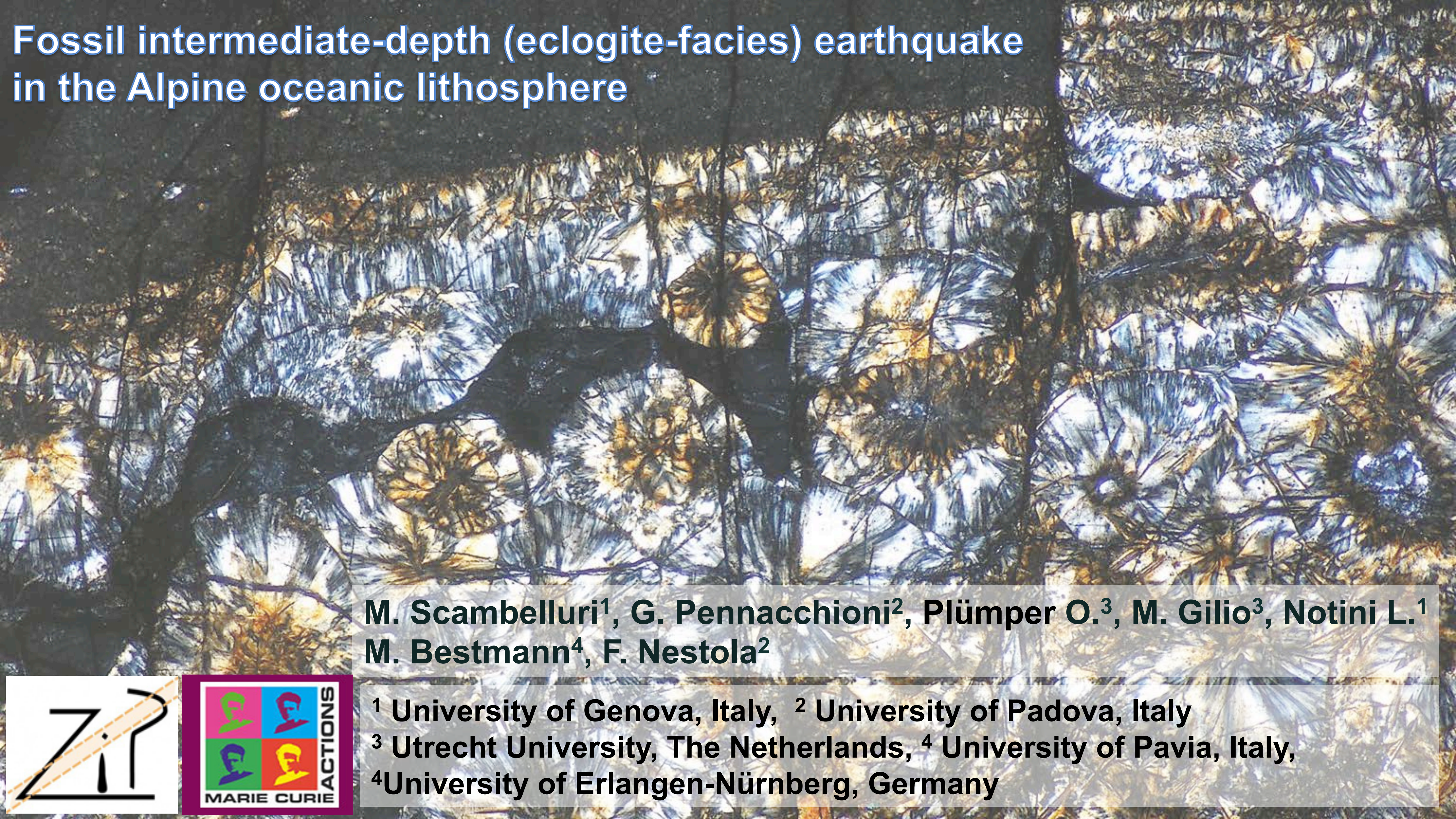


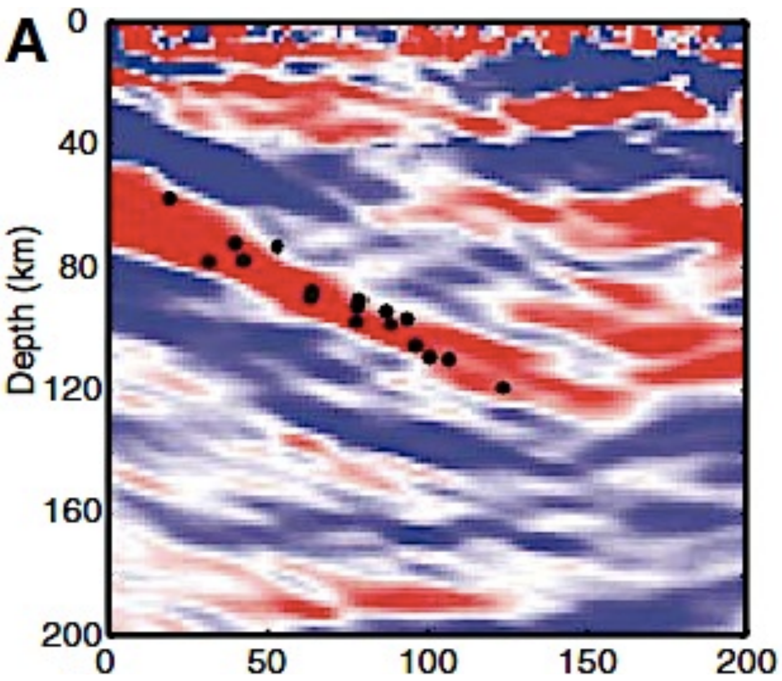
Fossil intermediate-depth (eclogite-facies) earthquake in the Alpine oceanic lithosphere

M. Scambelluri[1], G. Pennacchioni[2], Plümper O.[3], M. Gilio[3], Notini L.[1]
M. Bestmann[4], F. Nestola[2]

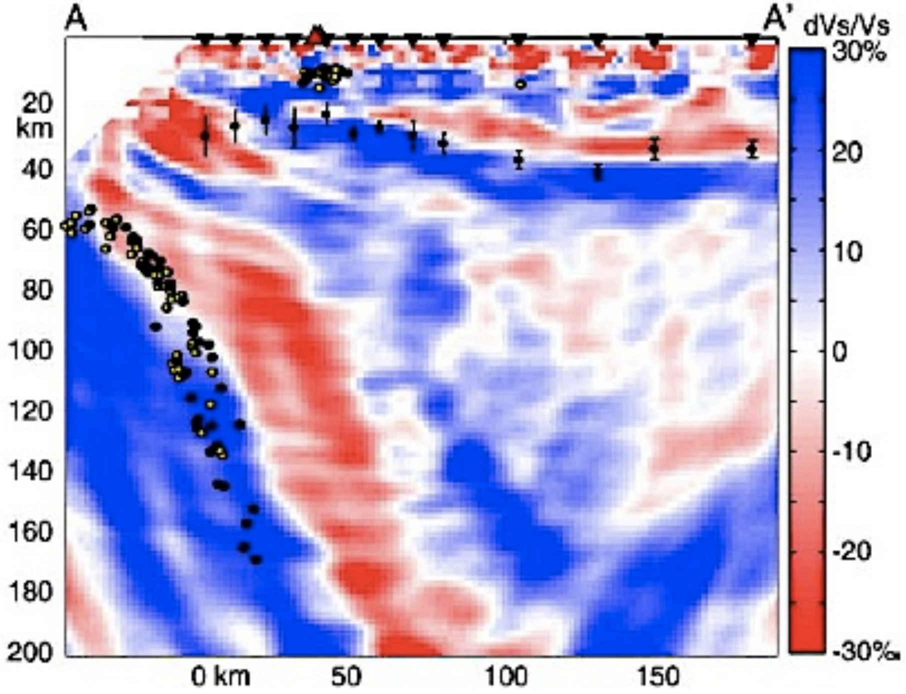
[1] University of Genova, Italy, [2] University of Padova, Italy
[3] Utrecht University, The Netherlands, [4] University of Pavia, Italy,
[4]University of Erlangen-Nürnberg, Germany

MARIE CURIE ACTIONS

Geophysical, experimental and modelling studies provide most information on subduction earthquakes and their mechanics



Alaska, (Rondenay et al., 2008)



Central America (MacKenzie et al., 2010)

Bostock, 2013 Tectonophysics

Earthquakes locate in km-thick Low Velocity Zones made of hydrous rocks hosting pressurized pore fluids or in the dry lithospheric mantle of the subducting slab.

Most accredited mechanisms are dehydration embrittlement and thermal runaway

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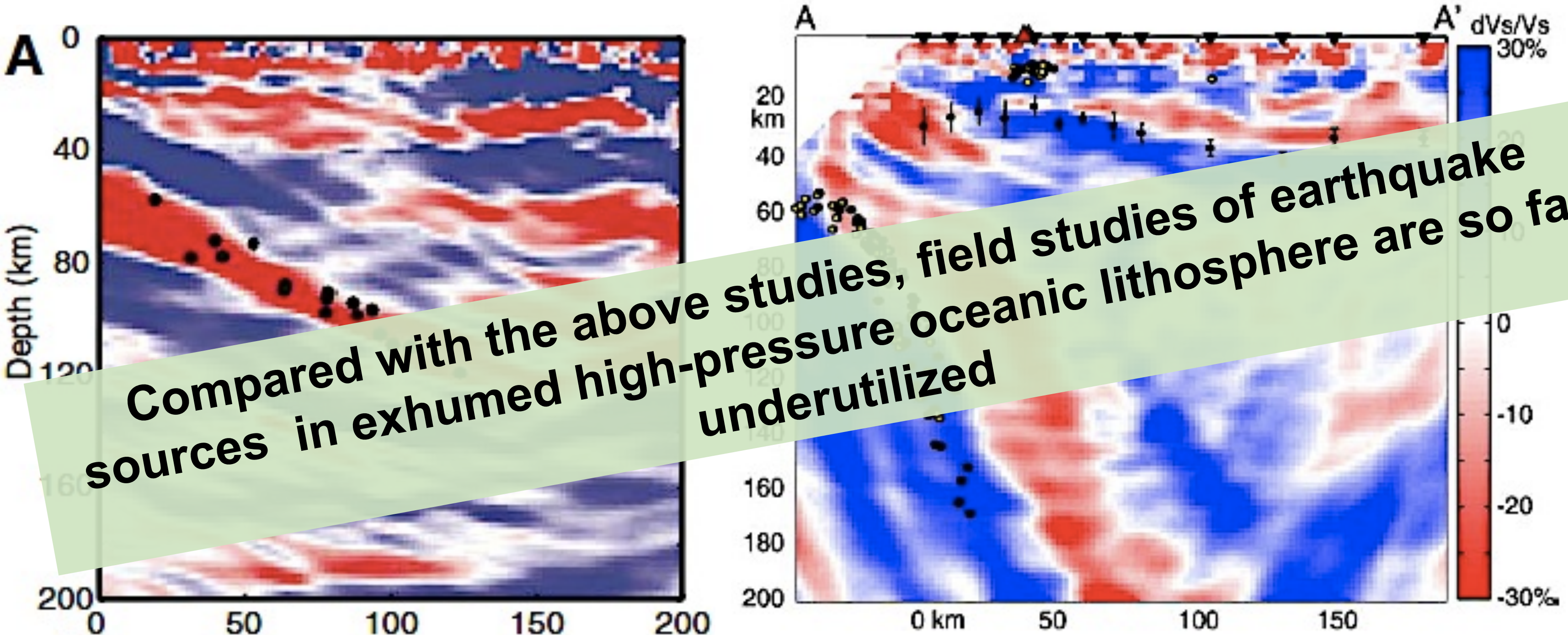

Compared with the above studies, field studies of earthquake sources in exhumed high-pressure oceanic lithosphere are so far underutilized

Alaska, (Rondenay et al., 2008) Central America (MacKenzie et al., 2010)

Bostock, 2013 Tectonophysics

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Subduction zone pseudotachylyte

Friction-induced melts during seismic faulting
Unequivocal rock-records of subduction earthquakes

Limited to a few case studies:

- **eclogitic continental crust (*Austrheim & Boundy, 1994*)**
- **eclogitic ophiolite (*John & Schenk, 2006*).**
- **blueschist ophiolite (*Austrheim & Andersen, 2004*)**

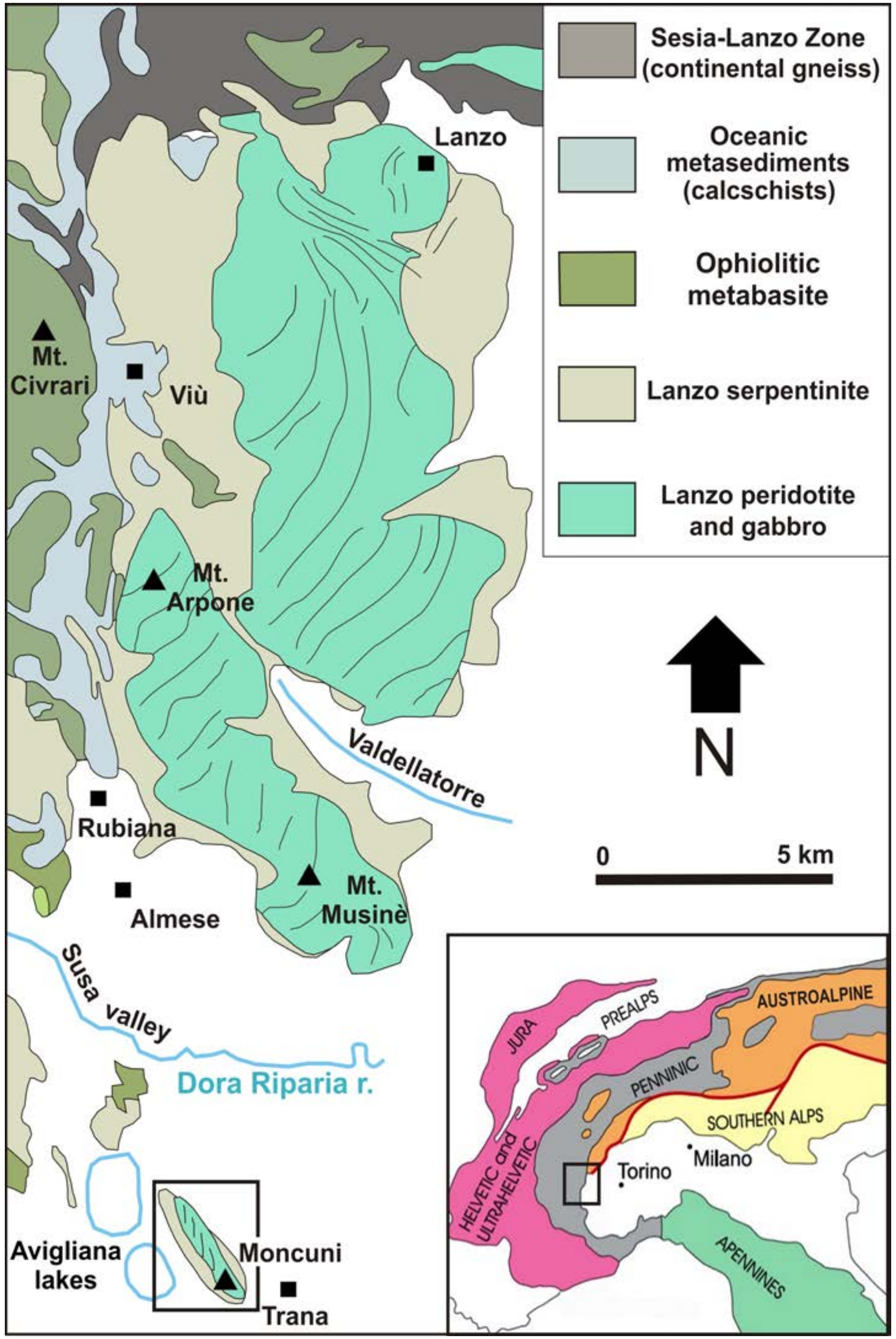
Pseudotachylyte in cold oceanic lithosphere from intermediate subduction depths, the analogue of present-day circum-Pacific slabs, has yet to be described.

