Seismic Anisotropy of Mafic Blueschists: Constraints from Exhumed Rock-Record with Implications for the Subduction Interface

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I. Motivation

- Loading of seismogenic zone and production of arc-magmas driven by ductile deformation and metamorphic reactions at plate interface
- Seismic anisotropy can illuminate subduction zone structure and link deep processes to geological hazards at the surface
- Constraining the seismic anisotropy of mafic blueschists, a key constituent of subducting slabs, will improve imaging of the subduction zone interface

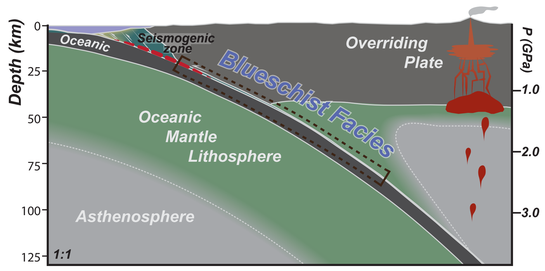
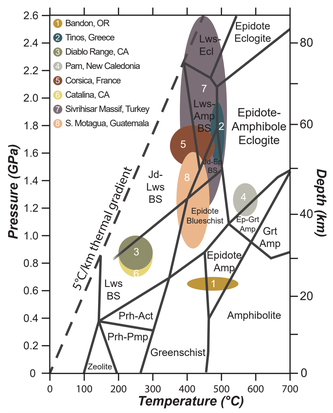


Diagram of a typical subduction zone illustrating major structural features and increasing pressure with depth

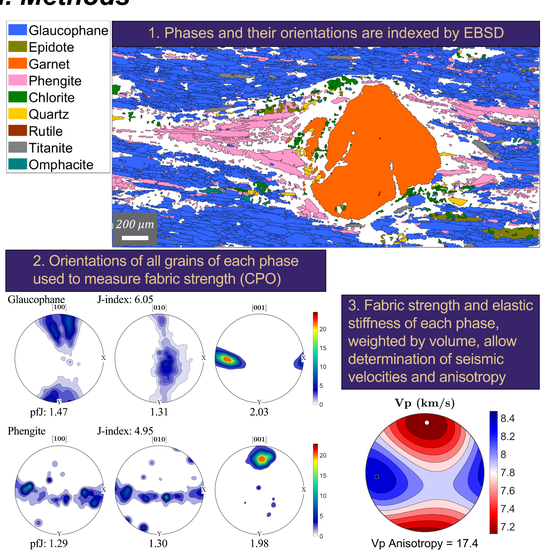
II. Materials

- 14 mafic blueschists from 8 exhumed subduction terranes
- 9 epidote blueschists
- 5 lawsonite blueschists
- Variable mineralogies spanning a broad range of the blueschist facies P-T conditions
- Samples display diverse deformation histories preserved as lineation, foliation, and crystallographic preferred orientation (CPO)
- Kinematically oriented thin sections prepared (foliation normal/ lineation parallel) for EBSD analysis



