**References**

Abt, D. L., Fischer, K. M., French, S. W., Ford, H. A., Yuan, H., and Romanowicz, B., 2010. North American lithospheric discontinuity structure imaged by Ps and Sp receiver functions, J. Geophys. Res. 115 (B09301), 1-24, doi:10.1029/2009JB006914.

Adams, A., Nyblade, A., Weeraratne, D., 2012. Upper mantle shear wave velocity structure beneath the East African plateau: evidence for a deep, plateau-wide low velocity anomaly, Geophys. J. Int. 189, 123–142, <https://doi.org/10.1111/j.1365-246X.2012.05373.x>.

Afonso, J. C., Ranalli, G., Fernàndez, M., Griffin, W. L., O’Reilly, S. Y. and Faul, U., 2010. On the Vp/Vs–Mg# correlation in mantle peridotites: Implications for the identification of thermal and compositional anomalies in the upper mantle. Earth Planet. Sci. Lett. 289, 606–618.

Afonso, J. C. and Schutt, D. L., 2012. The effects of polybaric partial melting on density and seismic velocities of mantle restites. Lithos 134-135, 289–303.

Audet, P., 2016. Receiver functions using OBS data: Promises and limitations from numerical modelling and examples from the Cascadia Initiative, Geophys. J. Int. 205, 1740–1755. doi:10.1093/gji/ggw111.

Auer, L., Boschi, L., Becker, T. W., Nissen-Meyer, T., Giardini, D., 2014. Savani: a variable resolution whole-mantle model of anisotropic shear-velocity variations based on multiple datasets. J. Geophys. Res. 119, 3006–3034. doi:10.1002/2013JB010773.

Auer, L., Becker, T., Boschi, L. and Schmerr, N., 2015. Thermal structure, radial anisotropy, and dynamics of oceanic boundary layers, Geophys. Res. Lett. 42, 9740-9749, doi:10.1002/2015gl066246.

Aulbach, S., Massuyeau, M., and Gaillard, F., 2017. Origins of cratonic mantle discontinuities: A view from petrology, geochemistry and thermodynamic models. Lithos 68, 364-382.

Bagley, B., and Revenaugh, J., 2008. Upper mantle seismic shear discontinuities of the Pacific. J. Geophys. Res. 113(B12).

Becker, T. W., 2017. Superweak asthenosphere in light of upper mantle seismic anisotropy, Geochem. Geophys. Geosyst., 18, 1986–2003, doi:10.1002/2017GC006886.

Beghein, C., Yuan, K. Q., Schmerr, N., Xing, Z., 2014. Changes in seismic anisotropy shed light on the nature of the Gutenberg Discontinuity, Science 343, 1237-1240, doi:10.1126/science.1246724.

Beghein, C., Xing., Z., and Goes, S., 2019. Thermal nature and resolution of the lithosphere-asthenosphere boundary under the Pacific from surface waves, Geophys. J. Int. 216, 1441–1465, doi:[10.1093/gji/ggy490](https://doi.org/10.1093/gji/ggy490).

Behn, M. D., Hirth, G., Elsenbeck, J. R., 2009. Implications of grain size evolution on the seismic structure of the oceanic upper mantle, Earth Planet. Sci. Lett. 282, 178-189, doi: 10.1016/J.Epsl.2009.03.014.

Bodin, T., Yuan, H., and Romanowicz, B., 2013. Inversion of receiver functions without deconvolution - application to the Indian craton, Geophys. J. Int. 196, 1025-1033, doi:10.1093/gji/ggt431.

Bostock, M. G., 1998. Mantle stratigraphy and evolution of the Slave Province, J. Geophys. Res., 103, 21,183-121,200.

Boyd, F. R., 1989. Compositional distinction between oceanic and cratonic lithosphere, Earth Planet. Sci. Lett. 96, 15-26.

Bruneton, M., Pedersen, H. A., Vacher, P., Kukkonen, I. T., Arndt, N. T., Funke, S., Friederich, W., and Farra, V. (2004), Layered lithospheric mantle in the central Baltic shield from surface waves and xenolith analysis, Earth Planet. Sci. Lett. 226, 41–52, doi:10.1016/j.epsl.2004.07.034.

Burgos, G., Montagner, J.-P., Beucler, E., Capdeville, Y., Mocquet, A. & Drilleau, M., 2014. Oceanic lithosphere–asthenosphere boundary from surface wave dispersion data, J. Geophys. Res. 119, 1079–1093, doi:10.1002/2013jb010528.

Calo, M., Bodin, T., and Romanowicz, B., 2016. Layered structure in the upper mantle across North America from joint inversion of long and short period seismic data, Earth Planet. Sci. Lett., 449, 164-175, doi:10.1016/j.epsl.2016.05.054.

Cammarano, F., and Guerri, M., 2017, Global thermal models of the lithosphere, Geophys. J. Int., 210, 56-72, doi: 10.1093/gji/ggx144.