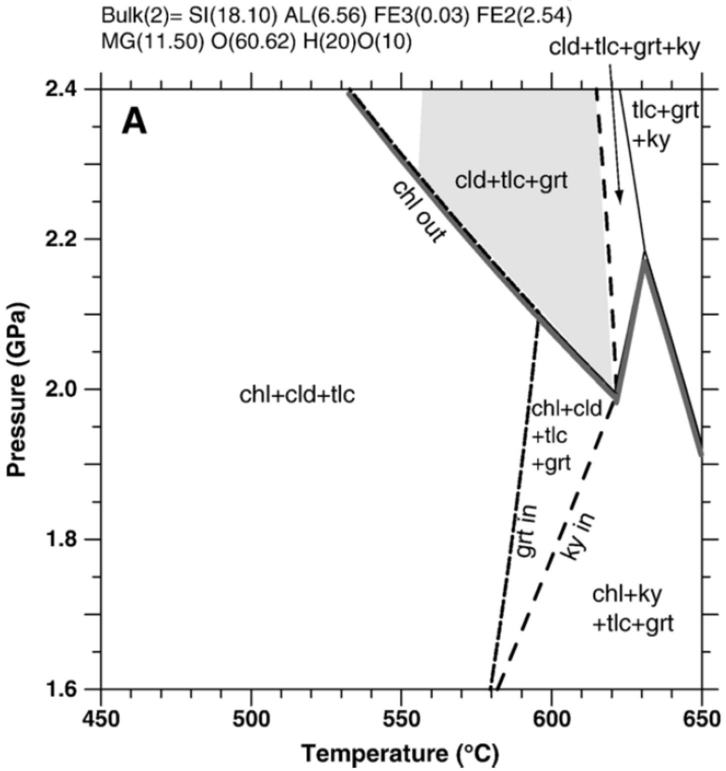
We show the Lanzo pseudotachylyte formed at eclogite-facies conditions, making these rocks a unique window on deep, natural, seismic subduction environments.

Lanzo pseudotachylyte

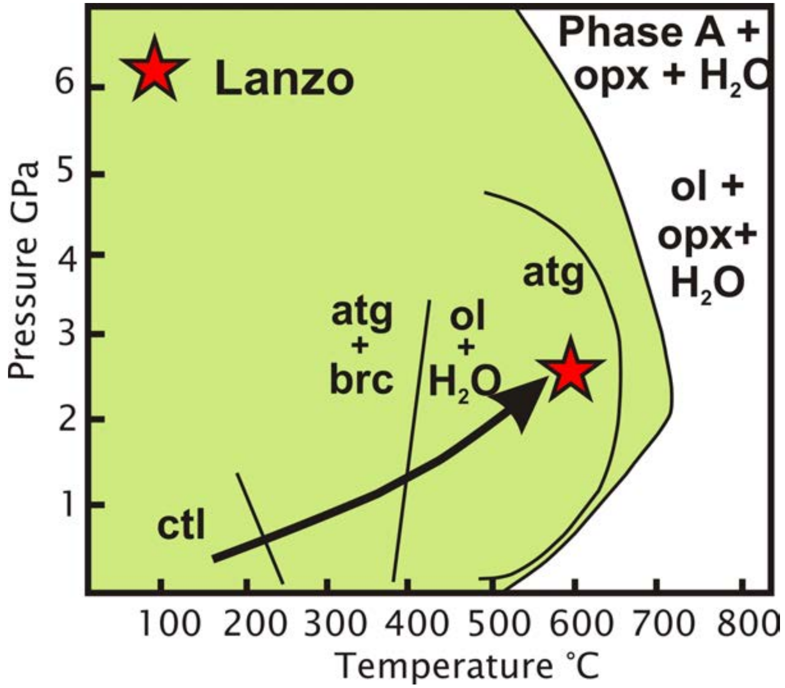
Lanzo

20 x 9 km-wide sliver of fresh spinel to plagioclase oceanic peridotite intruded by discrete bodies and dykes of oceanic gabbro (160 My old).





Pelletier & Muentener, 2006 Lithos



Debret et al., 2013, JMG

It records:

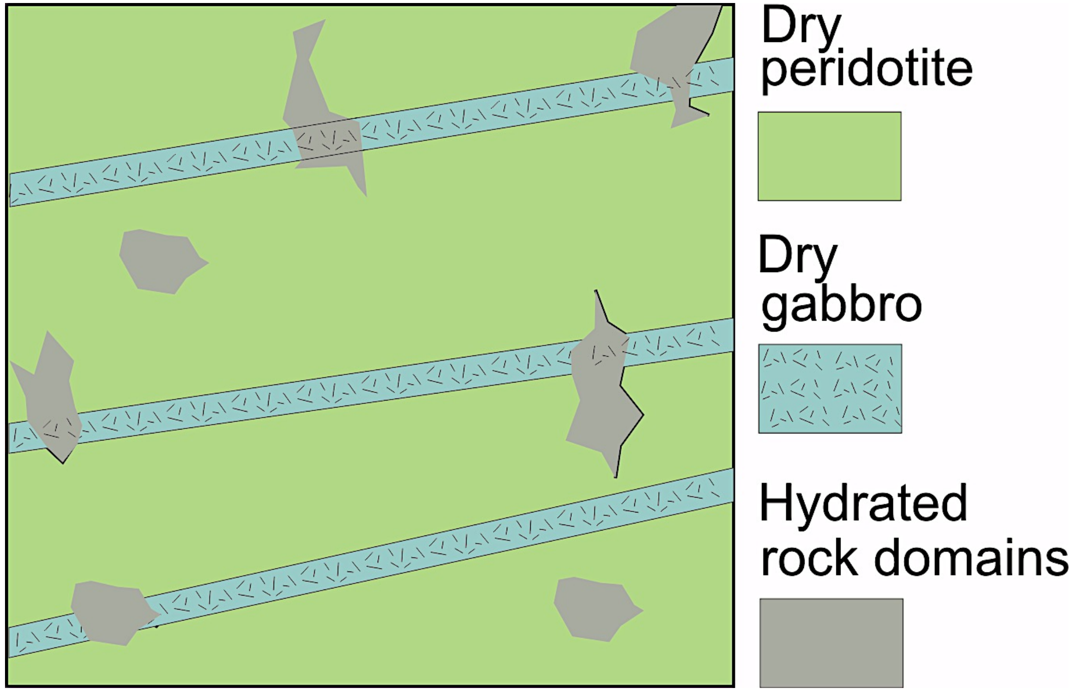
- oceanic serpentinization around unaltered peridotite cores,

- Alpine subduction and eclogite-facies metamorphism (2-2.5 GPa-550-620 °C; 55-46 Ma)

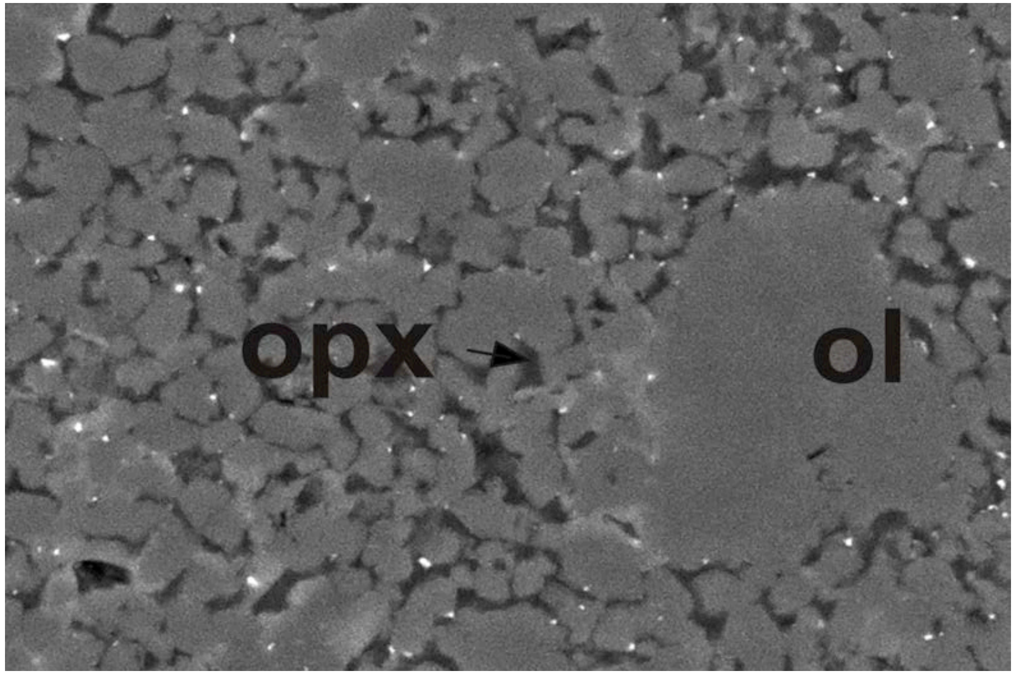
LANZO MASSIF – Field occurrence

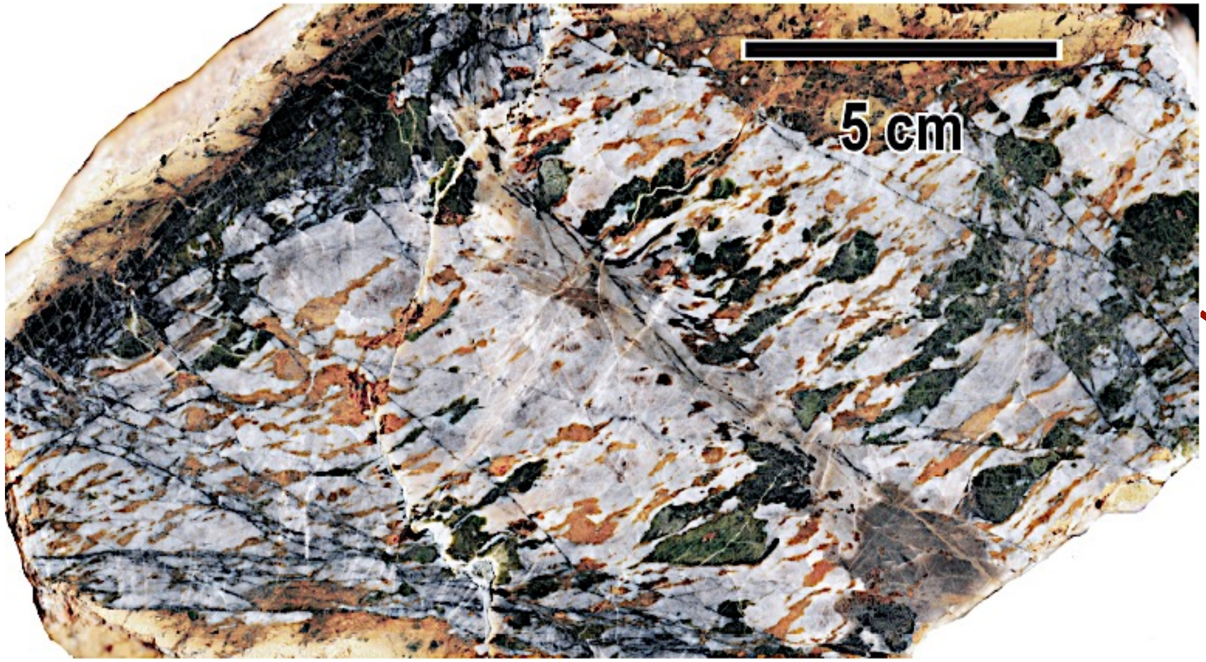
presence of domains of both
DRY (dominant) and HYDRATED rock domains

