The low velocity layer (LVL) in modern subduction zones is a 3-5 km thick region that parallels the top of the downgoing slab and is characterized by anomalously high $V_p/V_s$ ratios (1.8-2.5) consistent with 2.5-4% fracture porosity at near-lithostatic pore fluid pressures. The LVL has been previously interpreted as partially hydrated, relatively undeformed oceanic crust at the top of the downgoing slab, but collocation of the LVL with episodic tremor and slow slip events (ETS) in modern subduction zones suggests that the LVL may alternatively represent the seismic signature of a subduction interface shear zone.

To test this hypothesis, we use field & structural observations, geochronology, and seismic velocity calculations to compare and contrast the bulk seismic properties of a fossil subduction interface shear zone (Condrey Mountain Schist, CMS, northern CA) to properties of modern LVLs. Specifically, we 1) determined thicknesses of underplated packages (interpreted to represent the maximum thickness of the actively deforming interface) using depositional age discontinuities and high resolution structural mapping, 2) averaged the bulk rock seismic velocities weighted by mapped lithologic proportions and corrected for pressure-temperature effects, and 3) used field evidence of modifying factors (e.g., microcracks, fluid-filled veins, mineral anisotropy) to further refine the possible range of seismic velocities and effects on $V_p/V_s$ ratio.

The CMS greenschist- to blueschist-facies units were subducted to ~25-35 km (450°C, 0.8-1.0 GPa) with limited retrogression or exhumational overprint. These rocks were underplated episodically at depth in three packages individually up to 4.5 km thick from 155-135 Ma, based on detrital zircon data. Each package is dominantly composed of metasedimentary rocks with m- to km-scale metamafic and serpentinized ultramafic lenses. Strain localization to ~1 km thick ductile shear zones between underplating episodes is collocated with km-scale serpentinitized ultramafic lenses at the base of each package. Deformation was distributed and ductile with rare macro- or micro-scale prograde brittle failure in the metasedimentary or metamafic units. In the serpentinitized ultramafics, ductile shear zones wrap massive blocks with prograde brittle fracture. Maximum fracture porosity estimated from relict veins is ~10%. Average $V_p/V_s$ for the CMS is ~1.6 (lithology alone) but up to 3.0 (accounting for maximum fracture porosity).

The fossil subduction interface shear zone preserved in the CMS is consistent in both thickness
and seismic signature with the LVL in modern subduction zones. Estimated $V_p/V_s$ is higher than the LVL but assumes that all fractures are simultaneously open. The total thickness of the CMS (10+ km) is greater than the LVL, however, so previously underplated material must lose its anomalous seismic signature during underplating (e.g., due to fluid loss and transport up the slab during or after underplating). Our results support the hypothesis that LVLs in modern subduction zones represent the seismic signature of the subduction interface shear zone.