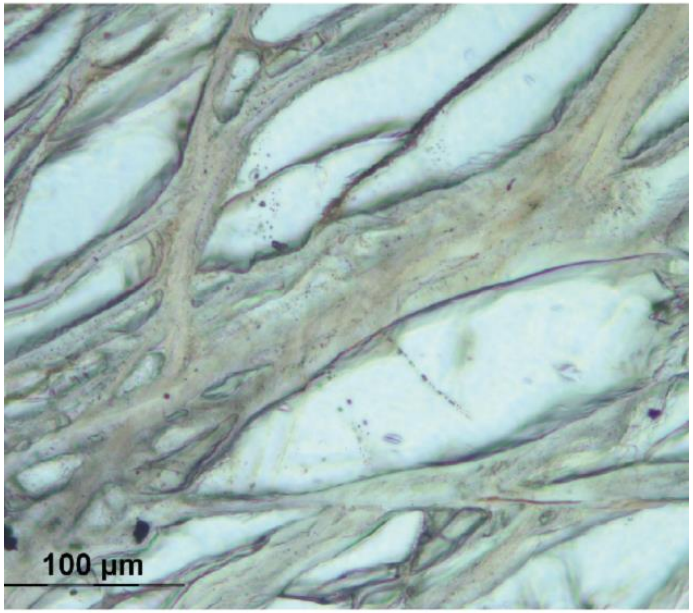


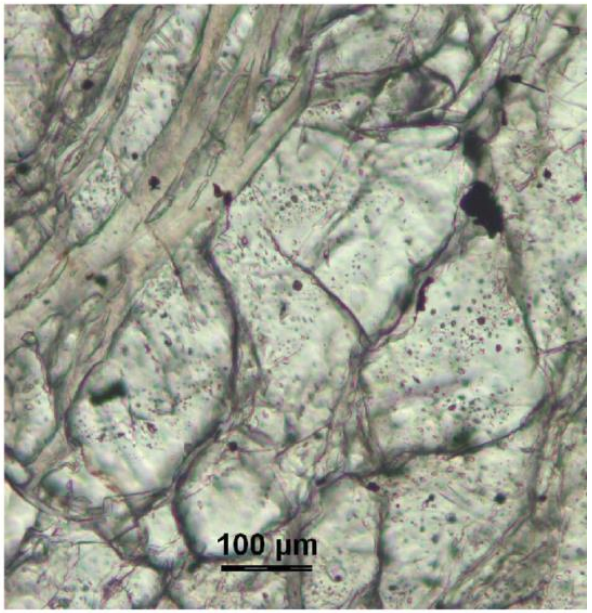
Ol1:Primary Olivine, Ol2:Metamorphic Olivine, Atg1: First generation Antigorite, Atg2: Second generation Antigorite, Di:Diopside, Mgt:Magnetite , Chr:Chromite

