

Pacific and African anomalies, Earth's early differentiation, mantle dynamics and geochemistry

L. WEN¹ AND Y. HE^{1,2}

¹Department of Geosciences, Stony Brook University, Stony Brook, NY 11794 (lianxing.wen@sunysb.edu)

²Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing (hym@mail.iggcas.ac.cn)

We present high-resolution mapping of structural feature and velocity structure of these two prominent low velocity anomalies in the lower mantle beneath Africa (the African anomaly) and western Pacific (the Pacific anomaly). The African anomaly has an L-shaped very low velocity province (VLVP) near the core-mantle boundary (CMB) and extends continuously 1300 km above the CMB with both sides of the anomaly dipping toward the apex beneath southern Africa. The VLVP exhibits rapidly varying thicknesses from 300 km to 0 km, steeply dipping edges, and a linear gradient of shear velocity reduction from -2% (top) to -9% - -12% (bottom). The anomaly in the mid-lower mantle has an average shear velocity reduction of -2% - -3%. These structural and velocity features unambiguously indicate that the VLVP is compositionally distinct, and they can best be explained by partial melt driven by a compositional change produced early in the Earth's history. The geometry of the African anomaly in the lower mantle further indicates the anomaly is geologically stable. The Pacific anomaly consists of at least two separated portions with a 740-km wide gap between them. The western portion of the anomaly is about 1050 km wide, extends at least 730 km above the CMB and exhibits a trapezoidal shape with lateral dimension increasing slightly with depth. The average velocity reductions of the western portion of the anomaly are -5% in the bottom 100 km of the mantle and about -3% to -3.5% above. The eastern portion of the anomaly has an 1800-km wide base and reaches at least 340 km above the CMB with an average shear velocity reduction of -3%. The Pacific anomaly also contains internal heterogeneities with large velocity reductions and length-scales from tens to hundreds kilometers. These results suggest that the Pacific anomaly represents a cluster of metastable thermo-chemical piles or plumes, with small-scale partially molten pockets at its base. We will discuss implications of the geometries and velocity structures of the anomalies to mantle dynamics and Earth's early differentiation. We will also explore the connection of these two anomalies to two distinct isotopic anomalies noted on the ocean floor, the DUPAL anomaly in south Atlantic and Indian oceans and the South Pacific isotopic and thermal anomaly in the western Pacific.

Quasielastic neutron scattering coupled with classical molecular dynamics simulations of water diffusion at metal oxide surfaces

D.J. WESOLOWSKI^{1*}, E. MAMONTOV¹, L. VLCEK²,
W. WANG¹, P.T. CUMMINGS³, J. ROSENQVIST¹,
L.M. ANOVITZ¹ AND D.R. COLE¹

¹Oak Ridge National Laboratory, Oak Ridge, TN, 37831-6110, USA (*correspondence: wesolowskid@ornl.gov)

²Institute for Chemical Process Fundamentals, Prague, Czech Republic

³Vanderbilt University, Nashville, TN, 37235-1604 USA

Quasielastic neutron scattering (QENS) probes the diffusional dynamics of hydrogen-bearing species (such as water and hydroxyls on metal oxide surfaces). We have conducted QENS studies of isostructural rutile (TiO₂) and cassiterite (SnO₂) nanopowders with the (110) crystal surface predominant, and with 1-3 sorbed water layers. Experiments were conducted using the Disk Chopper Spectrometer (DCS) and High Flux Backscatter Spectrometer (HFBS) at NIST [1] and the newly-commissioned BASIS backscatter spectrometer at ORNL's Spallation Neutron Source. Three dynamic components are observed – in the picosecond, tens of picoseconds and nanosecond time scales at 195-345K. The DCS and BASIS results are in quantitative agreement for the intermediate component and the BASIS and HFBS give qualitatively similar results for the slow, non-Arrhenius motion, consistent with the very different energy transfer ranges of these two spectrometers.

Ab initio-optimized classical molecular dynamics (CMD) simulations of (SPC/E) water in contact with the (110) surfaces of rutile and cassiterite have been shown to be quantitatively consistent with synchrotron X-ray studies of bulk water in contact with the (110) single crystal surfaces [2,3], revealing three distinct surface structural layers (L₁-L₃), which are virtually identical in the presence or absence of a bulk liquid phase beyond L₃ [1]. From the CMD trajectories, we determined that the QENS dynamic components can be assigned to: a.) coupled rotation-translation in L₃ (fast); b.) rotation-like localized motions of water molecules in all layers (intermediate); and c.) translational jumps of strongly H-bonded L₂ water molecules (slow).

Research sponsored by the BES/Geoscience Program of the U.S. Department of Energy.

[1] Mamontov *et al.* (2007) *J. Phys. Chem. C* **111**, 4328-4341.
[2] Zhang *et al.* (2007) *Surf. Sci.* **601**, 1129-1143. [3] Vlcek *et al.* (2007) *Langmuir* **23**, 4925-4937.