Chantel, J., Manthilake, G., Andrault, D., Novella, D., Yu, T., and Wang, Y., 2016. Experimental evidence supports mantle partial melting in the asthenosphere. ScienceAdvances 2, e1600246.

Chen, C.W., Rondenay, S., Evans, R. L., and Snyder, D. B., 2009. Geophysical detection of relict metasomatism from an Archean (~3.5 Ga) subduction zone, Science 326, 1089-1091.

Chen, L., Jiang, M., Yang, J., Wei, Z., Liu, C., and Ling, Y., 2014. Presence of an intralithospheric discontinuity in the central and western North China Craton: Implications for destruction of the craton, Geology 42, 223-226, doi:10.1130/G35010.1.

Chu, R., Schmandt, B., and Helmberger, D. V., 2012. Upper mantle P velocity structure beneath the Midwestern United States derived from triplicated waveforms. Geochem., Geophys., Geosys. 13, Q0AK04, doi:10.1029/2011GC003818.

Clark, A. N., and C. E. Lesher (2017), Elastic properties of silicate melts: Implications for low velocity zones at the lithosphere-asthenosphere boundary, Science Advances 3.

Clerc, F., Behn, M. D., Parmentier, E. M., and Hirth, G. (2018). Predicting rates and distribution of carbonate melting in oceanic upper mantle: Implications for seismic structure and global carbon cycling. Geophysical Research Letters, 45, 6944–6953. https://doi.org/10.1029/2018GL078142

Connolly, J.A.D., 2009. The geodynamic equation of state: What and how, Geochem., Geophys., Geosys. 10, Q10014, doi:10.1029/2009GC002540.

Cooper, C. M. and Miller, M. S., 2014. Craton formation: Internal structure inherited from closing of the early oceans, Lithosphere 6, 35-42.

Cooper, C. M., Miller, M. S., and Moresi, L. M., 2017. The structural evolution of the deep continental lithosphere, Tectonophys. 695, 100–121.

Crosby, A. G., and McKenzie, D., 2009. An analysis of young ocean depth, gravity and global residual topography, Geophys. J. Int. 178, 1198-1219, doi:10.1111/j.1365-246X.2009.04224.x.

Crough, S., 1983. Hotspot Swells, Ann. Rev. Earth Planet. Sci. 11, 165 - 193.

Dalton, C.A., Bao, X., and Ma, Z., 2017. The thermal structure of cratonic lithosphere from global Rayleigh wave attenuation, Earth Planet. Sci. Lett. 457, 250-262.

Debayle, E., and Kennett, B. L. N., 2000. Anisotropy in the Australasian upper mantle from Love and Rayleigh waveform inversion. Earth Planet. Sci. Lett. 184, 339-351.

Debayle, E. and Ricard, Y., 2012. A global shear velocity model of the upper mantle from fundamental and higher Rayleigh mode measurements, J. Geophys. Res. 117, 1–24.

Doin, M. P., and Fleitout, L, 1996. Thermal evolution of the oceanic lithosphere: An alternative view, Earth Planet. Sci. Lett. 142, 121-136, doi: 10.1016/0012-821x(96)00082-9.

Dziewonski, A. M., and Anderson, D. L., 1981. Preliminary reference Earth model, Phys. Earth Planet. Int. 25, 297-356.

Eaton, D. W., Darbyshire, F., Evans, R. L., Grutter, H., Jones, A. G., and Yuan, X., 2009. The elusive lithosphere–asthenosphere boundary (LAB) beneath cratons. Lithos 109, 1–22.

Eeken, T., Goes, S.. Pedersen, H. A., Arndt, N.T., and Bouilhol, P, 2018. Seismic evidence for depth-dependent metasomatism in cratons, Earth Planet. Sci. Lett. 491, 148-159.

Eilon, Z., Fischer, K. M., and Dalton, C. A., 2018. An adaptive Bayesian inversion for upper-mantle structure using surface waves and scattered body waves. Geophys. J. Int. 214, 232-253.

Ekström, G. (2011). A global model of Love and Rayleigh surface wave dispersion and anisotropy, 25-250 s. Geophys. J. Int. 187, 1668-1686.

Fischer, K. M., Ford, H. A., Abt, D. L., and Rychert, C. A., 2010. The lithosphere-asthenosphere boundary, Ann. Rev. Earth Planet. Sci. 38, 551-575, doi:10.1146/annurev-earth-040809-152438.

Fischer, K. M., Crust and Lithospheric Structure - Seismological Constraints on the Lithosphere-Asthenosphere Boundary, 2015. In: Gerald Schubert (editor-in-chief) Treatise on Geophysics, 2nd edition, Oxford: Elsevier, pp. 587-612, [doi:10.1016/B978-0-444-53802-4.00026-9](http://dx.doi.org/10.1016/B978-0-444-53802-4.00026-9).

