Strength and rheology of continental lithosphere: a perspective from some recent seismic investigations (to large arrays in North America, Asia, and Antarctica)

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Mechanical properties (i.e., strength and rheology) of the continental lithosphere are of primary importance for interpretation its deformation at all spatial and time scales, but have been a topic of debate since the early 20th century (Burov and Watts, 2006, Burov, 2011). Deciphering these properties requires knowing the basic physical and chemical attributes, such as thickness, thermal state, and composition, but these attributes are difficult to be directly measured due to the inaccessibility of the interior of the Earth. Elastic information extracted from the high-resolution seismic models, especially those derived from the newly developed imaging techniques and large seismic arrays systematically deployed across the globe, on the other hand, can provide a path to estimate of these key attributes.

In this presentation, I will discuss how thermal and chemical properties of the continental lithosphere can be inferred by investigating its seismic properties. Particularly, I will show that 1) Multiple types of seismic observables made with the seismic arrays in North America, East Asia, and Antarctica enable us to obtain the elastic properties of the lithosphere; 2) Thermal properties of the continent (e.g., geothermal heat flux, a boundary condition that is vital in modeling the glacial dynamics for continent like Antarctica) can be derived from the seismic models; 3) Other attributes such as the thickness of the lithosphere (defined as a thermal boundary layer) and the rheology of the upper mantle can also be inferred by relating the seismic properties with temperature profiles using thermodynamic inversions and empirical relationships; 4) Elastic properties of the crust (e.g., the absolute seismic speed, speed ratio between P and shear waves) help quantify the chemical composition (i.e., silica content) in a systematic fashion for continents, providing additional information of the strength envelope of the lower crust, a key to the coupling (or decoupling) between the crust and mantle lithosphere. Finally, I will discuss how these investigations can incorporate the involvement of undergraduate students (especially those from local community colleges) and help them set up a starting point of a career path in geosciences.

References:

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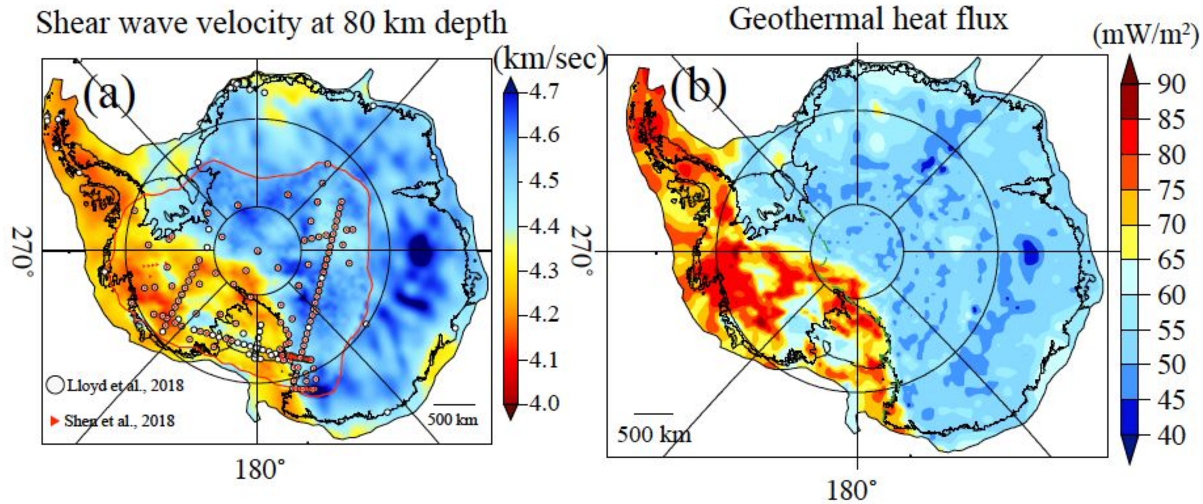

Figure 1. Thermal properties of the continental Antarctica derived from the recent seismic tomography using the seismic data compiled during the past 2 decades. (a) Seismic stations used by two recent tomographic studies for Antarctica (Shen et al., 2018; Lloyd et al., 2018) are plotted on top of the 80 km shear velocity map generated by combining the two seismic models. The red contour highlights the West and central Antarctica region within which most stations are located and in which a high resolution model emerges from the joint interpretation of ambient noise-based and earthquake-based surface wave and receiver functions. (b) Seimologically derived geothermal heat flux map of the continental Antarctica constructed by empirically relating the upper mantle shear velocity structure with thermal state of the lithosphere.