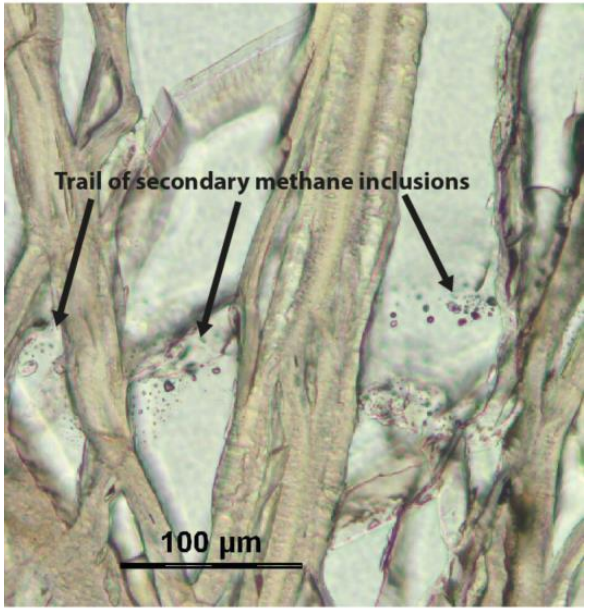


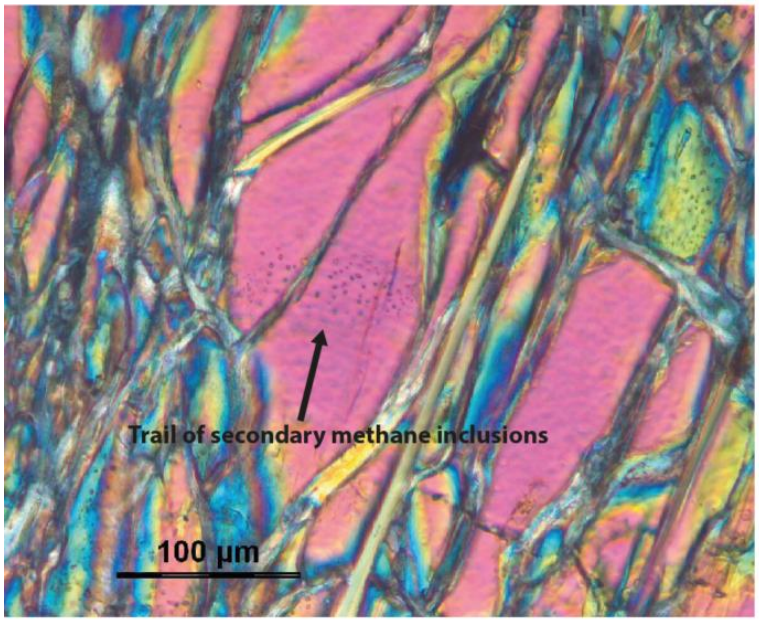
- Metamorphic olivine: higher Mg# and MnO content
- Zoned antigorite, bright core enriched in Cr and Al
- Atg2 replaces both primary olivine and metamorphic olivine
  - ➢ Second generation of antigorite formation is post metamorphic olivine formation
- Presence of Fe-Ni alloy indicates low fO_2 condition