Ford, H. A., Fischer, K. M., Abt, D. L., Rychert, C. A., Elkins-Tanton, L. T., 2010. The lithosphere-asthenosphere boundary and cratonic lithospheric layering beneath Australia from Sp wave imaging, Earth Planet. Sci Lett. 300, 299-310, doi:10.1016/j.epsl.2010.10.007.

Ford, H. S., Fischer, K. M., and Lekic, V., 2014. Localized shear in the deep lithosphere beneath the San Andreas fault system, Geology 42, 295-298, doi:10.1130/G35128.1.

Ford, H. A., Long, M. D., and Wirth, E. A., 2016. Mid-lithospheric discontinuities and complex anisotropic layering in the mantle lithosphere beneath the Wyoming and Superior Provinces, J. Geophys. Res. 121, 6675-6697.

Foster, A., Nettles, M., and Ekström, G.. 2014a. Overtone interference in array‐based Love‐wave phase measurements. Bull. Seism. Soc. Am. 104, 2266-2277.

Foster, K., Dueker, K., Schmandt, B., and Yuan, H., 2014b. A sharp cratonic lithosphere-asthenosphere boundary beneath the American Midwest and its relation to mantle flow, Earth Planet. Sci. Lett. 402, 82-89, doi:10.1016/j.epsl.2013.11.018.

French, S. W., Lekic, V., and Romanowicz, B., 2013. Waveform Tomography Reveals Channeled Flow at the Base of the Oceanic Asthenosphere, *Science*, *342*(6155), 227-230, doi:10.1126/science.1241514.

French, S. W., and Romanowicz, B. A., 2014. Whole-mantle radially anisotropic shear velocity structure from spectral-element waveform tomography, Geophys. J. Int., 199, 1303-1327, doi:10.1093/gji/ggu334.

Furumura, T., Kennett, B.L.N., 2005. Subduction zone guided waves and the heterogeneity structure of the subducted plate: Intensity anomalies in northern Japan. J. Geophys. Res. 110.

Gaherty, J. B., Jordan, T. H., and Gee, L. S., 1996. Seismic structure of the upper mantle in a central Pacific corridor, J. Geophys. Res. 101, 22291-22309.

Garber, J. M., Maurya, S., Hernandez, J.-A., Duncan, M. S., Zeng, L., Zhang, H. L., Faul, U., McCammon, C., Montagner, J.-P., Moresi, L., Romanowicz, B. A., Rudnick, R. L. and Stixrude, L., 2018. Multidisciplinary constraints on the abundance of diamond and eclogite in the cratonic lithosphere, Geochem., Geophys., Geosys. 19, 2062–2086.

Geissler, W. H., F. Sodoudi, and R. Kind, 2010. Thickness of the central and eastern European lithosphere as seen by S receiver functions, Geophys. J. Int. 181, 604-634, doi:10.1111/j.1365-246X.2010.04548.x.

Godfrey, K. E., Dalton, C. A., and Ritsema, J., 2017. Seafloor age dependence of Rayleigh wave phase velocities in the Indian Ocean, Geochem., Geophys., Geosys.18, 1926-1942, doi:10.1002/2017GC006824.

Goes, S., Armitage, J., Harmon, N., Smith, H., and Huismans, R., 2012. Low seismic velocities below mid‐ocean ridges: Attenuation versus melt retention. J. Geophys. Res. 117.

Gung, Y., Panning, M., and Romanowicz, B., 2003. Global anisotropy and the thickness of continents, Nature 422, 707-710.

Griffin, W. L., O’Reilly, S. Y., and Ryan, C. G., 1999. The composition and origin of subcontinental lithospheric mantle, Geochem. Soc. Spec. Publ., 6, 13–45.

Gripp, A. E., and Gordon, R. G., 2002. Young tracks of hotspots and current plate velocities. Geophys. J. Int. 150, 321-361.

Hacker, B. R., Abers, G. A., and Peacock, S. M., 2003. Subduction factory 1. Theoretical mineralogy, densities, seismic wave speeds, and H2O contents. J. Geophys. Res. 108.

Hammond, W. C., and E. D. Humphreys, 2000. Upper mantle seismic wave velocity: Effects of realistic partial melt geometries, J. Geophys. Res. 105, 10975-10986.

Hannemann, K., Kruger, F., Dahm, T., and Lange, D., 2017. Structure of the oceanic lithosphere and upper mantle north of the Gloria Fault in the eastern mid‐Atlantic by receiver function analysis, J. Geophys. Res. 122, 7927–7950, doi:10.1002/2016jb013582.

Hansen, S. E., Nyblade, A. A., and Julia, J., 2009. Estimates of crustal and lithospheric thickness in sub-saharan Africa from S-wave receiver functions, South African J. Geol. 112, 229-240, doi:10.2113/gssajg.112.3-4.229.