Hydrated rocks recrystallized to eclogite-facies conditions during subduction

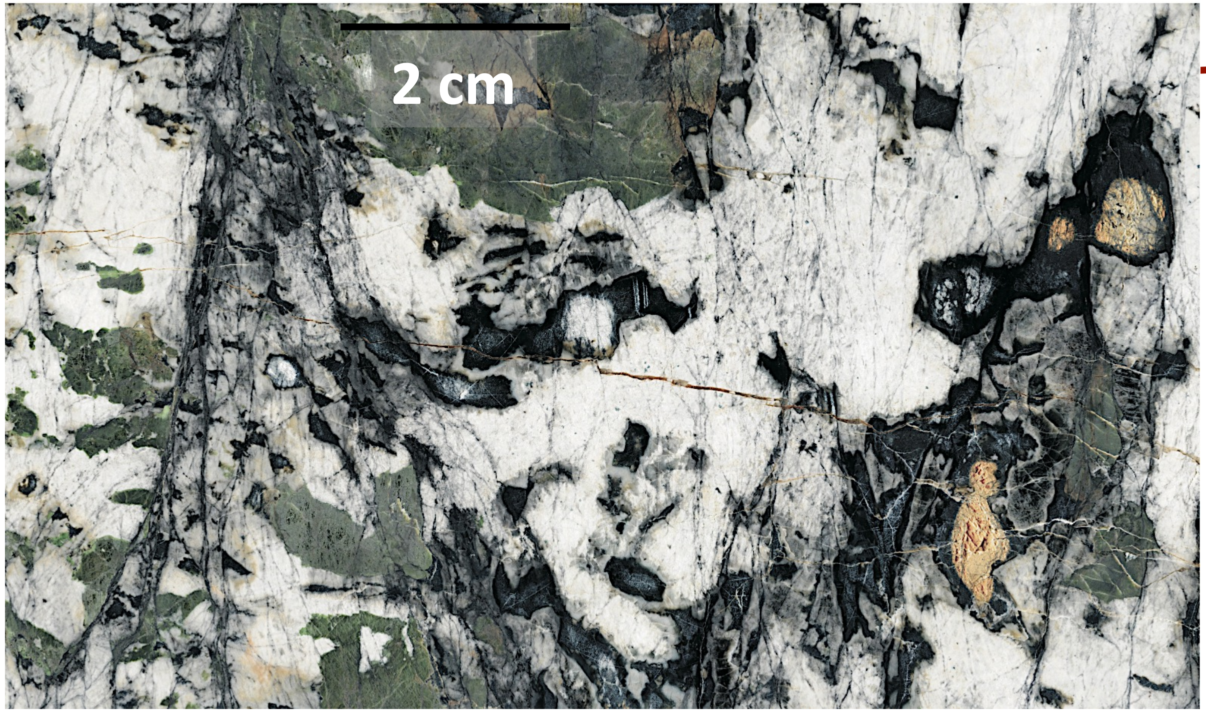


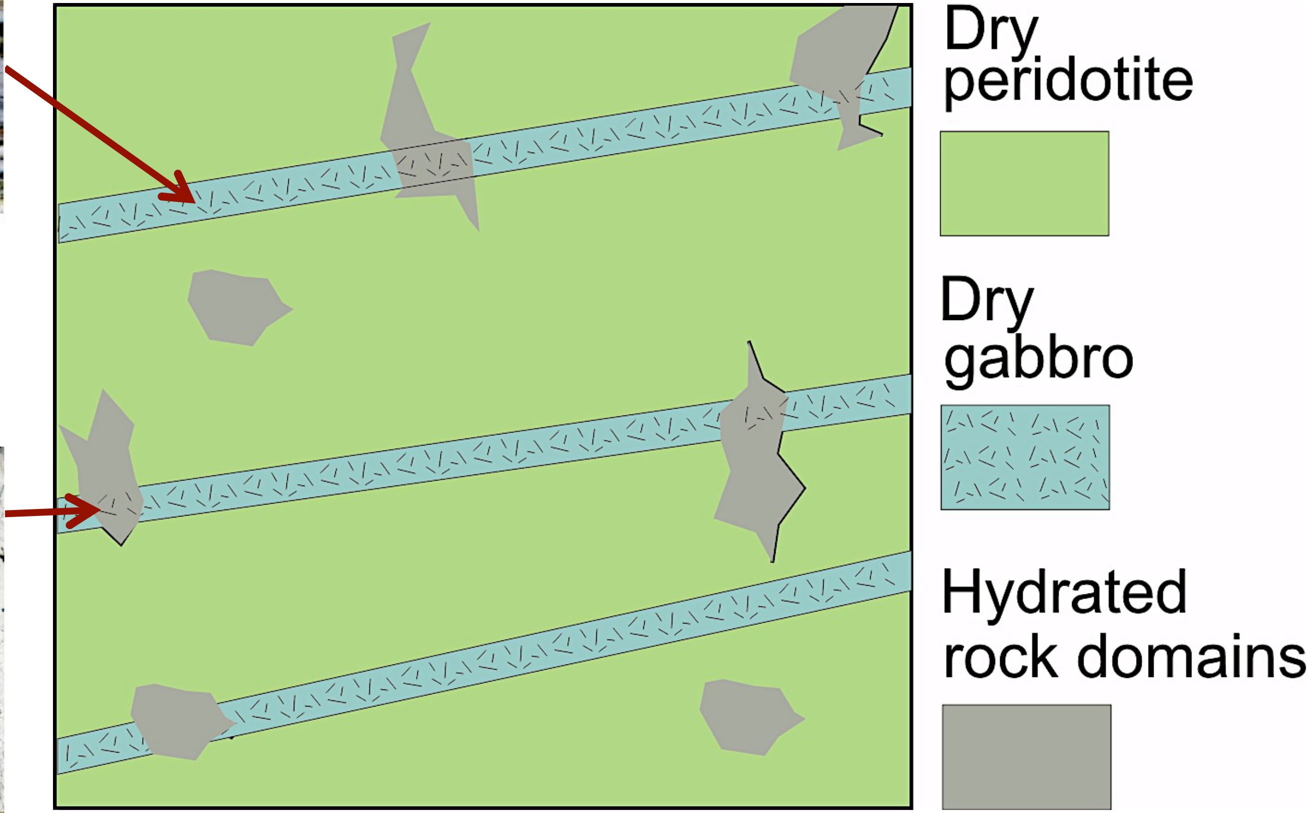
PERIDOTITE



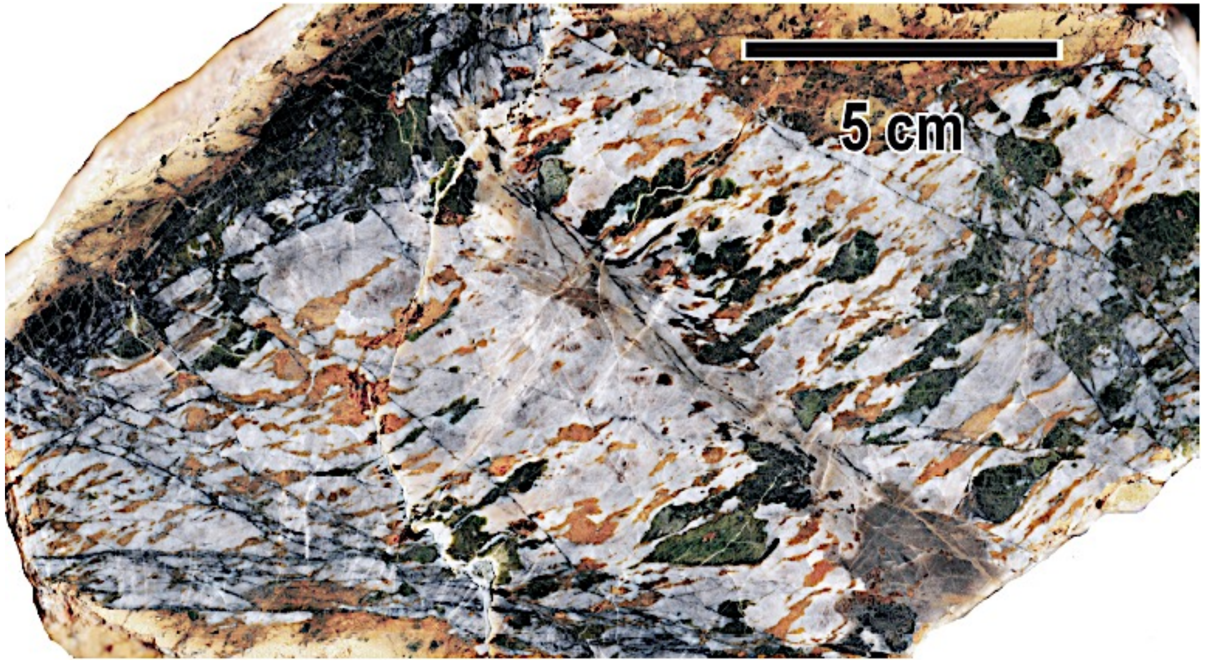


GABBRO Preserved mantle, magmatic and high-T oceanic mineralogy and textures – DOMINANT





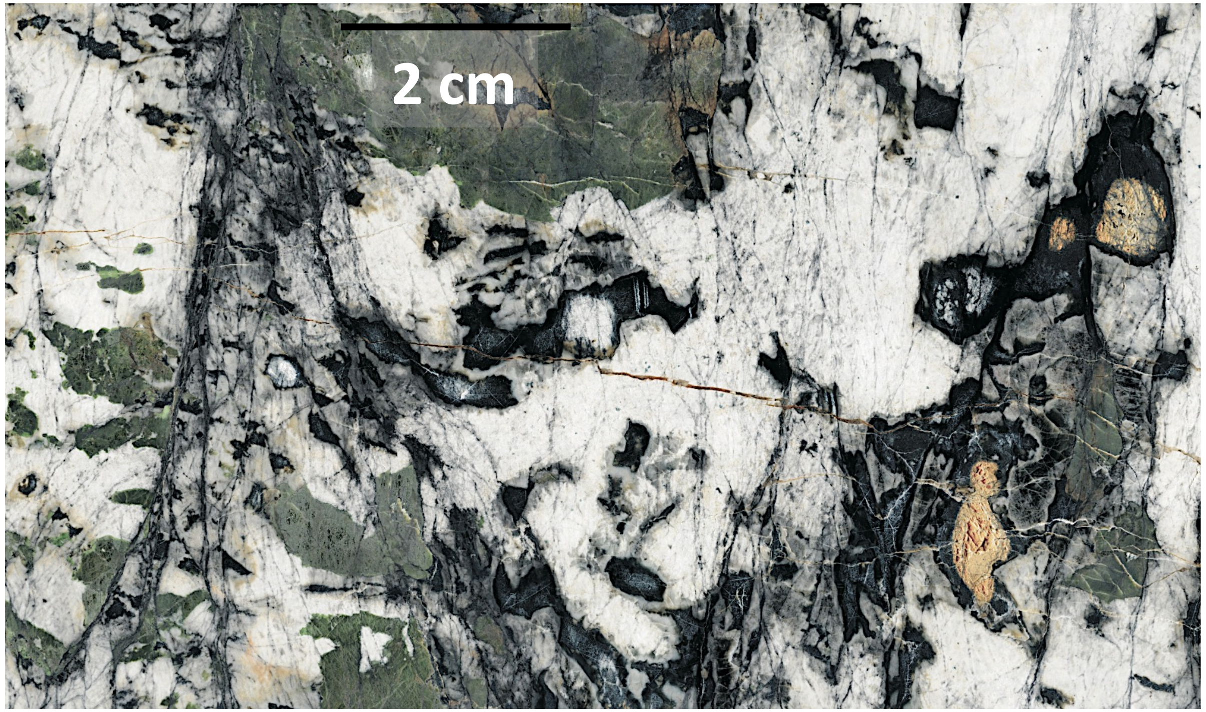
ECLOGITIC METAGABBRO Static overprint of mantle-to-oceanic textures by eclogite-facies metamorphic assemblages - SUBORDINATE



GABBRO Preserved mantle, magmatic and high-T oceanic mineralogy and textures – DOMINANT

No ductile deformation postdates the mantle-to oceanic textures during subduction and exhumation

Pseudotachylyte cuts all rocks and pervasive brittle deformation occurs

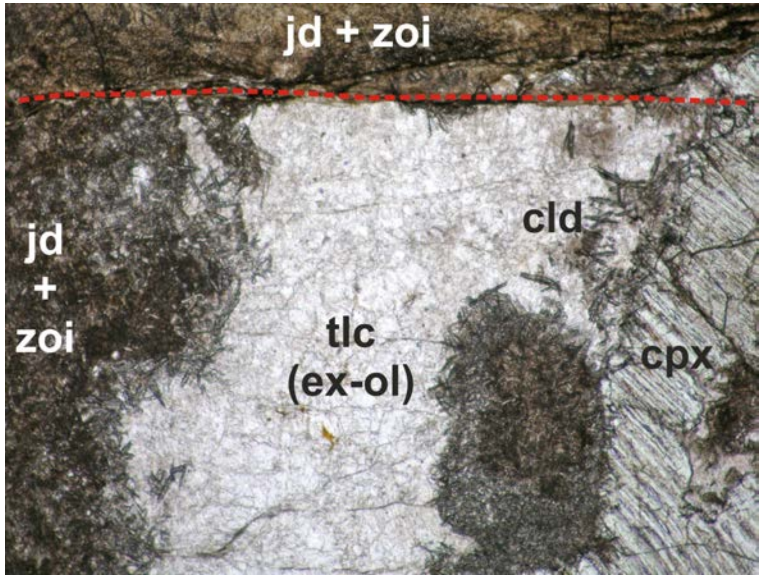


ECLOGITIC METAGABBRO Static overprint of mantle-to-oceanic textures by eclogite-facies metamorphic assemblages

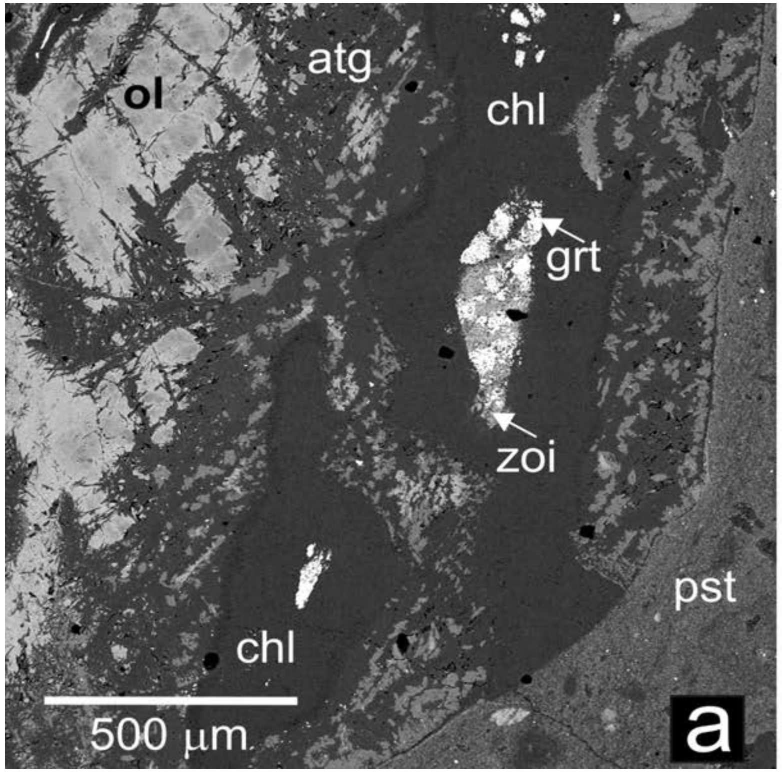
PETROGRAPHY

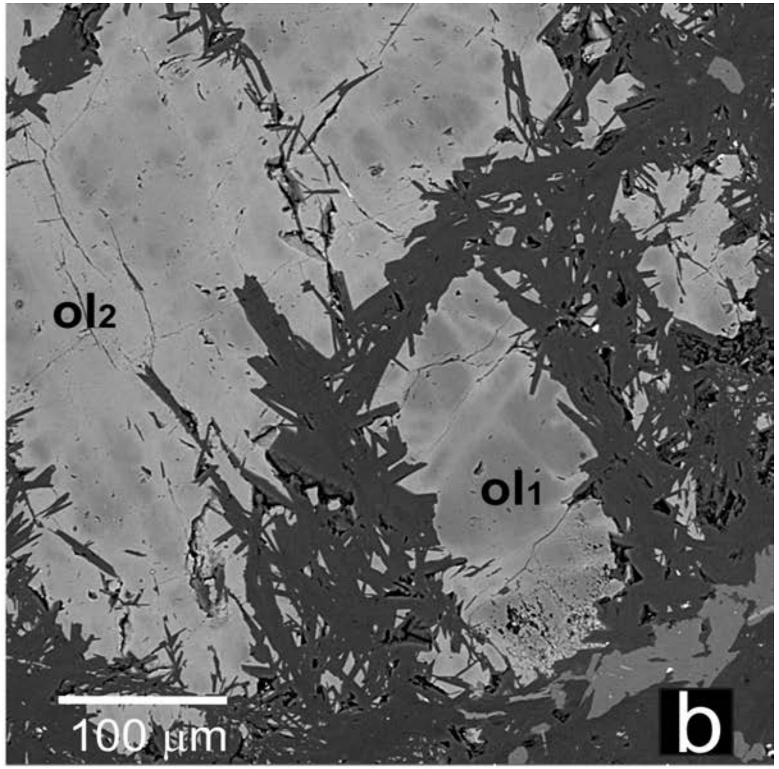
Minor (< 5%), hydrated volumes, consist of eclogitic metagabbro and metaperidotite.

METAGABBRO



METAPERIDOTITE





Metagabbro

Micofaults parallel to pseudotachylyte

1. induce cpx brecciation and recrystallization to omphacite matrix;
2. cut zoisite+ jadeite after plag;
3. Are overgrown by dendritic garnet

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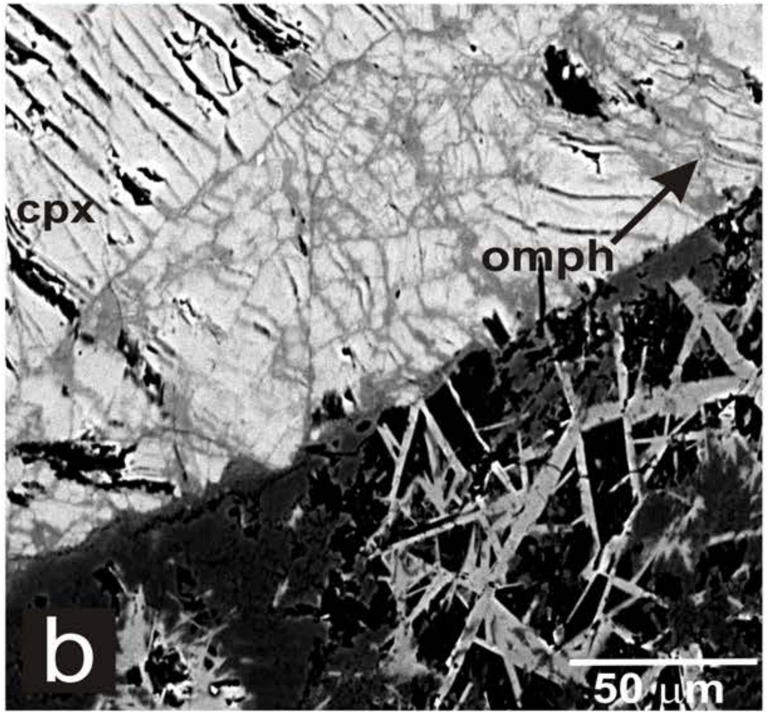

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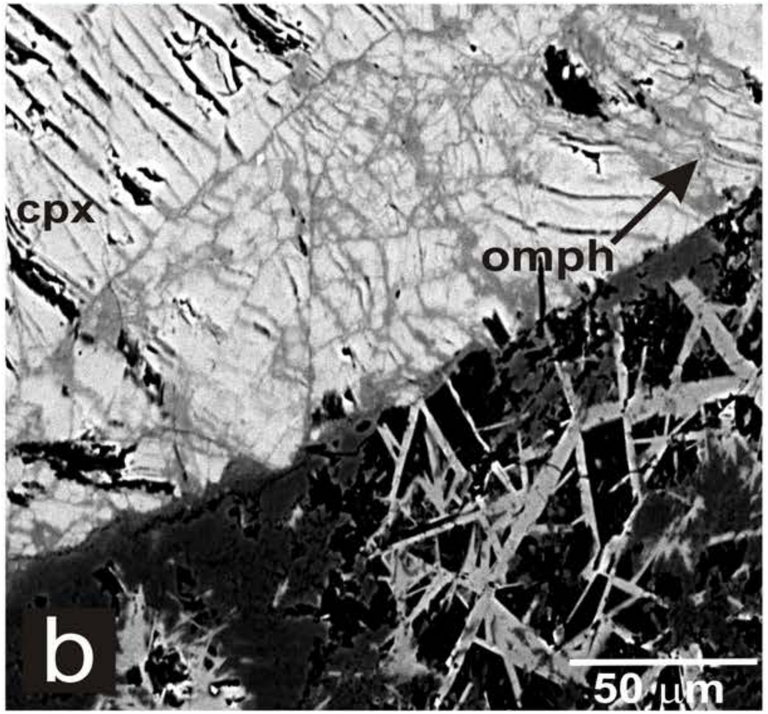