Fluid inclusions



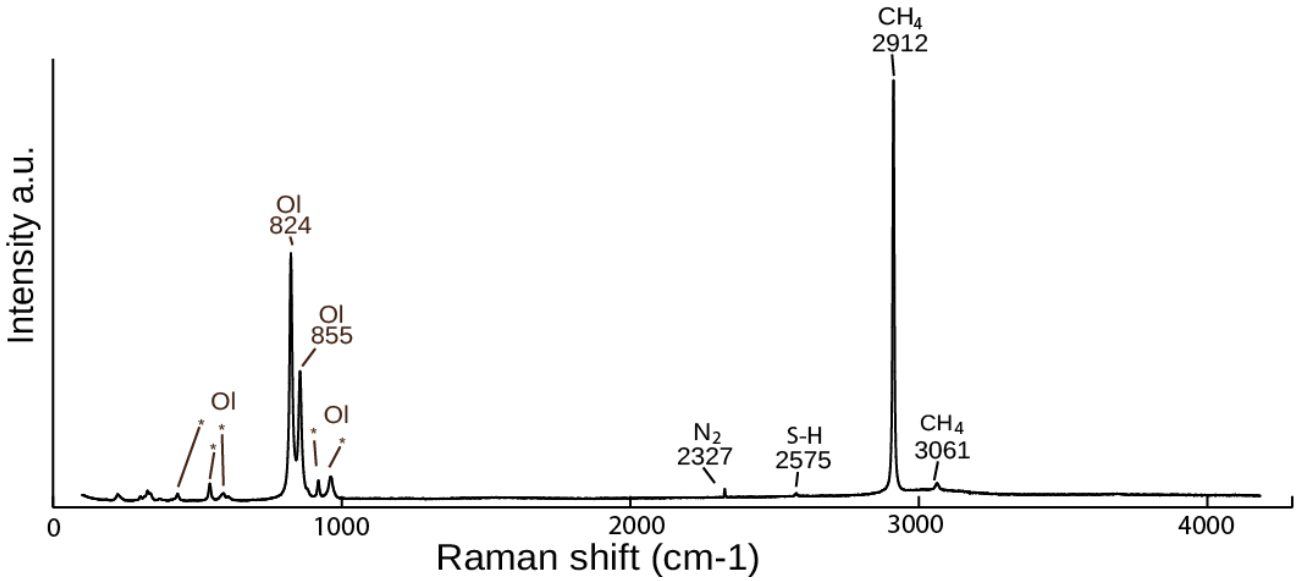


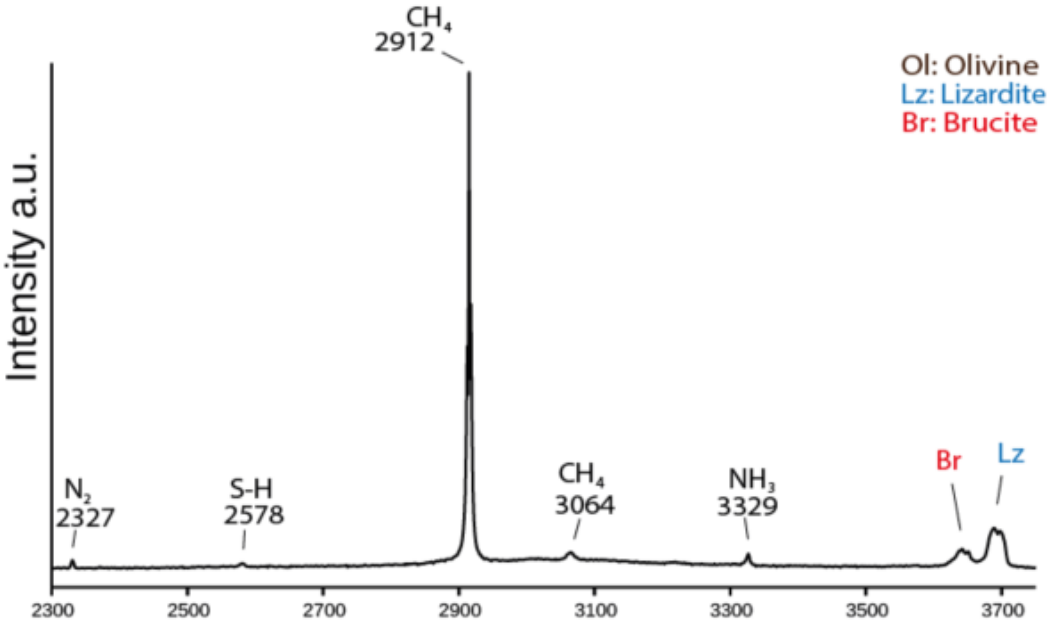




- Methane-rich inclusion trails in primary olivine
- Trails are probably syn-antigorite
  - ➢ Fluid trapping linked to the serpentinization event

Fluid inclusions: Raman spectra





- Ubiquitous CH_4
- Presence of N in all inclusions
  - Consistent with subduction fluids
- Presence of NH_3 and S-H bond
- Lizardite and Brucite as step-daughter minerals (H_2O initially present)
- Absence of H_2

Interpretations and conclusion

- Two stages serpentinization in the Belvidere with a least one in the antigorite stability field indicating an event of high pressure serpentinization in the subduction zone
- Antigorite growth on metamorphic olivine indicates hydration in subduction conditions
- Methane inclusions are associated with the antigorite serpentinization event, and the presence of alloys that can be catalysts for CH_4 formation
- Presence of nitrogen in the fluid inclusions is consistent with metamorphic fluid in subduction zones
- The Belvidere massif recorded high-pressure serpentinization and associated genesis of deep abiotic CH_4