Hansen, S. M., Dueker, K. G., Stachnik, J. C., Aster, R. C., and Karlstrom, K. E., 2013. A rootless rockies: Support and lithospheric structure of the Colorado Rocky Mountains inferred from CREST and TA seismic data, Geochem. Geophys. Geosys. 14, 2670-2695, doi:10.1002/ggge.20143.

Hansen, S. M., Dueker, K., and Schmandt, B., 2015. Thermal classification of lithospheric discontinuities beneath USArray, Earth Planet. Sci. Lett. 431, doi:10.1016/j.epsl.2015.09.009.

Harmon, N., Forsyth, D. W., and Weeraratne, D. S., 2009. Thickening of young Pacific lithosphere from high-resolution Rayleigh wave tomography: A test of the conductive cooling model. Earth Planet. Sci. Lett. 278, 96-106

Harmon, N. Rychert, C A, Kendall, J M, Agius, M, Bogiatzis, P. , Tharimena, S., Evolution of the oceanic Lithosphere in the equatorial Atlantic from Rayleigh Wave tomography, evidence for small-scale convection from the PI-LAB experiment, Geochem. Geophys. Geosys., doi:10.1029/2020GC009174

Hasterok, D., 2013a. Global patterns and vigor of ventilated hydrothermal circulation through young seafloor, Earth Planet. Sci. Lett. 380, 12-20, doi:10.1016/j.epsl.2013.08.016.

Hasterok, D., 2013b. A heat flow based cooling model for tectonic plates. Earth Planet. Sci. Lett. 361, 34-43.

Heit, B., Sodoudi, F., Yuan, X., Bianchi, M., Kind, R., 2007. An S receiver function analysis of the lithospheric structure in South America. Geophys. Res. Lett. 34.

Hieronymus, C. F., and Goes, S., 2010. Complex cratonic seismic structure from thermal models of the lithosphere: Effects of variations in deep radiogenic heating, Geophys. J. Int. 180, 999–1012, doi:10.111/j.1365-246X.2009.04478.x.

Hirsch, A. C., Dalton, C. A., and Ritsema, J., 2015. Constraints on shear velocity in the cratonic upper mantle from Rayleigh wave phase velocity, Geochem. Geophys. Geosys. 16, doi:10.1002/2015GC006066.

Hirschmann, M. M., 2010. Partial melt in the oceanic low velocity zone. Phys. Earth Planet. Int. 179, 60-71.

Hirth, G., and Kohlstedt, D. L., 1995. Experimental constraints on the dynamics of the partially molten upper-mantle. 2. Deformation in the dislocation creep regime, J. Geophys. Res. 100, 15441-15449.

Hirth, G., and Kohlstedt, D. L., 1996. Water in the oceanic upper mantle: implications for rheology, melt extraction and the evolution of the lithosphere. Earth Planet. Sci. Lett. 144, 93-108.

Hopper, E., Ford, H. A., Fischer, K. M., Lekic, V., and Fouch, M. J., 2014. The lithosphere-asthenosphere boundary and the tectonic and magmatic history of the northwestern United States, Earth. Planet. Sci. Lett. 402, 69-81, doi: 10.1016/j.epsl.2013.12.016.

Hopper, E., and Fischer, K. M., 2015. The meaning of mid-lithospheric discontinuities: A case study in the northern U.S. craton, Geochem. Geophys. Geosyst.16, 4057–4083, doi: 10.1002/2015GC006030.

Hopper, E., and Fischer, K. M., 2018. The changing face of the lithosphere‐asthenosphere boundary: Imaging continental scale patterns in upper mantle structure across the contiguous US with Sp converted waves, Geochem. Geophys. Geosyst. 19, 2593-2614.

Hu, J., Liu, L., Faccenda, M., Zhou, Q., Fischer, K. M., Marshak, S., and Lundstrom, C., 2018. Modification of the Western Gondwana craton by plume–lithosphere interaction. Nature Geoscience, 11, 203-210.

Hua, J., Fischer, K. M., and Savage, M. K., 2018. The lithosphere–asthenosphere boundary beneath the South Island of New Zealand. Earth. Planet. Sci. Lett. 484, 92-102.

Jackson, I., and Faul, U. H., 2010. Grainsize-sensitive viscoelastic relaxation in olivine: Towards a robust laboratory-based model for seismological application. Phys. Earth Planet. Int. 183, 151-163.

Jackson, I., Faul, U. H., Fitz Gerald, J. D., and Morris, S. J. S., 2006. Contrasting viscoelastic behavior of melt-free and melt-bearing olivine: Implications for the nature of grain-boundary sliding, Materials Science and Engineering: Structural Materials Properties Microstructure and Processing 442, 170-174, doi:10.1016/J.Msea.2006.01.136.

James, E. K., Dalton, C. A., and Gaherty, J. B., 2014. Rayleigh wave phase velocities in the Atlantic upper mantle, Geochem. Geophys. Geosyst. 15, 4305-4324. doi:10.1002/2014GC005518.

Jordan, T. H., 1978. Composition and development of the continental tectosphere, Nature 274, 544-548.

