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# Plate Tectonics: From Initiation of Subduction to Global Plate Motions (Augustus Love Medal Lecture)

Michael Gurnis
Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125 USA

Plates are driven by buoyancy forces distributed in the mantle, within cooling oceanic plates (ridge push) and within subducted slabs. Although the case is often made that subducted slabs provide the principle driving force on plate motion, consensus has not been achieved. This is at least partially due to the great difficulty in realistically capturing the role of slabs in observationally-constrained models as slabs act to drive and resist plate motions through their high effective viscosity. Slab buoyancy acts directly on the edge of the plate (slab pull), while inducing mantle flow that tends to drag both subducting and overriding plates toward the trench. While plates bend during subduction they undergo a form of 'plastic failure' (as evident through faulting, seismicity and reduction of flexural parameters at the outer trench wall). The birth of a new subduction zone, subduction initiation, provides important insight into plate motions and subduction dynamics. About half of all subduction zones initiated over the Cenozoic and the geophysical and geological observations of them provide first order constraints on the mechanics of how these margins evolved from their preexisting tectonic state to self-sustaining subduction. We have examples of subduction initiation at different phases of the initiation process (e.g. early versus late) as well as how margins have responded to different tectonic forcings. The consequences of subduction initiation are variable: intense trench roll back and extensive boninitic volcanism followed initiation of the Izu-Bonin-Mariana arc while both were absent during Aleutian arc initiation. Such differences may be related to the character of the preexisting plates, the size of and forces on the plates, and how the lithosphere was initially bending during initiation. I will address issues associated with the forces driving plate tectonics and initiating new subduction zones from two perspectives. A common thread is the origin and evolution of intense back arc spreading and rapid roll back associated with some ocean-ocean subduction zones. I will look at the dynamics driving global plate motions and the time-dependence of trench rollback regionally. Capitalizing on advances in adaptive mesh refinement algorithms on parallel computers with individual plate margins resolved down to a scale of 1 kilometer, observationally constrained, high-resolution models of global mantle flow now capture the role of slabs and show how plate tectonics is regulated by the rheology of slabs. Back-arc extension and slab rollback are emergent consequences of slab descent in the upper mantle. I will then describe regional, time-dependent models, address the causes and consequences of subduction initiation, and show that most back arc extension follows subduction initiation. Returning to the global models, inverse models using the full adjoint of the variable viscosity, Stokes equation are now possible and allow an even greater link between present-day geophysical observations and the dynamics from local to global scales.