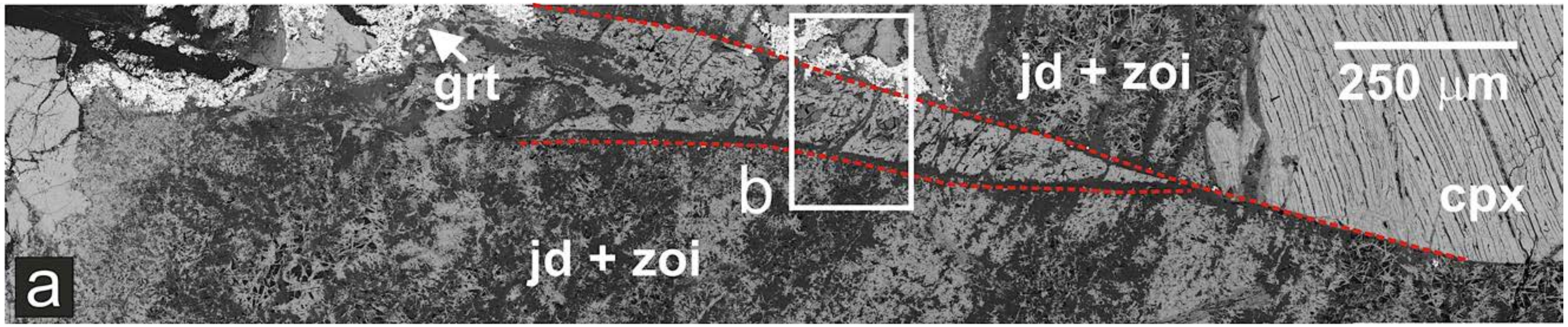

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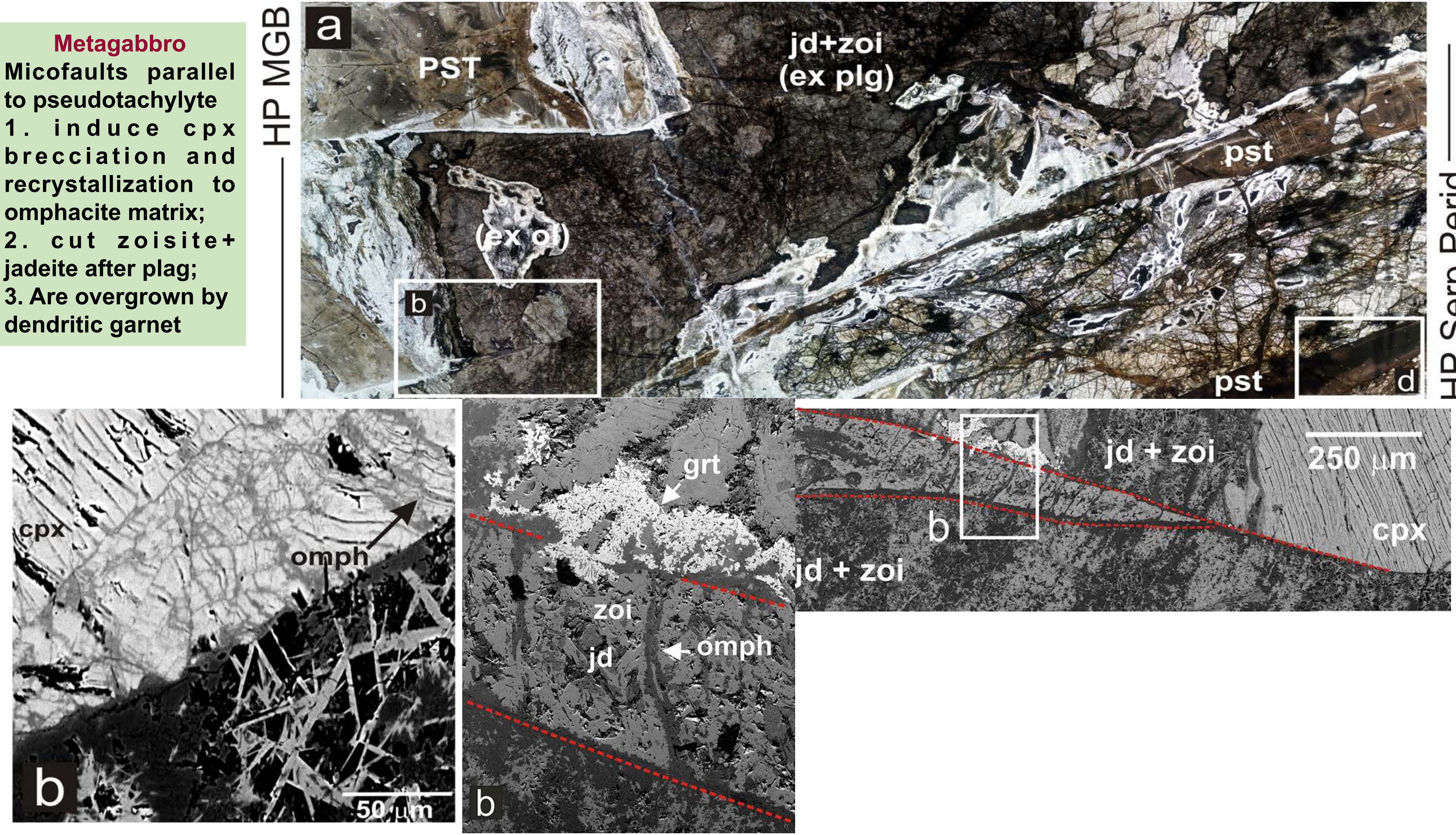

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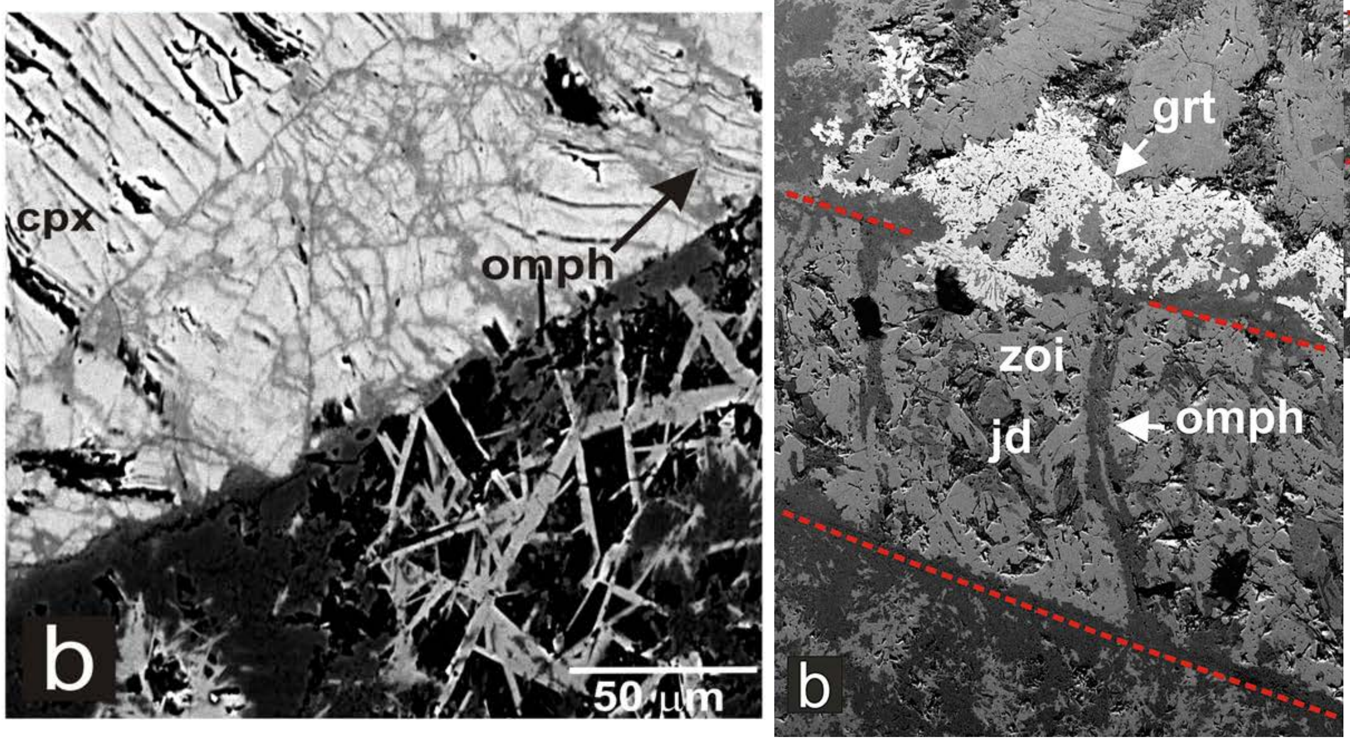
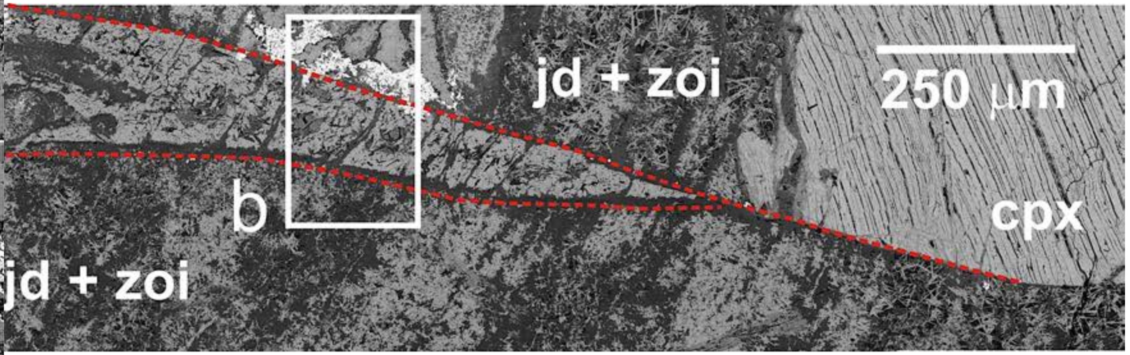


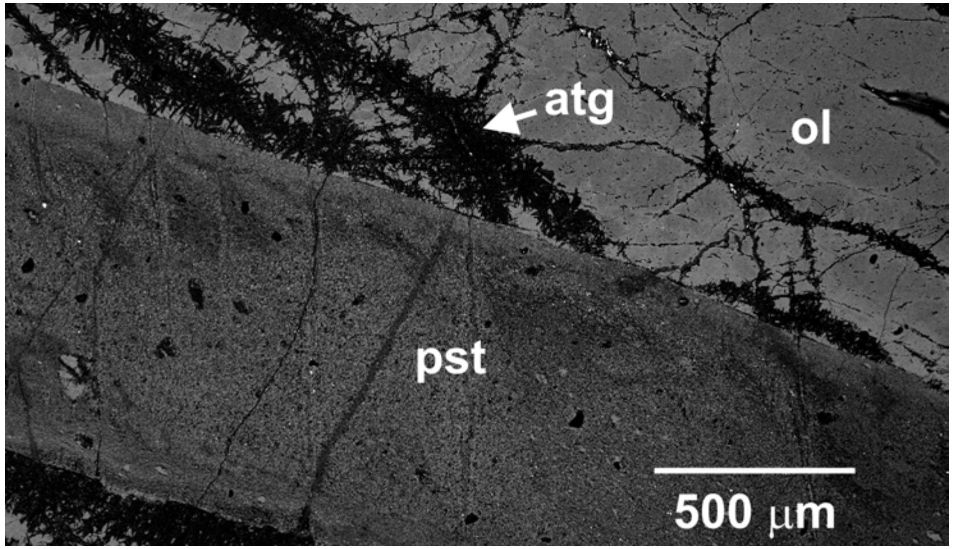


Microfaults are ECLOGITIC

Pseudotachylyte in metaperidotite

1. cuts antigorite veins;

2. includes clastic fragments of host-rock high-pressure minerals



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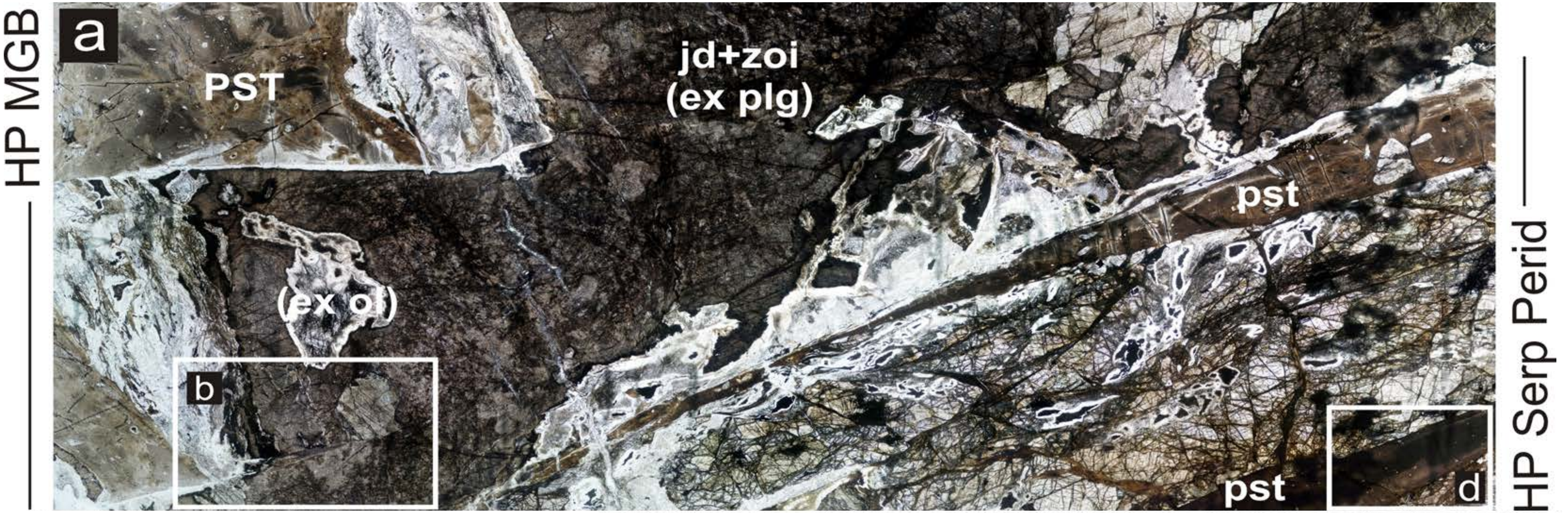