Jordan, T. H., and Paulson, E. M., 2013. Convergence depths of tectonic regions from an ensemble of global tomographic models, J. Geophys. Res. 118, 4196–4225, doi:10.1002/jgrb.50263.

Karato, S. I., and Jung, H., 1998. Water, partial melting and the origin of the seismic low velocity and high attenuation zone in the upper mantle. Earth. Planet. Sci. Lett. 157, 193-207.

Karato, S. I., 2012. On the origin of the asthenosphere. Earth. Planet. Sci. Lett. 321, 95-103.

Karato, S. I., Olugboji, T., and Park, J., 2015. Mechanisms and geologic significance of the mid-lithosphere discontinuity in the continents. Nature Geo. 8, 509-514.

Karato, S.-I., and Park, J., 2019. On the origin of the upper mantle seismic discontinuities, In Lithospheric Discontinuities, In Lithospheric Discontinuities, ed. Yuan, H., and Romanowicz, B.A., AGU Geophysical Monograph 239, 5-34.<https://doi.org/10.1002/9781119249740.ch8>.

Kawakatsu, H., Kumar, P., Takei, Y., Shinohara, M., Kanazawa, T., Araki, E., and Suyehiro, K., 2009., Seismic evidence for sharp lithosphere-asthenosphere boundaries of oceanic plates, Science 324, 499-502.

Kennett, B. L. N., 2015. Lithosphere–asthenosphere P-wave reflectivity across Australia. Earth. Planet. Sci. Lett. 431, 225-235.

Kennett, B. L., Engdahl, E. R., and Buland, R., 1995. Constraints on seismic velocities in the Earth from traveltimes, Geophys. J. Int. 122, 108-124.

Kennett, B. L. N., Yoshizawa, K., and Furumura, T., 2017. Interactions of multi-scale heterogeneity in the lithosphere: Australia, Tectonophys. 717, 193-213.

Kind, R., Yuan, X., Kumar, P., 2012. Seismic receiver functions and the lithosphere–asthenosphere boundary, Tectonophys. 536-537, 25–43.

Kind, R., Sodoudi, F., Yuan, X., Shomali, H., Roberts, R., Gee, D., Eken, T., Bianchi, M., Tilmann, F., Balling, N., Jacobsen, B. H., Kumar, P., and Geissler, W. H., 2013. Scandinavia: A former Tibet, Geochem. Geophys. Geosyst. 14, 4479-4487, doi:10.1002/ggge.20251.

Kind, R., Handy, M. R., Yuan, X., Meier, T., Kampf, H., and Soomro, R., 2017. Detection of a new sub-lithospheric discontinuity in Central Europe with S-receiver functions, Tectonophys. 700-701, 19-31, doi:10.1016/j.tecto.2017.02.002.

Kind, R., and Yuan, X., 2019. Perspectives of the S-receiver-function-method to image lithospheric discontinuities, In Lithospheric Discontinuities, ed. Yuan, H., and Romanowicz, B.A., AGU Geophysical Monograph 239, 139-154, doi: [10.1002/9781119249740.ch8](https://doi.org/10.1002/9781119249740.ch8).

Knapmeyer-Endrun, B., Kruger, F., Geissler, W. H., and PASSEQ Working Group, 2017. Upper mantle structure across the Trans-European Suture Zone imaged by S-receiver functions, Earth Planet. Sci. Lett. 458, 429–441.

Korenaga, T., and Korenaga, J., 2008. Subsidence of normal oceanic lithosphere, apparent thermal expansivity, and seafloor flattening, Earth Planet. Sci. Lett. 268, 41-51, doi: 10.1016/J.Epsl.2007.12.022.

Kumar, P., and Kawakatsu, H., 2011. Imaging the seismic lithosphere‐asthenosphere boundary of the oceanic plate. Geochem. Geophys. Geosyst. 12.

Kumar, P., Yuan, X., Kumar, M. R., Kind, R., Li, X., and Chadha, R. K., 2007. The rapid drift of the Indian tectonic plate, Nature 449, 894-897, doi:10.1038/nature06214.

Kumar, P., Kind, R., Yuan, X., and Mechie, J., 2012. USArray receiver function images of the lithosphere–asthenosphere boundary. Seism. Res. Lett. 83, 486–491.

Kustowski, B., Ekstrom, G., and Dziewonski, A. M., 2008. Anisotropic shear-wave velocity structure of the Earth’s mantle: A global model, J. Geophys. Res. 113, 1–23.

Laske, G., Masters, G., Ma, Z., and Pasyanos, M., 2013. Update on CRUST1.0 - A 1-degree global model of Earth's crust, in EGU Gen. Assem. 2013, 15, 2658.

Lebedev, S. and van der Hilst, R. D., 2008. Global upper-mantle tomography with the automated multimode inversion of surface and S-wave forms, Geophys. J. Int. 173, 505–518.