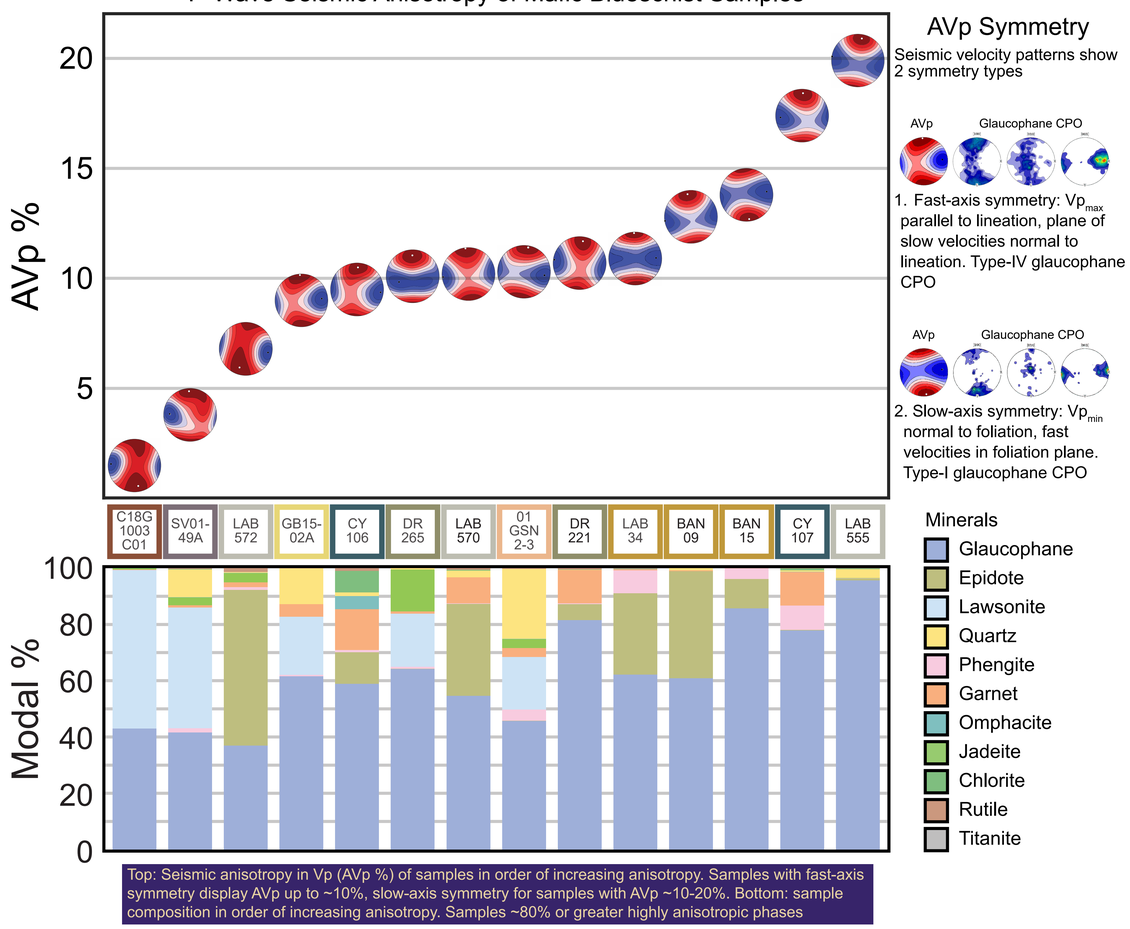
Blueschist sample P-T estimates from the literature overlain on metamorphic facies diagram (after Peacock, 2009)

III. Methods



Blueschists show strong seismic anisotropy (up to 20%), scaling with glaucophane abundance & fabric strength. This suggests potential for improved imaging of subducting slabs with receiver functions.

IV. Results and Discussion



Top: Seismic anisotropy in Vp (AVp %) of samples in order of increasing anisotropy. Samples with fast-axis symmetry display AVp up to ~10%, slow-axis symmetry for samples with AVp ~10-20%. Bottom: sample composition in order of increasing anisotropy. Samples ~80% or greater highly anisotropic phases

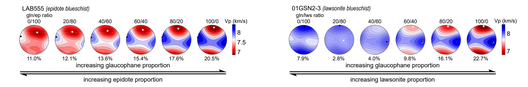
AVp Symmetry

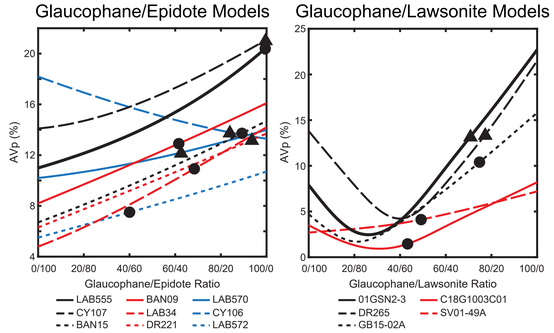
Seismic velocity patterns show 2 symmetry types

1. Fast-axis symmetry: Vp_{max} parallel to lineation, plane of slow velocities normal to lineation. Type-IV glaucophane CPO

2. Slow-axis symmetry: Vp_{min} normal to foliation, fast velocities in foliation plane. Type-I glaucophane CPO

Rock-Recipe Modeling

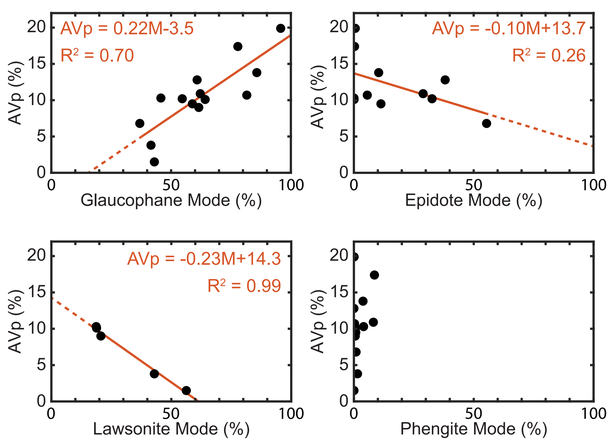




AVp for gln/ep 2-phase models show monotonic increase with glaucophane abundance. Vp max/min consistently oriented due to complementary CPOs in glaucophane and epidote