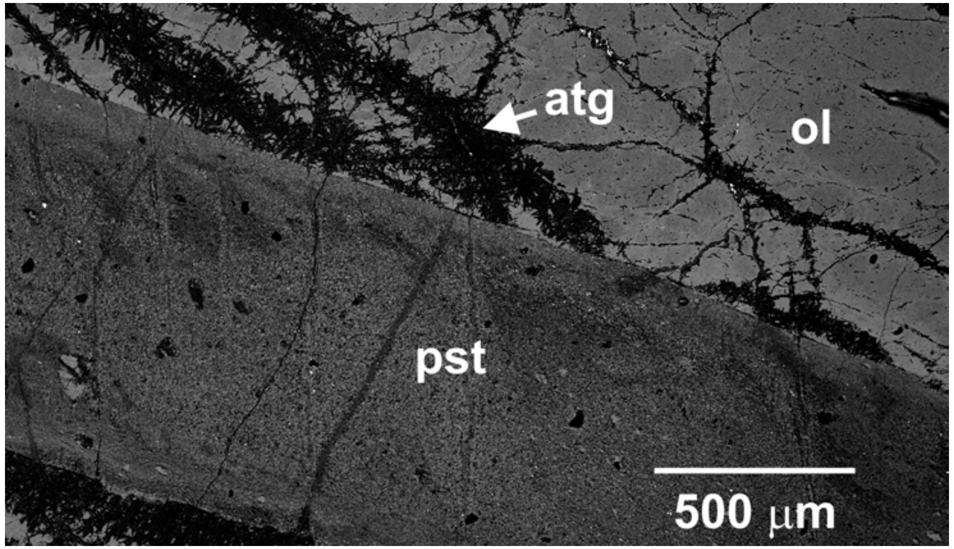

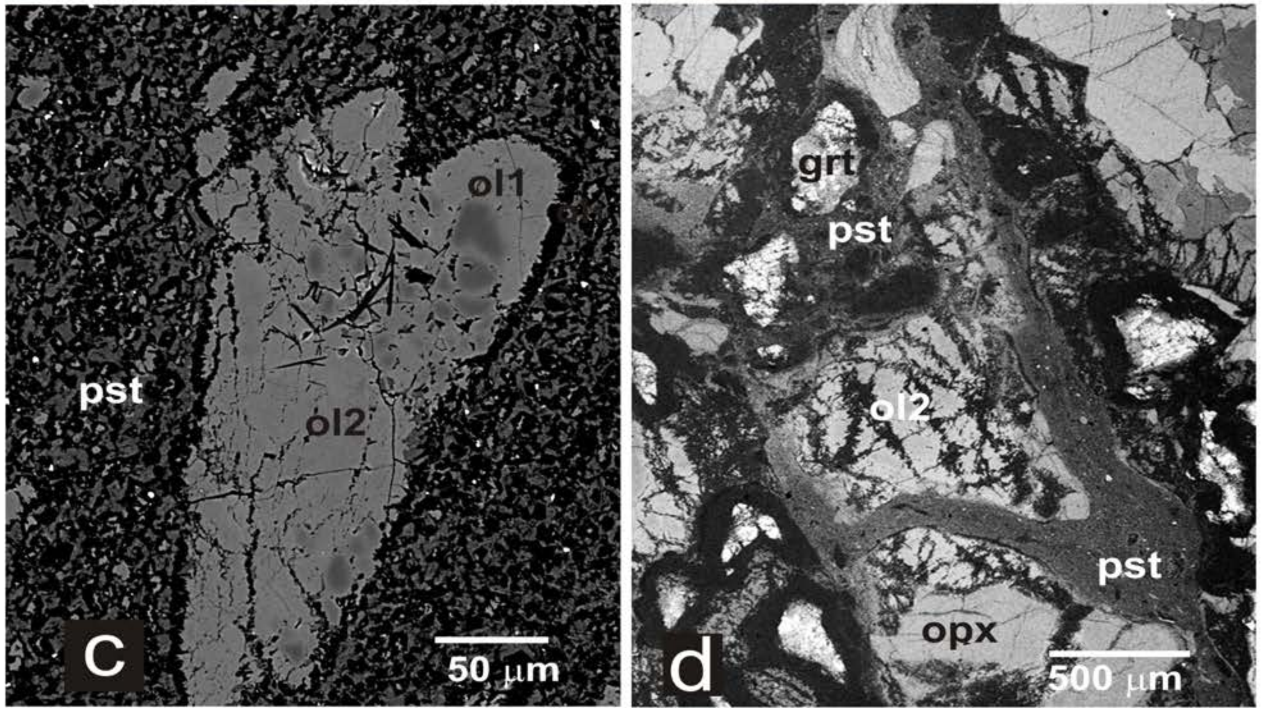

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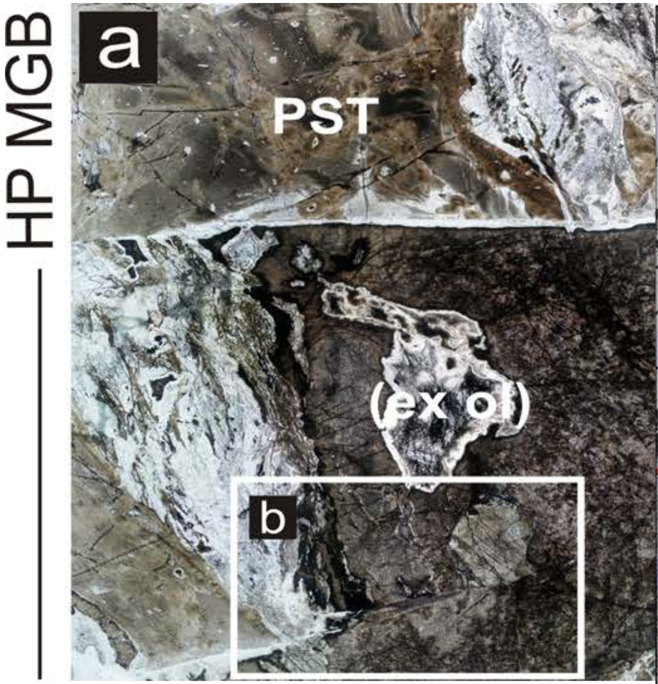

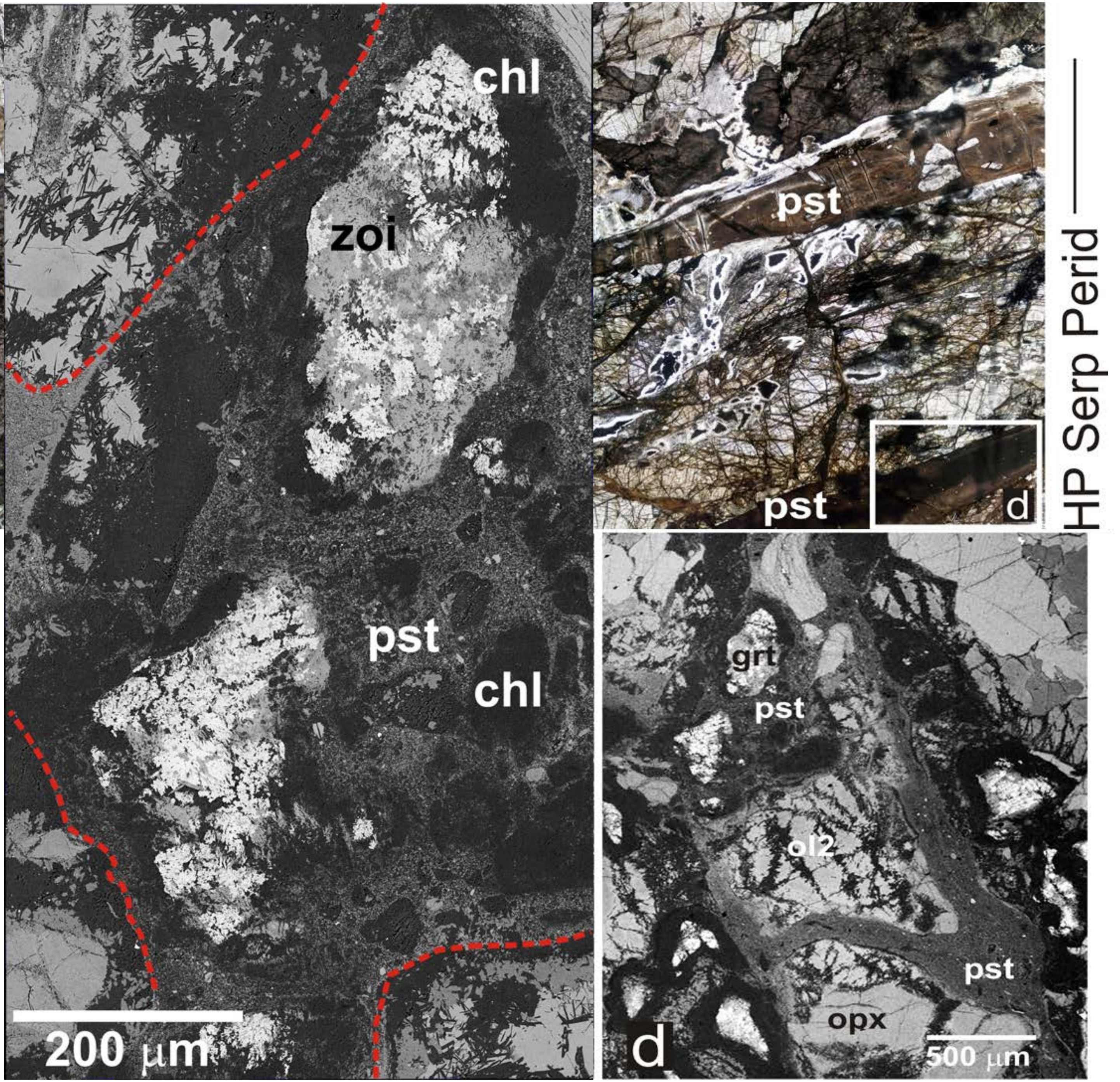

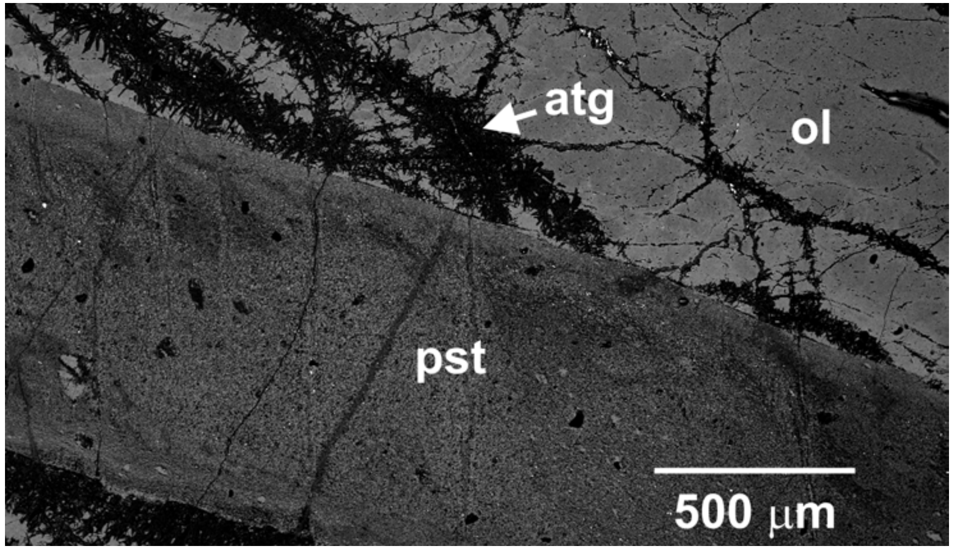

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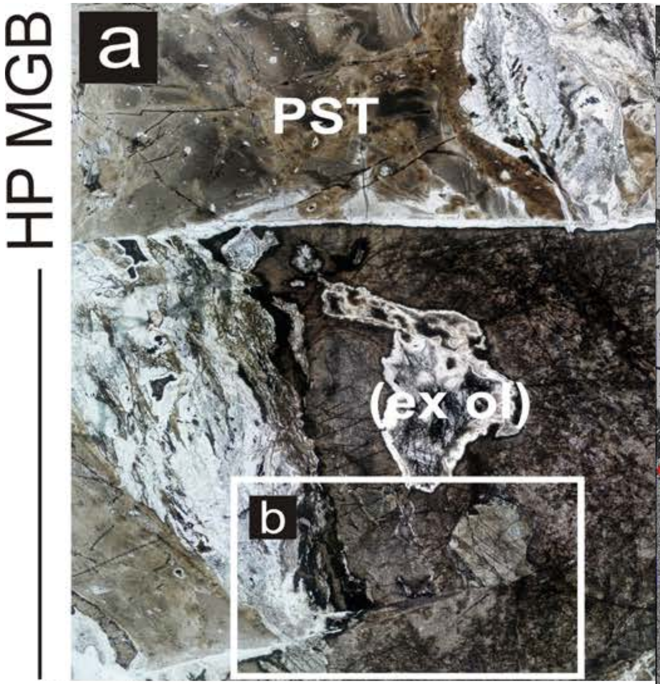
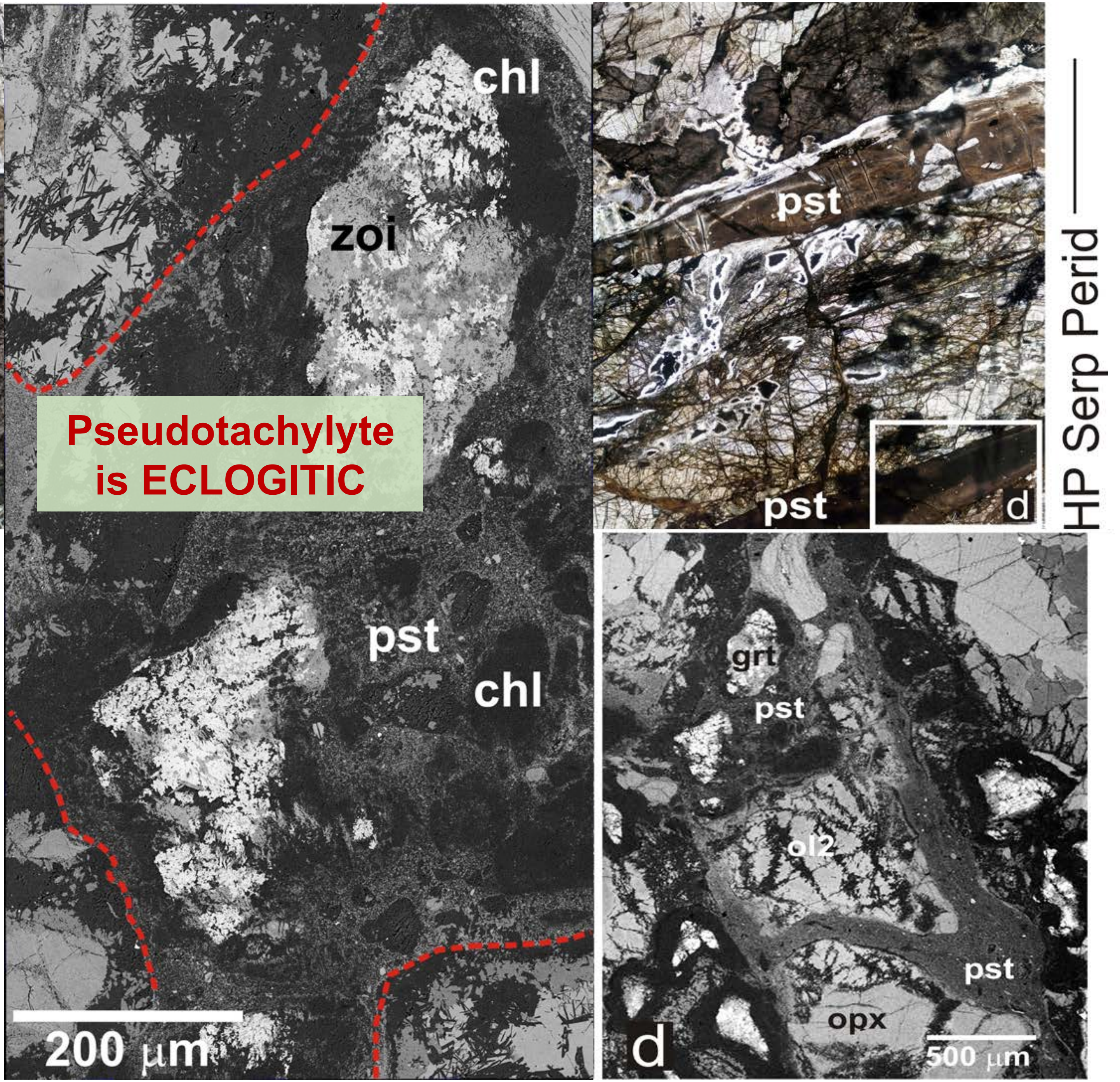
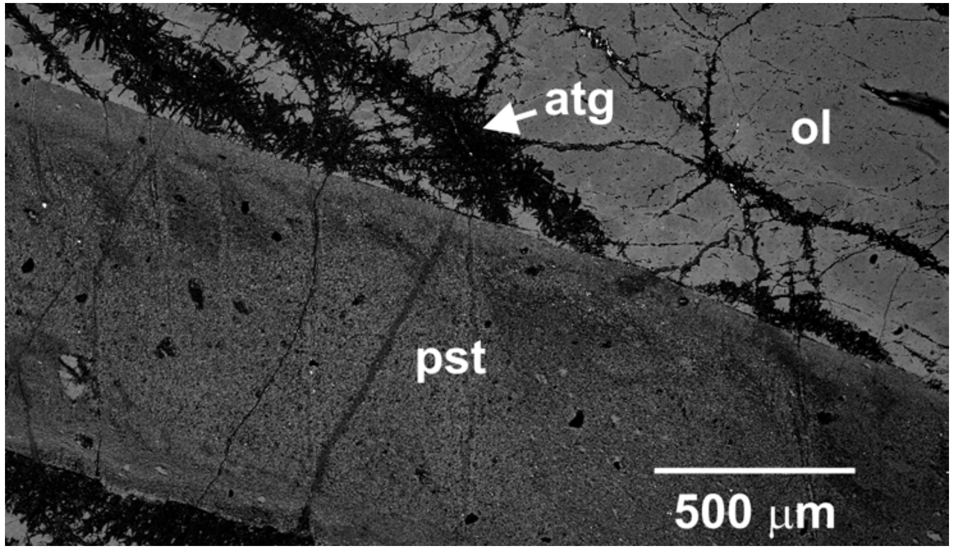
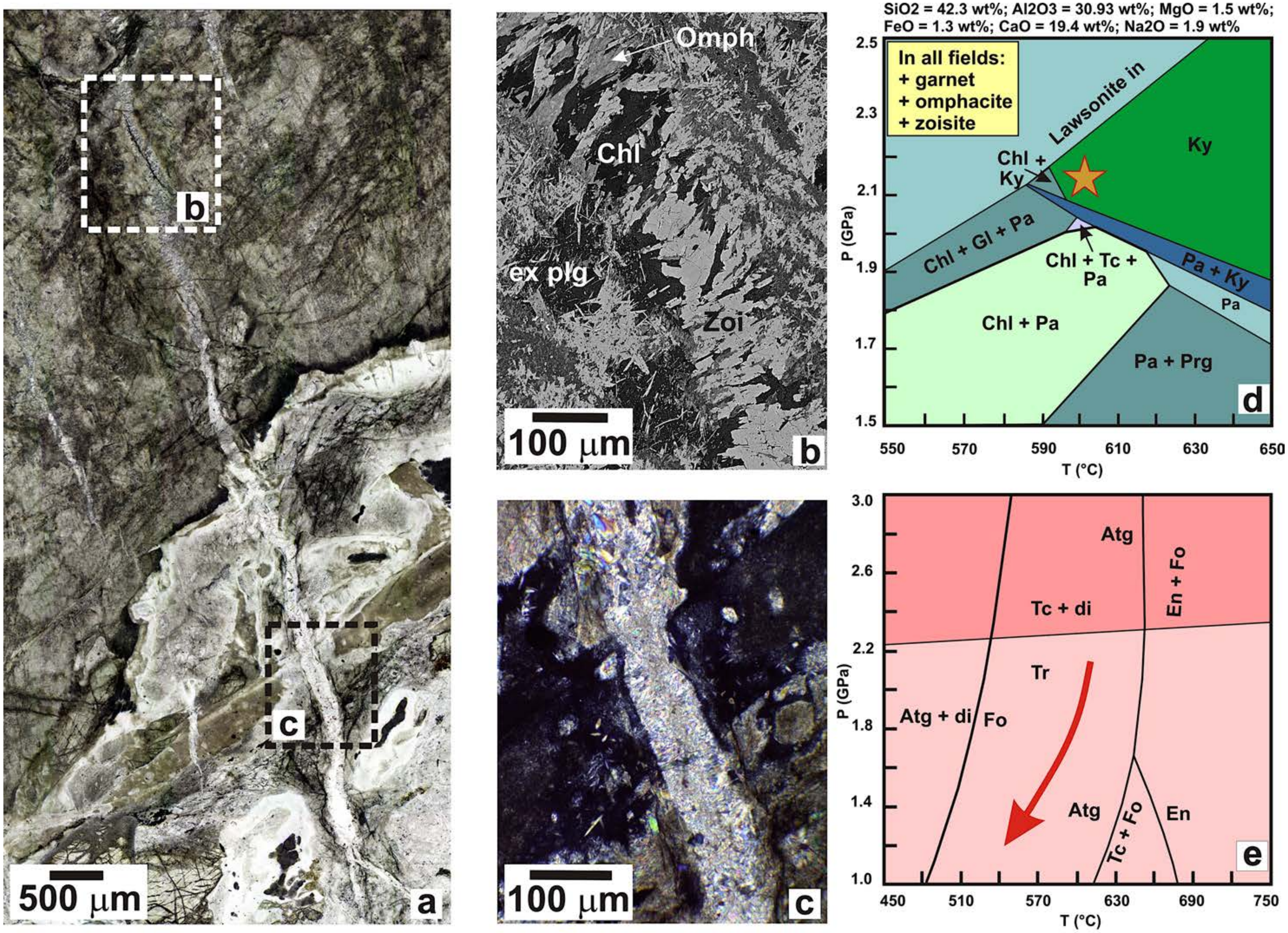