Lebedev, S., Boonen, J., and Trampert, J., 2009. Seismic structure of Precambrian lithosphere: New constraints from broad-band surface wave dispersion, Lithos 109, 96–111, doi:10.1016/j.lithos.2008.06.010.

Lee C.-T. A., 2006. Geochemical/petrologic constraints on the origin of cratonic mantle. In Archean Geodynamics and Environments, ed. Benn, K., Mareschal, J.-C., Condie, K. C., AGU Geophysical Monograph, 164, 89–114.

Lee, C.-T. A., Luffi, P., and Chin, E. J., 2011. Building and destroying continental mantle, Ann. Rev. Earth Planet. Sci. 39, 59–90, doi: 10.1146/annurev-earth-040610-133505.

Lekic, V., and Romanowicz, B., 2011. Inferring upper-mantle structure by full waveform tomography with the spectral element method, Geophys. J. Int. 185, 799–831.

Lekic, V., French, S. W., and Fischer, K. M., 2011. Lithospheric thinning beneath rifted regions of Southern California, Science 334, 783-787, 10.1126/science.1208898.

Lekic, V., and Fischer, K. M., 2014. Contrasting lithospheric signatures across the western United States revealed by Sp receiver functions, Earth. Planet. Sci. Lett. 402, 90-98, doi: 10.1016/j.epsl.2013.11.026.

Levander, A., and Miller, M. S., 2012. Evolutionary aspects of lithosphere discontinuity structure in the western U.S., Geochem. Geophys. Geosyst. 13, Q0AK07, doi:10.1029/2012GC004056.

Levin, V., and Park, J., 1997. P-SH conversions in a flat-layered medium with anisotropy of arbitrary orientation. Geophys. J. Int. 131, 253-266.

Ligorria, J. P., and Ammon, C. J., 1999. Iterative deconvolution and receiver-function estimation. Bull. Seism. Soc. Am. 89, 1395-1400.

Lin, P., Gaherty, J. B., Jin, G., Collins, J., Lizarralde, D., Evans, R. L., and Hirth, G. (2016), High‐resolution seismic constraints on flow dynamics in the ocean asthenosphere, Nature 535, 538–541. doi:10.1038/nature18012.

Liu, L., Morgan, J. P., Xu, Y., & Menzies, M. (2018). Craton destruction 1: Cratonic keel delamination along a weak midlithospheric discontinuity layer. J. Geophys. Res. 123, 10-040.

Ma, Z., and Dalton, C. A., 2019. Evidence for dehydration-modulated small-scale convection in the oceanic upper mantle from seafloor bathymetry and Rayleigh wave phase velocity, Earth. Planet. Sci. Lett. 510, doi.org/10.1016/j.epsl.2018.12.030.

Ma, Z., Dalton, C. A., Russell, J. B., Gaherty, J. B., Hirth, G., and Forsyth, D. W., 2020. Shear attenuation and anelastic mechanisms in the central Pacific upper mantle. Earth. Planet. Sci. Lett. 536, 116148.

Maggi, A., Debayle, E., Priestley, K., and Barruol, G., 2006. Multimode surface waveform tomography of the Paciﬁc Ocean: a closer look at the lithospheric cooling signature, Geophys. J. Int. 166, 1384–1397, doi:10.1111/j.1365-246x.2006.03037.x.

Mareschal, J. C., and Jaupart, C., 2004. Variations of surface heat flow and lithospheric thermal structure beneath the North American craton, Earth Planet. Sci. Lett. 223, 65-77.

Mancinelli, N. J., K. M. Fischer, C. A. Dalton, 2017. How sharp is the cratonic lithosphere-asthenosphere transition?, Geophys. Res. Lett. 44, 10-189.

Masters, G., Barmine, M.P., and Kientz, S., 2007. Mineos user’s manual, in Computational Infrastructure for Geodynamics, California Institute of Technology.

Mehouachi, F., and Singh, S., 2018. Water-rich sublithospheric melt channel in the equatorial Atlantic Ocean, Nat. Geosci. 11, 65-69, doi:doi:10.1038/s41561-017-0034-z.

Miller, M. S., and Eaton, D. W., 2010. Formation of cratonic mantle keels by arc accretion: Evidence from S receiver functions, Geophys. Res. Lett. 37, 1-5, doi:10.1029/2010GL044366.

Miller, M. S., O'Driscoll, L. J., Butcher, A. J., Thomas, C., 2015. Imaging Canary Island hotspot material beneath the lithosphere of Morocco and southern Spain. Earth Planet. Sci. Lett. 431, 186-194.

Montagner, J. P., 2002. Upper mantle low anisotropy channels below the Pacific Plate. Earth Planet. Sci. Lett. 202, 263-274.

Morgan, J. P., Parmentier, E. M., and Lin, J., 1987. Mechanisms for the origin of midocean ridge axial topography - Implications for the thermal and mechanical structure of accreting plate boundaries, J. Geophys. Res. 92, 12823-12836, doi:10.1029/JB092iB12p12823.

