## Seismic signatures of a hydrated mantle wedge from antigorite crystal preferred orientation (CPO)

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## Motivation

#### **Observations of seismic anisotropy**



## Motivation

## **Observations of seismic anisotropy Non-unique interpretations**



# 2D corner flow with olivine type-B

trench-parallel flow with olivine type-A, -C, or -E



### Case study – Subduction zones

#### Focus on antigorite:

- High temperature serpentine
  polymorph stable in subduction
  zones
- Links to seismicity hydration/ dehydration
- Sheet silicate highly anisotropic elastic properties

#### Case study – Subduction zones

Antigorite single crystal seismic properties



## Strategy

- 1) Measure antigorite CPO using electron backscatter diffraction (EBSD)
- 2) Calculate aggregate elastic properties using single crystal elastic constants  $(C_{ij})$ and measured CPO [e.g. *Mainprice*, 1990]
- 3) Model seismic properties of subduction zones

## Study Area





# Nearly pure antigorite schists Medium- to fine-

grained

Thin sections
 prepared ~parallel
 to foliation and
 lineation

#### Crossed polarized light

1/4 wavelength



500 µm

Two EBSD maps were measured for each sample:

- 1. Finescale EBSD maps to image microstructure
- 2. Coarse (100 µm step size) maps to cover as much area as possible for CPO determination

Measurements conducted in low vacuum, with no carbon coat at 20 kV and 70° tilt

## EBSD Fine-scale maps

#### Band Contrast Image

#### Euler Angle Image



## **EBSD** Fine-scale maps

#### Band Contrast Image

#### Euler Angle Image











## EBSD Coarse maps/ CPOs

What we expect:

- (001) ~perpendicular to foliation [all previous studies]
- 2) (001) girdle-like distribution [*Niishi et al.* 2011; *Soda and Takagi,* 2010]
- [100] parallel to lineation [*Bezacier et al.*, 2010; *Katayama et al.*, 2009]
   [010] parallel to lineation [*Hirauchi*

et al., 2010; Niishi et al., 2011]

## EBSD Coarse maps/ CPOs



## EBSD Coarse maps/ CPOs

Range of observed CPOs for samples with foliation/ lineation N essentially undetermined

Girdle-like distribution of (001)



## Velocity calculations

Minimum Vp and Vs anisotropy perpendicular to foliation

Vs1 polarization perpendicular to lineation for both observed CPOs



Velocities calculated using Cij from Bezacier et al., [2010]

## Velocity calculations

Anisotropy ranges from ~5 to 30% for Vp and Vs in all 7 samples measured

Girdle distributions of (001) result in the weakest anisotropy



Velocities calculated using Cij from Bezacier et al., [2010]

## CPO resulting from growth

- Vein growth will result in basal plane perpendicular to vein walls – (001) girdle
- Antigorite displays topotactic relationship with olivine
  - (010)atg always parallel to [001]ol(001)atg parallel to [100]ol OR [010]ol
- Predicts bi-modal or girdle distribution of (001)atg
- Topotactic antigorite results in orthogonal shearwave polarizations

1. Simplified mineral assemblages from *Perple\_X* calculations



 Foliation orientations from 2D corner flow calculations in *Long et al.*, [2007] and *Kneller et al.*, [2008]



3. CPOs specified by predominant mineral slip systems and CPO strength varying with strain according to *kneller et al.* [2008]

Mineral	Specified slip system
Quartz	Prism <a></a>
Plagioclase	[h01](010)
Albite	[h01](010)
Biotite	[hk0](001)
Phengite	[hk0](001)
Hornblende	[001](100)
Glaucophane	[001](001)
Omphacite	[001](010)
Diopside	[001](010)
Jadeite	[001](010)
Olivine	A-[100](010); B-[001](010)
Antigorite	[010](001)
Zoisite	[010](001)
Garnet	random

3. CPOs specified by predominant mineral slip systems and CPO strength varying with strain according to *kneller et al.* [2008]



Velocities for vertical propagation

No antigorite

50 vol% topotactic antigorite

50 vol% antigorite (001)atg || fol.



## Conclusions

#### Antigorite CPOs are variable

(001)atg either forms girdle or point distribution with maximum perpendicular to foliation

[010]atg or [100]atg are parallel to lineation

- Variability in observed CPO may be related to growth (i.e. vein growth or topotaxy)
- Hydration in the mantle wedge is likely to contribute to trench-parallel shear wave splitting magnitude and directions

## Future work/ questions?

- How does olivine with topotactic antigorite deform?
- Better/ more advanced approximations for CPO development in model?
- What are the effects of vein-growth antigorite?
- What other geophysical methods can we combine to refine interpretations of subduction zone anisotropy?
- Lower crustal effects?

## Carbonate and antigorite

