Structural Seismology: Exploring the Correspondence between Surface Geological Features and Heterogeneities in the Earth's Crust and Mantle

GAO Stephen-Shangxing[1,*], LIU Kelly-Hong[1], FU Xiaofei[2], Haider DAHM[1,3], KONG Fansheng[1,4], LIU Lin[1,5], Cory REED[1], SUN Muchen[1,2] and YU Youqiang[1,6]

[1] *Missouri University of Science and Technology, Rolla, Missouri 65409, USA*
[2] *Northeast Petroleum University, Daqing, Heilongjiang 163318, China*
[3] *Misan University, Amarah, Iraq*
[4] *Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China*
[5] *Stanford University, Stanford, California 94305, USA*
[6] *Tongji University, Shanghai 200072, China*

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Abstract: It has long been recognized that the formation and evolution of large geological features observed on the Earth's surface, such as volcanic provinces, rifted valleys, and linear mountain chains, are closely related to dynamic processes in the crust and mantle. Structural seismology, which is a branch of seismology aiming at imaging the velocity, anisotropy, attenuation, and layered structures of the Earth's interior using elastic waves produced by earthquakes, is the most effective approach for delineating such processes. Our recent and ongoing studies using structural seismological techniques including receiver function stacking, shear wave splitting analysis, and seismic tomography in various parts of the world have revealed new and refined previously-recognized connections between surface geological features and crustal and mantle structures. Results from these investigations indicate that 1) the initiation and early-stage development of continental rifts in Africa are controlled by differential basal drag applied to the bottom of the continental lithosphere, along margins of thick lithospheric blocks (Yu et al., 2015; Reed et al., 2017); 2) enhanced volcanic activities in the Indochina Peninsula, Sumatra, and Alaska are closely related to advective thermal upwelling through gaps in the subducted oceanic slab (Yu et al., 2017; Dahm et al., 2017; and ongoing research by Kong et al.); 3) hypothesized mantle plumes in North America and Africa are most likely limited in the upper mantle (Gao and Liu, 2014; Sun et al., 2017; Reed et al., 2016); 4) intracontinental volcanisms observed beneath Northeast Asia are associated with areas with stagnant oceanic slabs in the mantle transition zone which is bordered by the 410 and 660 km discontinuities (ongoing research by M. Sun et al.); and 5) there is a toroidal mantle flow system induced by slab subduction and rollback beneath the eastern Himalayan syntaxis recently revealed by a systematic analysis of shear wave splitting parameters (ongoing research by L. Liu et al.). Results from these and other structural seismological studies play an essential role for improving our understanding of large geological features observed on or near the surface of the Earth, and are important for mineral exploration and natural hazard mitigation.

Key words: structural seismology, mantle plumes, continental rifts, slab subduction, mantle transition zone

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* Corresponding author. E-mail: sgao@mst.edu

About the first and corresponding author

GAO Stephen-Shangxing, male; born in 1964 in Zhangqiu County, Shandong Province. He received his BS degree in Marine Geology and Geophysics from Ocean University of China in 1984, and MS and PhD in Geophysics and Space Physics in 1993 and 1995 from the University of California, Los Angeles (UCLA). He was a post-doctoral researcher at UCLA and the Carnegie Institution of Washington, and now is a professor at Missouri University of Science and Technology. His main research interests are geophysical imaging of the Earth's crust and mantle and spatial and temporal distributions of earthquakes. Homepage: http://www.mst.edu/~sgao; E-mail: sgao@mst. edu; Phone: 18396808533.