Veins cutting the pseudotachylyte in metagabbro and metaperidotite

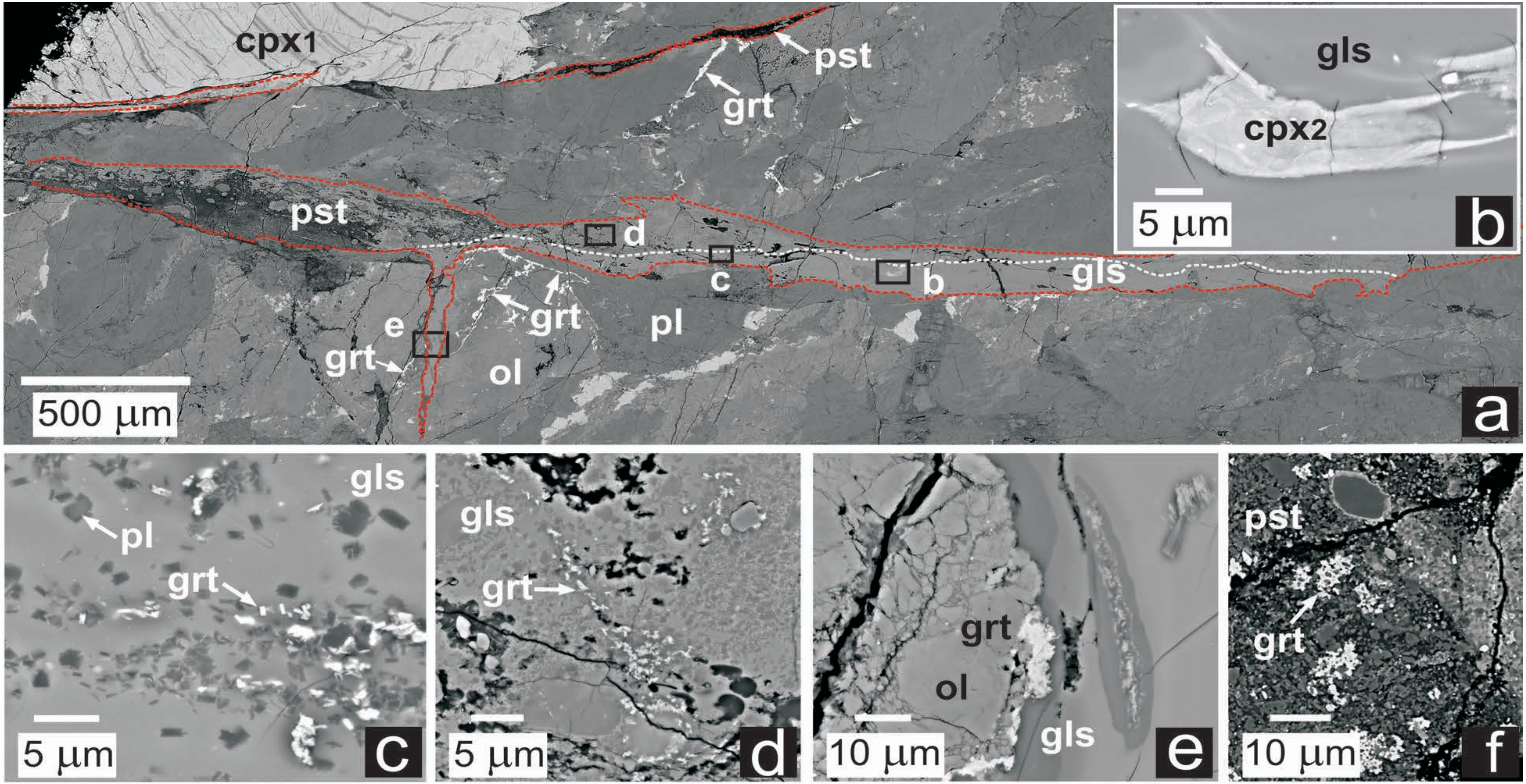
1. Contain zoisite and omphacite in metagabbro;

2. Contain tremolite and talc in metaperidotite

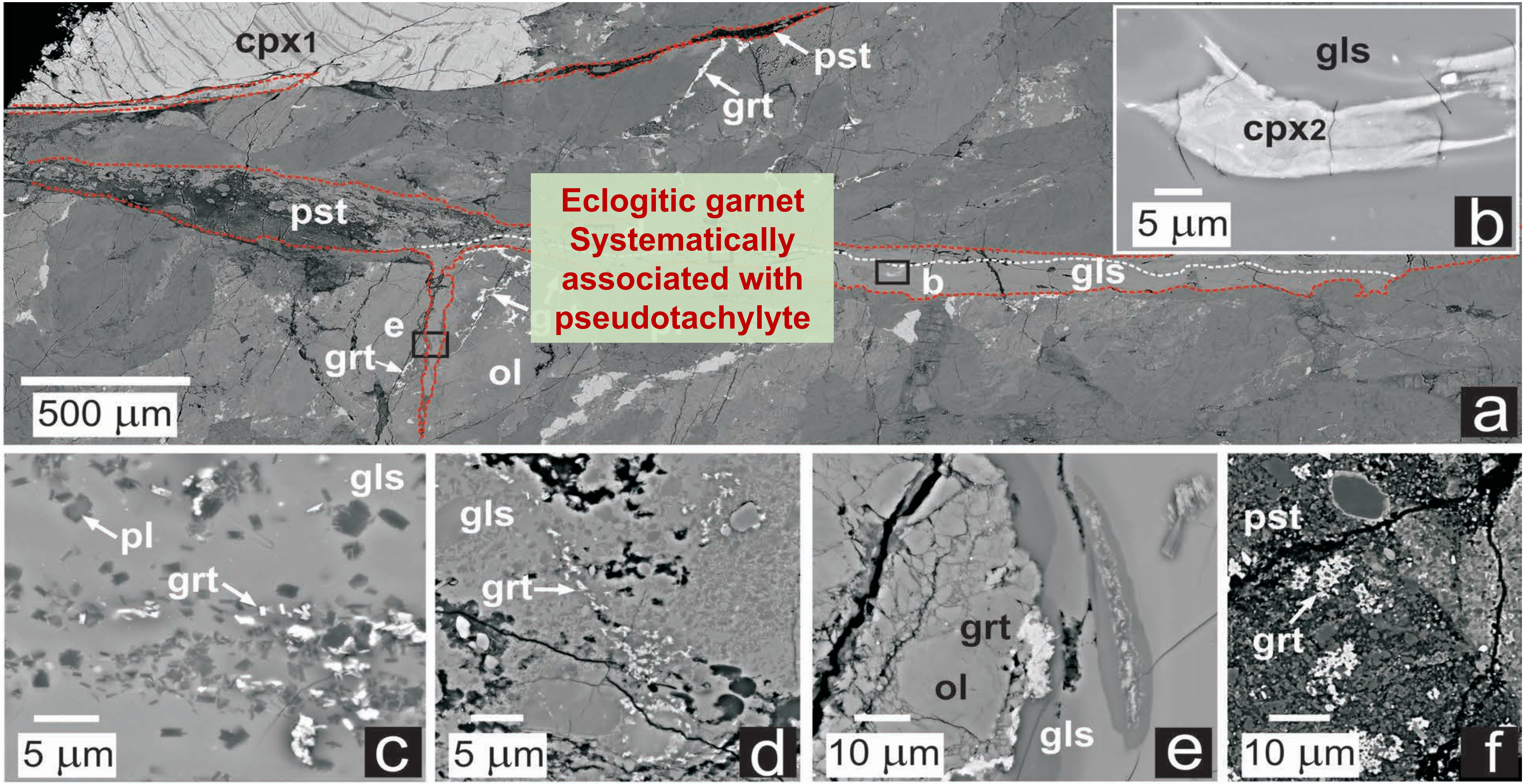
3 the vein formed when rocks were still at HP conditions