Nettles, M. and Dziewonski, A., 2008. Radially anisotropic shear velocity structure of the upper mantle globally and beneath North America, J. Geophys. Res. 113, B2, doi:[10.1029/2006JB004819](https://doi.org/10.1029/2006JB004819).

Nishimura, C. E., and Forsyth, D. W., 1989. The Anisotropic Structure of the Upper Mantle in the Pacific, Geophys. J. I. 96, 203-229.

O'Driscoll, L. J., and Miller, M. S., 2015. Lithospheric discontinuity structure in Alaska, thickness variations determined by Sp receiver functions. Tectonics 34, 694-714.

Ohira, A., Kodaira, S., Nakamura, Y., Fujie, G., Arai, R., and Miura, S., 2017. Evidence for frozen melts in the mid-lithosphere detected from active-source seismic data. Scientific Reports 7, 15770.

Olugboji, T. M., Karato, S. I., and Park, J., 2013. Structures of the oceanic lithosphere‐asthenosphere boundary: Mineral‐physics modeling and seismological signatures. Geochem. Geophys. Geosyst. 14, 880-901.

Olugboji, T. M., Park, J., Karato, S. I., & Shinohara, M. (2016). Nature of the seismic lithosphere‐asthenosphere boundary within normal oceanic mantle from high‐resolution receiver functions. Geochem. Geophys. Geosyst. 17, 1265-1282.

Panning, M. P., Lekic, V., and Romanowicz, B. A., 2010. Importance of crustal corrections in the development of a new global model of radial anisotropy, J. Geophys. Res., 115, B12325.

Parsons, B., and Sclater, J. G., 1977. Analysis of variation of ocean-floor bathymetry and heat-flow with age, J. Geophys. Res. 82, 803-827.

Pearson, D. G., Carlson, R. W., Shirey, S. B., Boyd, F. R., and Nixon, P. H., 1995. Stabilization of Archean lithospheric mantle: a Re-Os isotope study of peridotite xenoliths from the Kaapvaal craton, Earth Planet. Sci. Lett. 134, 341–357.

Pedersen, H. A., Fishwick, S., and Snyder, D. B., 2009. A comparison of cratonic roots through consistent analysis of seismic surface waves, Lithos 109, 81–95, doi:10.1016/j.lithos.2008.09.016.

Perry, H. K. C., Forte, A. M., and Eaton, D. W. S., 2003. Upper-mantle thermochemical structure belowNorth America from seismic-geodynamic flow models, Geophys. J. Int. 154, 279-299.

Plank, T., and Forsyth, D. W., 2016. Thermal structure and melting conditions in the mantle beneath the Basin and Range province from seismology and petrology, Geochem. Geophys. Geosyst. 17, doi:10.1002/2015GC006205.

Pollack H. N., Hurter, S. J., and Johnson, J. R., 1993. Heat flow from the Earth’s interior: Analysis of the global data set, Rev. Geophys. 31, 267–280.

Pollitz, F. F., and Mooney, W. D., 2016. Seismic velocity structure of the crust and shallow mantle of the Central and Eastern United States by seismic surface wave imaging. Geophys. Res. Lett. 43, 118-126.

Porritt, R. W., Allen, R. M., and Pollitz, F. F., 2014. Seismic imaging east of the Rocky Mountains with USArray, Earth Planet. Sci. Lett. 402, 16–25, doi:10.1016/j.epsl.2013.10.034.

Porritt, R. W., Miller M. S.,, and Darbyshire, F. A., 2015. Lithospheric architecture beneath Hudson Bay, Geochem. Geophys. Geosys. 16, 2262-2275.

Porter, R., Zandt, G., and McQuarrie, N., 2011. Pervasive lower-crustal seismic anisotropy in Southern California: Evidence for underplated schists and active tectonics. Lithosphere 3, 201-220.

Priestley, K., and McKenzie, D., 2006. The thermal structure of the lithosphere from shear wave velocities, Earth Planet. Sci. Lett. 244, 285-301, doi:10.1016/J.Epsl.2006.01.008.

Priestley, K., and McKenzie, D., 2013. The relationship between shear wave velocity, temperature, attenuation and viscosity in the shallow part of the mantle. Earth Planet. Sci. Lett. 381, 78-91.

Rader, E., Emry, E., Schmerr, N., Frost, D., Cheng, C., Menard, J., Yu, C.Q. and Geist, D., 2015. Characterization and petrological constraints of the midlithospheric discontinuity. Geochem., Geophys., Geosys. 16, 3484-3504.

Reeves, Z., Lekić, V., Schmerr, N., Kohler, M., and Weeraratne, D., 2015. Lithospheric structure across the California Continental Borderland from receiver functions. Geochem., Geophys., Geosys. 16, 246-266.

Revenaugh, J., and Jordan, T. H., 1991. Mantle layering from ScS reverberations: 3. The upper mantle. J. Geophys. Res. 96, 19781-19810.