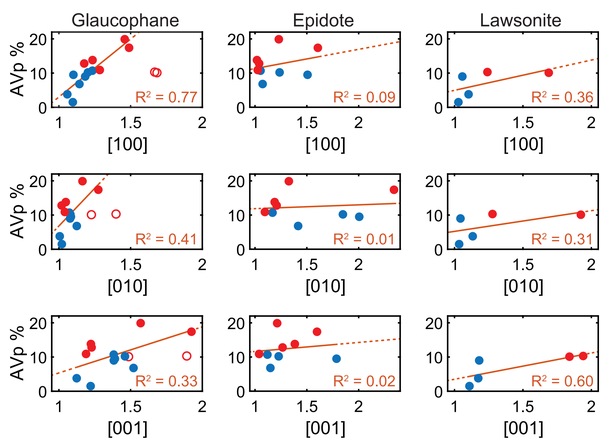
AVp for gln/lws 2-phase models show concave profile with min ~20-40% glaucophane. Symmetry of anisotropy (Vp max/min direction) changes at min due to antithetical gln/lws CPOs

AVp % versus Modal Abundance



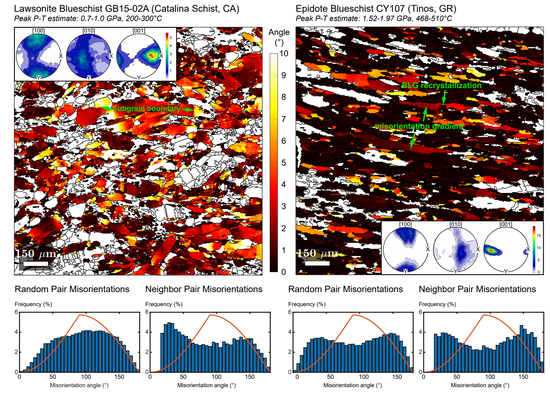
Seismic anisotropy versus modal abundance of glaucophane, epidote, lawsonite, and phengite. AVp % increases with increasing glaucophane abundance, but is diluted by increasing fractions of epidote or lawsonite. No AVp trend with increasing phengite

AVp % versus Fabric Strength (pfJ-Index)



AVp % vs CPO for each crystallographic axis (measured as pfJ-Index) for glaucophane epidote, and lawsonite. AVp shows strongest increase with CPO in glaucophane [100] and [010] axes, only weakly increases with epidote and lawsonite fabric strength

Glaucophane Deformation Microstructures



Misorientation to mean orientation maps (top L, R) show misorientation gradients, subgrain boundaries, and bulging recrystallization structures. Misorientation distributions (bottom) differ from untextured distribution (red curve), with higher frequency of low angle boundaries in neighboring grain-pairs (subgrain boundary recrystallization). The microstructural evidence is consistent with CPO-formation by climb-accommodated dislocation creep throughout blueschist stability field

V. Key Takeaways

- Mafic blueschists display a broad range of p-wave seismic anisotropy, ranging from AVp = 6.8 - 19.9% in epidote blueschists and AVp = 1.5 - 10.3% in lawsonite blueschists.
- Blueschist anisotropy is largely governed by glaucophane, increasing with both glaucophane modal abundance and CPO-strength.
- Increasing epidote/lawsonite dilutes bulk anisotropy; this effect is most pronounced in lawsonite due to antithetical fast/slow Vp-directions in lawsonite CPO versus glaucophane CPO.
- Blueschist anisotropy develops largely from ductile deformation and CPO formation in glaucophane by dislocation creep, active in glaucophane throughout blueschist stability field.

VI. References

Acknowledgements: Funding for this work is provided by the National Science Foundation Division of Earth Science (NSF EAR-XXXXXXX). Part of this work was conducted at the Molecular Analysis Facility, which is supported in part by funds from the Molecular Engineering & Sciences Institute, the Clean Energy Institute, the National Science Foundation (NNCI-2025489 and NNCI-1542101). The authors are indebted to Darrel S Cowan, Donna Whitney, Kayleigh Harvey, and Joshua M Garber for samples provided for inclusion in this study.