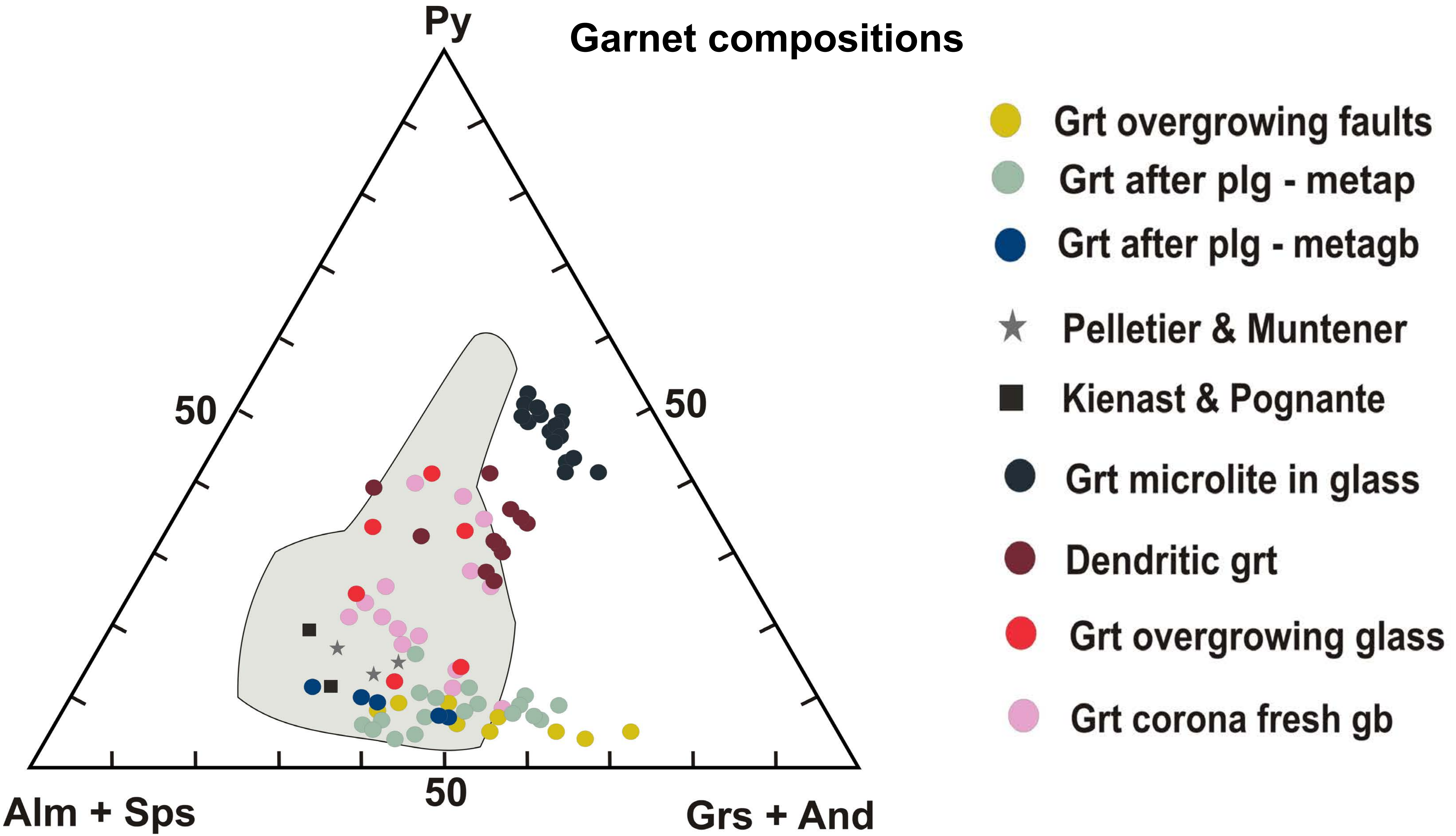

Thick pseudotachylyte veins in unaltered
preserved gabbro
5 cm

Glassy pseudotachylyte in unaltered, preserved gabbro

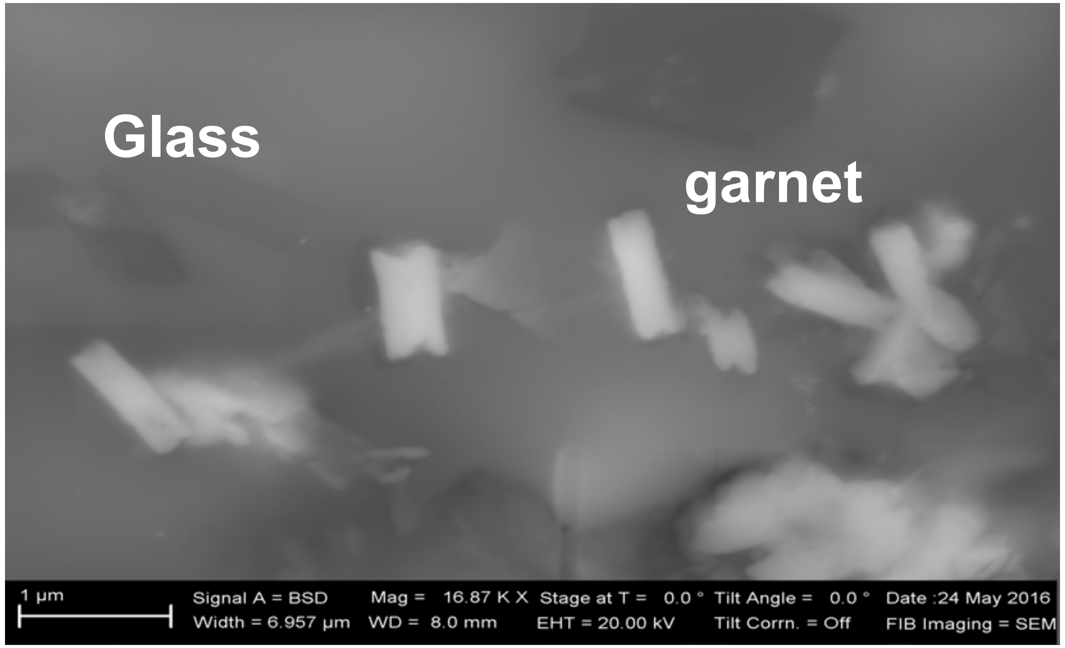


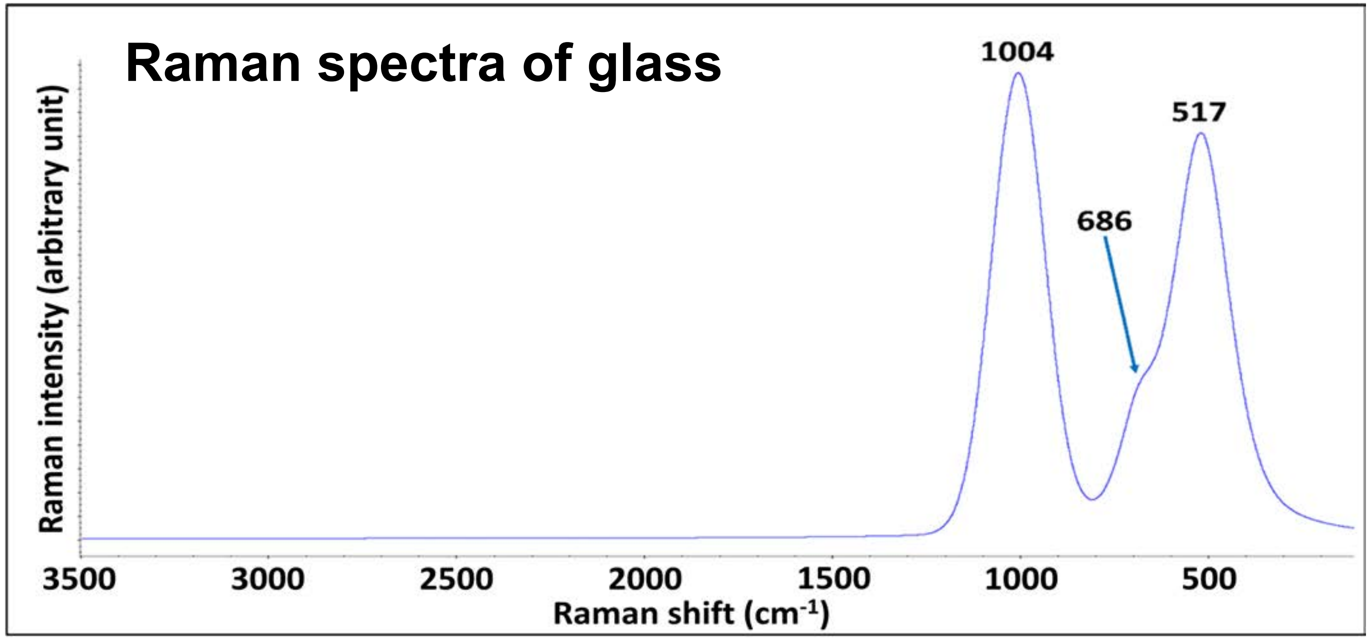
Glassy pseudotachylyte in unaltered, preserved gabbro

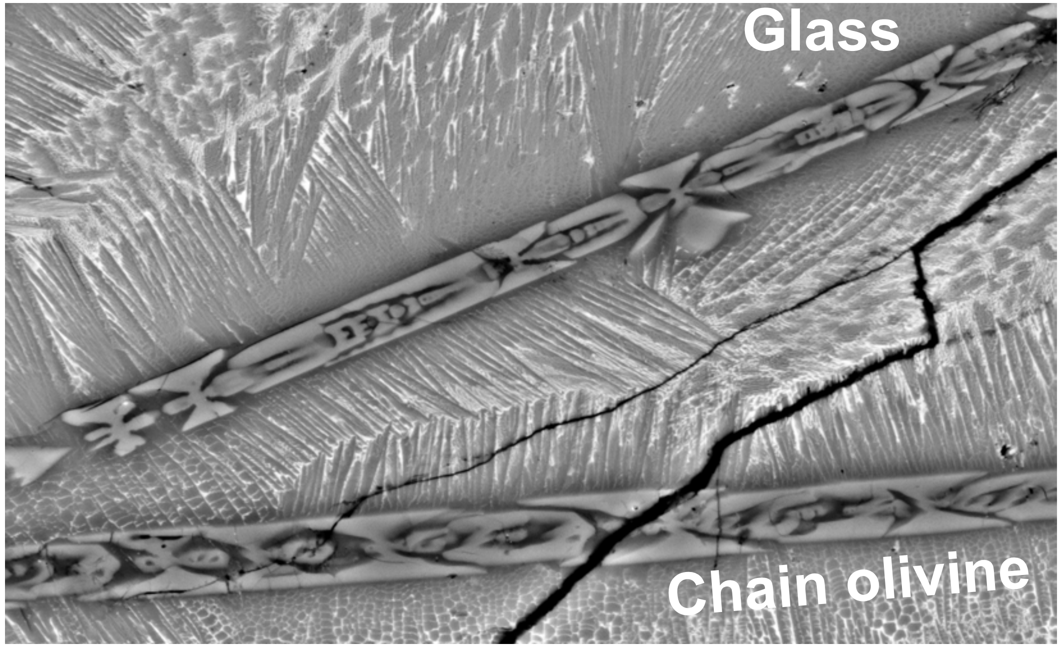




Garnet compositions
Py
50
50
50
Alm + Sps
Grs + And
Grt overgrowing faults
Grt after plg - metap
Grt after plg - metagb
Pelletier & Muntener
Kienast & Pognante
Grt microlite in glass
Dendritic grt
Grt overgrowing glass
Grt corona fresh gb



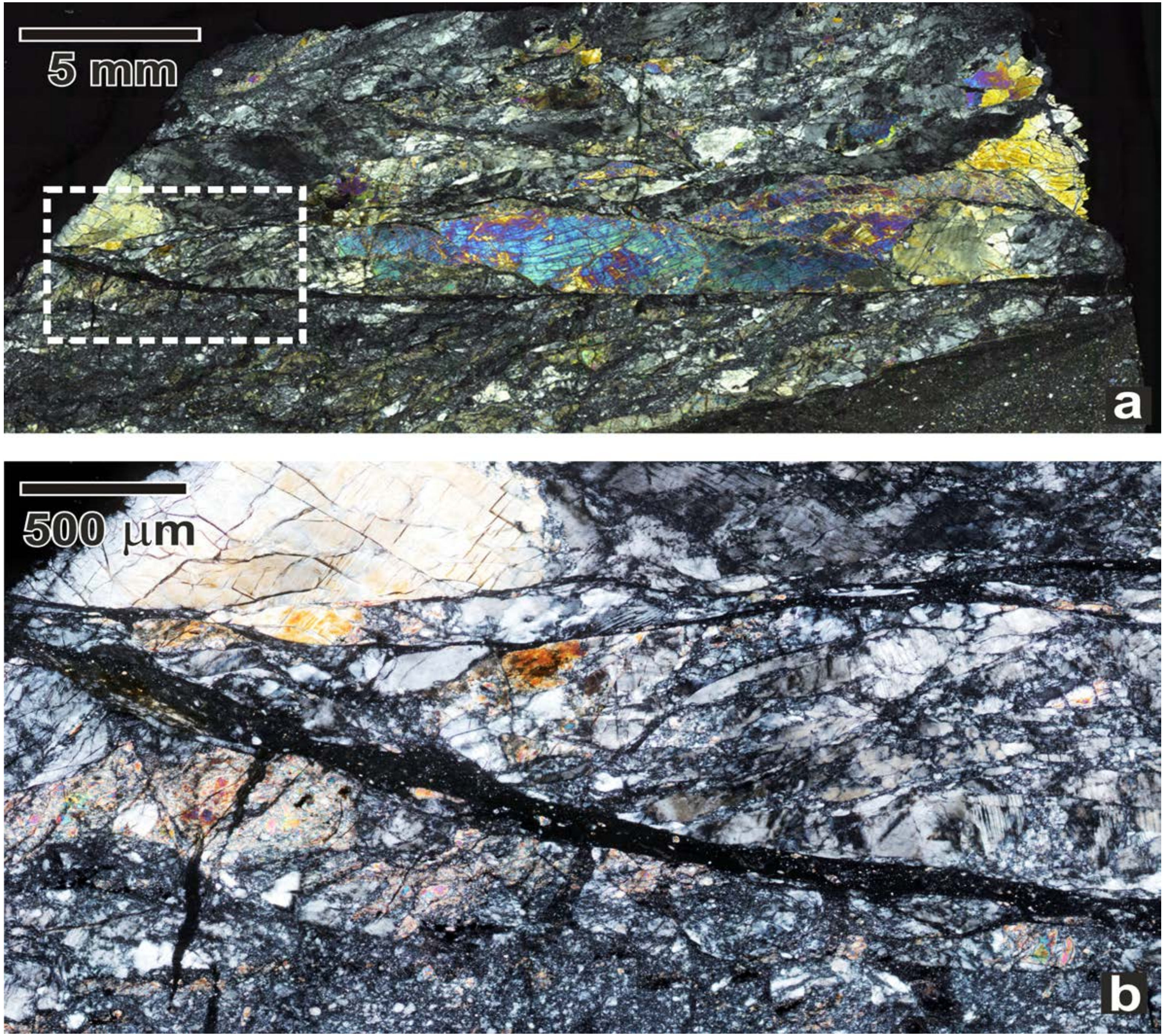




No peak in the OH- stretching region

No water available during seismic failure

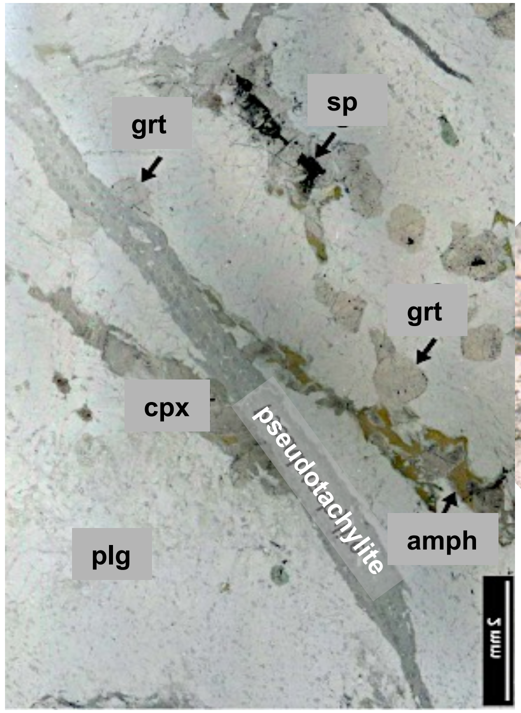
Information on <u>deformation mechanisms</u> and on the <u>subduction environment</u> for earthquake development

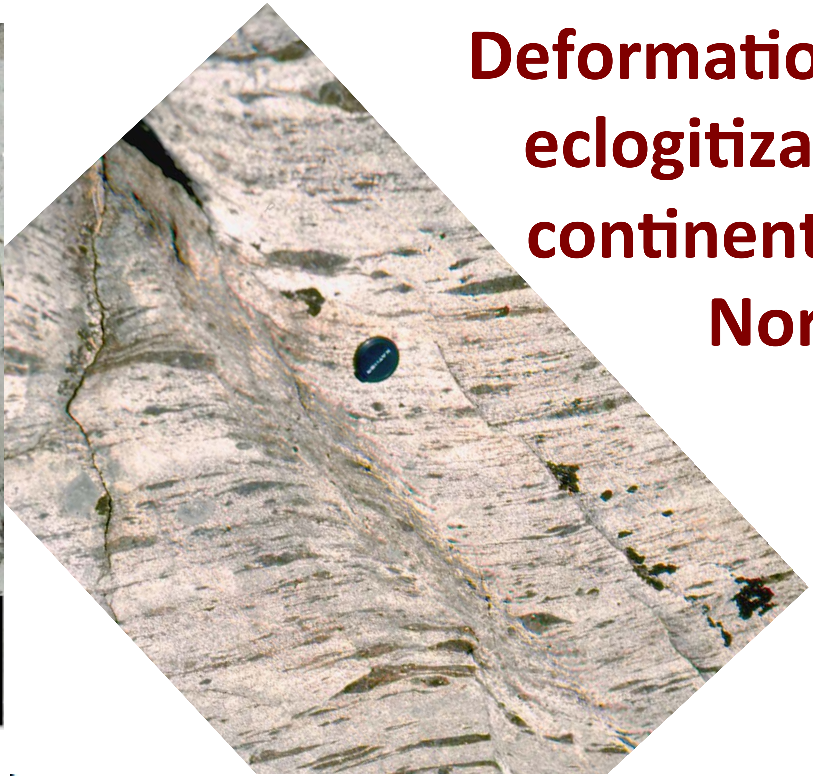


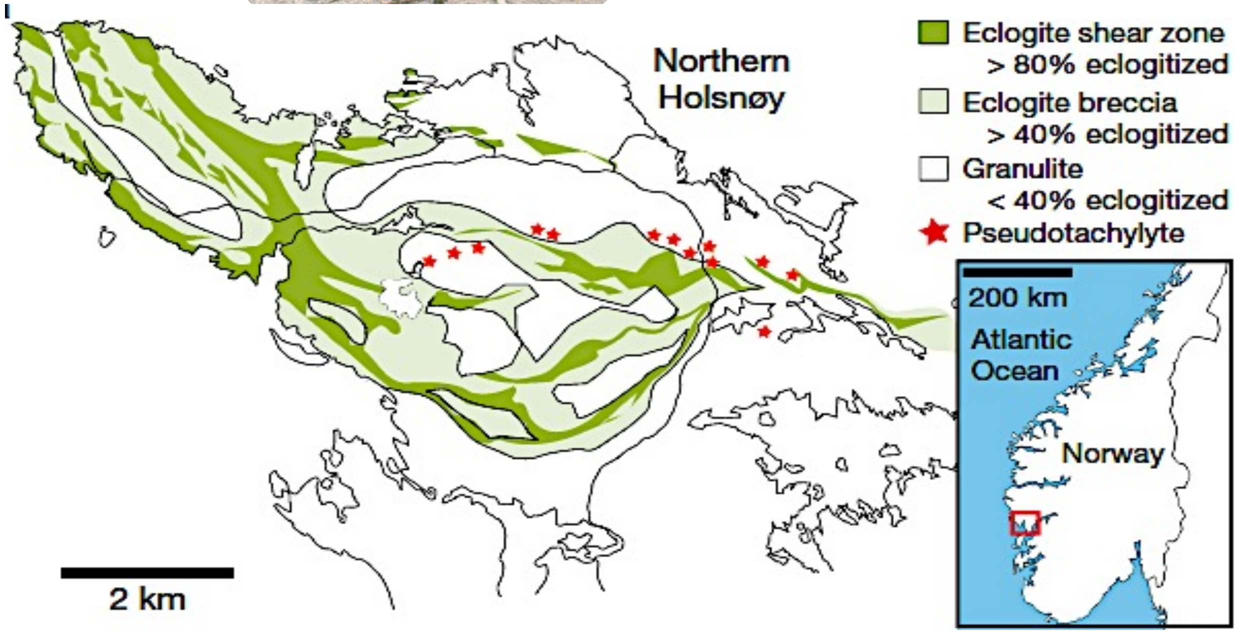
Pseudotachylyte and cataclastic damage in subducting oceanic gabbro and peridotite highly increases the rock porosity and opens the way to external fluids

Scambelluri et al. 2017 Nature Geoscience

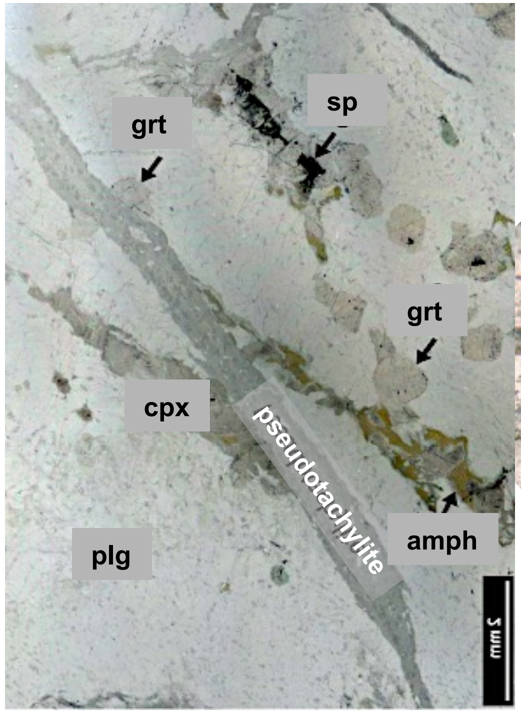
Deformation-enhanced eclogitization in the continental crust of Norway







Austrheim et al. 1987, EPSL;
Jamtveit et al. 2018 Nature;
Austrheim et al 2017, Science Advances

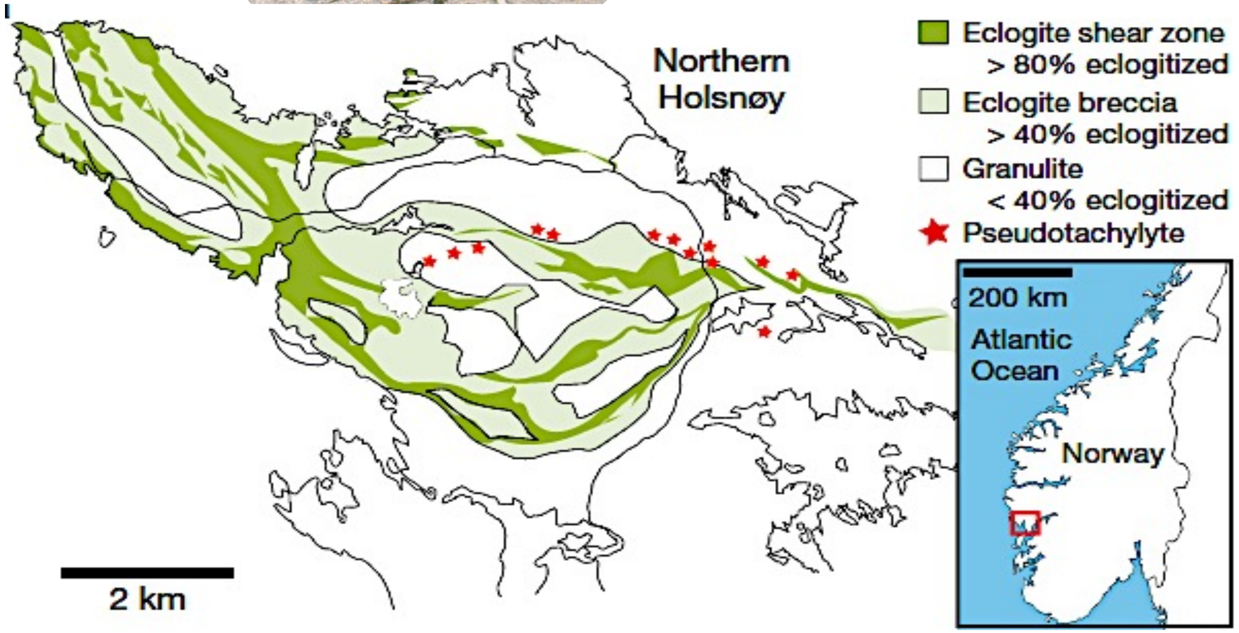


Deformation-enhanced eclogitization in the continental crust of Norway

No deformation + No fluid

=

No metamorphism



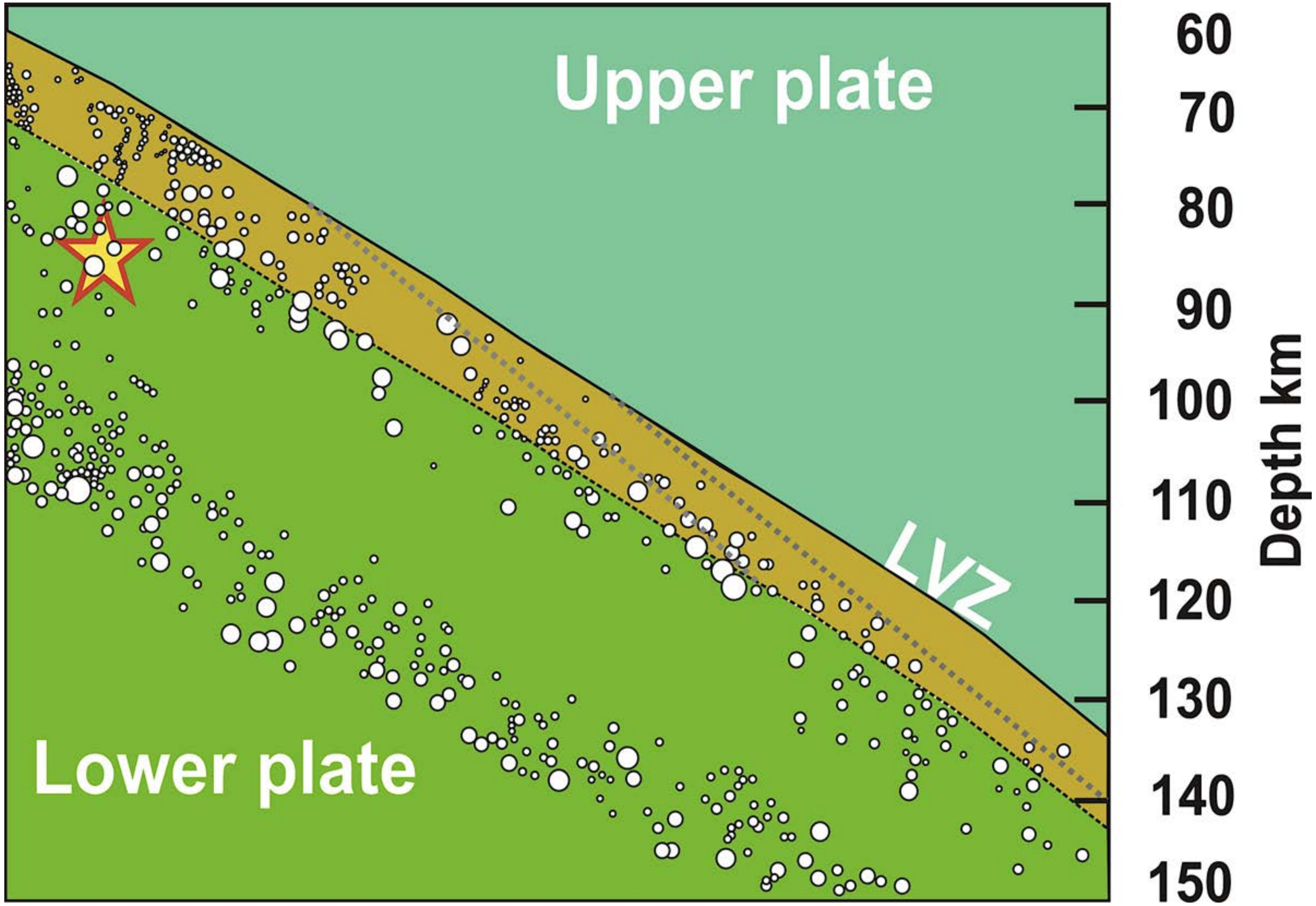
Austrheim et al. 1987, EPSL;
Jamtveit et al. 2018 Nature;
Austrheim et al 2017, Science Advances

Key points

Quite different from all Alpine ophiolites: from plate interface, where fluid availability favoured full recrystallization during subduction

Dry and metastable Moncuni rocks: lithospheric mantle of the subducting slab

Lanzo peridotite and gabbro: mostly unaltered (dry, metastable) and undeformed



Conclusions

Lanzo-Moncuni mantle → Fluid-free, metastable, dry, strong rocks

Accumulate large differential stress

Moncuni pseudotachylyte: unique occurrence of intermediate-depth (big) subduction earthquake in the the lithospheric slab mantle

Proxy of Circumpacific cold oceanic subducting slabs

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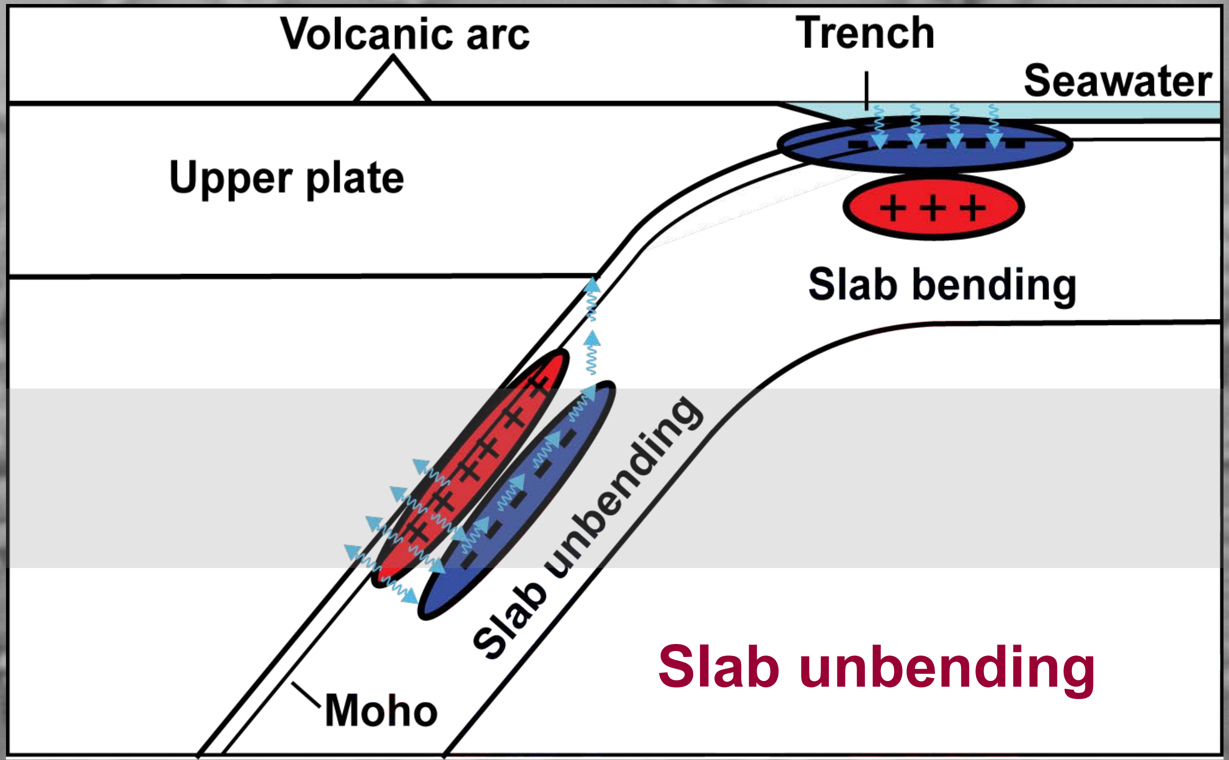
Proxy of Circumpacific cold oceanic subducting slabs

Mechanism

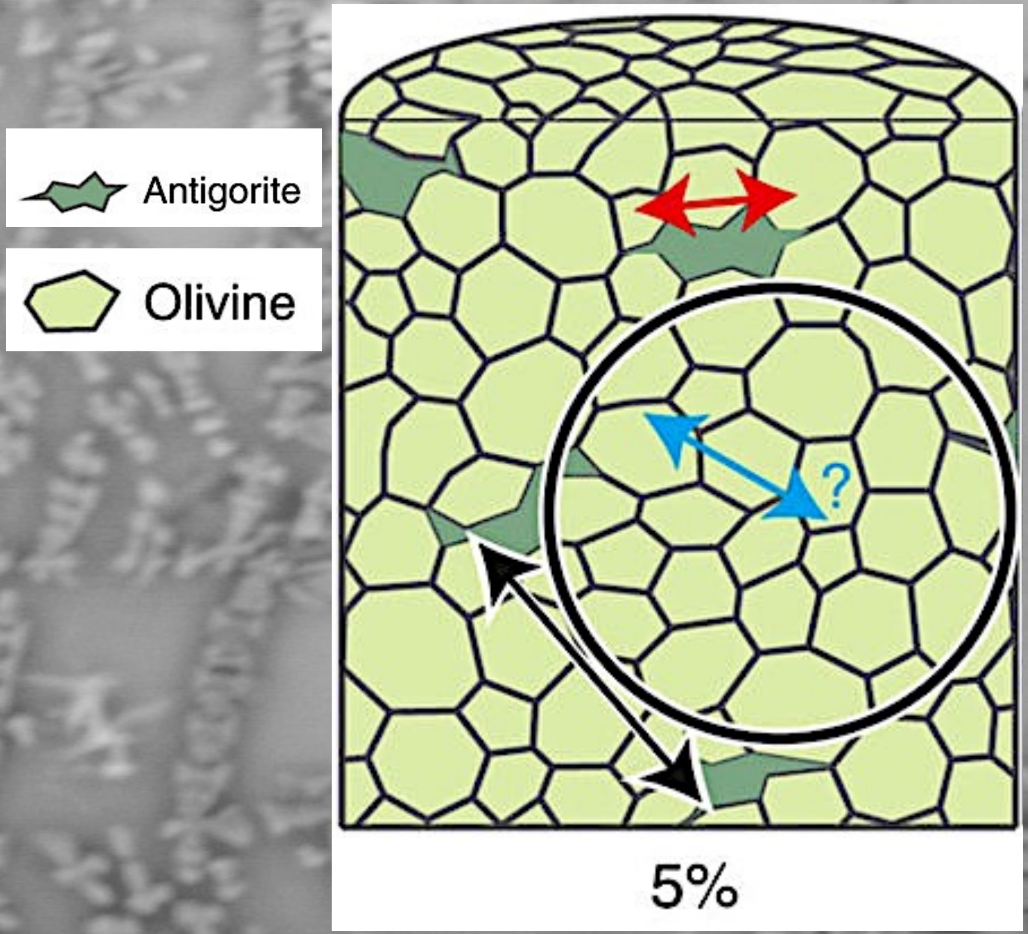
No deformation associated with pseudotachylyte: not triggered by thermal runaway

No dehydration embrittlement. The amount of water released by the subordinate hydrated rocks is insufficient to trigger seismic faulting in the whole Moncuni body.

Alternative hypotheses



Faccenda et al. 2012 G[3]



Stress percolation Experiments show that dehydrating serpentinite domains loose their load capacity and transfer stress to the peridotite, inducing faulting in the olivine-rich rock asperities

Ferrand et al., Nat Communications, 2017

More in Scambelluri et al. Nat Geoscience 2017

Thank you