Richardson, S. H., Gurney, J. J., Erlank, A. J., and Harris, J. W., 1984. Origin of diamonds in old enriched mantle. Nature 310, 198–202.

Richter, F. M., 1973. Convection and large-scale circulation of mantle, J. Geophys. Res. 78, 8735-8745.

Ritsema, J., Deuss, A., van Heijst, H. J., and Woodhouse, J. H., 2011. S40RTS: A degree-40 shear velocity model for the mantle from new Rayleigh wave dispersion, teleseismic traveltime and normal-mode splitting function measurements, Geophys. J. Int. 184, 1223–1236.

Ritzwoller, M. H., Shapiro, N. M., and Zhong, S. J., 2004. Cooling history of the Pacific lithosphere, Earth Planet. Sci. Lett. 226, 69-84, doi:10.1016/J.Epsl.2004.07.032.

Rudnick, R. L., and Nyblade, A. A., 1999. The thickness and heat production of Archean lithosphere: constraints from xenolith thermobarometry and surface heat flow, in Mantle Petrology: Field Observations and High Pressure Experimentation: A Tribute to Francis R. (Joe) Boyd, ed. Fei, Y., Bertka, C. M. and Mysen, B. O., pp. 3-12, The Geochemical Society, St. Louis, MO.

Russell, J.B., Gaherty, J.B., Lin, P.Y.P., Lizarralde, D., Collins, J.A., Hirth, G. and Evans, R.L., 2019. High‐resolution constraints on Pacific upper mantle petrofabric inferred from surface‐wave anisotropy, J. Geophys. Res. 124, 631-657, doi:10.1029/2018JB016598.

Rychert, C. A., Fischer, K. M., and Rondenay, S., 2005. A sharp lithosphere-asthenosphere boundary imaged beneath eastern North America, Nature 436, 542-545, doi:10.1038/nature03904.

Rychert, C. A., and Shearer, P. M., 2009. A global view of the lithosphere-asthenosphere boundary, Science 324, 495-498, doi:10.1126/science.1169754.

Rychert, C. A., and Shearer, P. M., 2011. Imaging the lithosphere‐asthenosphere boundary beneath the Pacific using SS waveform modeling. J. Geophys Res. 116.

Rychert, C. A., Shearer, P. M., Fischer, K. M., 2010. Scattered wave imaging of the lithosphere-asthenosphere boundary, Lithos 120, 173–185, doi:10.1016/j.lithos.2009.12.006.

Rychert, C.A., Hammond, J.O., Harmon, N., Kendall, J.M., Keir, D., Ebinger, C., Bastow, I.D., Ayele, A., Belachew, M. and Stuart, G., 2012. Volcanism in the Afar Rift sustained by decompression melting with minimal plume influence. Nature Geo. 5, 406-409, doi:10.1038/NGEO1455.

Rychert, C. A., and Harmon, N., 2017. Constraints on the anisotropic contributions to velocity discontinuities at ∼60 km depth beneath the Pacific. Geochem., Geophys., Geosys. 18, 2855-2871.

Rychert, C. A., and Harmon, N., 2018. Predictions and observations for the oceanic lithosphere from S-to-P receiver functions and SS precursors, Geophys. Res. Lett. 45, 5398-5406, doi:10.1029/2018gl077675.

Rychert, C. A., Harmon, N., and Tharimena, S., 2018a. Seismic Imaging of the base of the ocean plates. In Lithospheric Discontinuities, ed. Yuan, H., and Romanowicz, B.A., AGU Geophysical Monograph 239, 71-87. [doi: 10.1002/9781119249740.ch8](https://doi.org/10.1002/9781119249740.ch8).

Rychert, C. A., Harmon, N., and Tharimena, S., 2018b. Scattered wave imaging of the oceanic plate in Cascadia, Science Advances 4, eaao1908, doi:10.1126/sciadv.aao1908.

Rychert, C. A., et al., 2019. [A dynamic lithosphere-asthenosphere boundary dictated by variations in melt generation and migration: Results from the PI-LAB Experiment in the Equatorial Mid Atlantic](https://agu.confex.com/agu/fm19/meetingapp.cgi/Day/Paper/509936), Abstract T41B-02, presented at the AGU Fall Meeting, San Francisco, 9-13 Dec., 2019.

Saha, S., Dasgupta, R., and Tsuno, K., 2018. High pressure phase relations of a depleted peridotite fluxed by CO2‐H2O‐bearing siliceous melts and the origin of mid‐lithospheric discontinuity. Geochem., Geophys., Geosys. 19, 595-620.

Sakamaki, T., Suzuki, A., Ohtani, E., Terasaki, H., Urakawa, S., Katayama, Y., Funakoshi, K.I., Wang, Y., Hernlund, J.W. and Ballmer, M.D., 2013. Ponded melt at the boundary between the lithosphere and asthenosphere, Nature Geo. 6, 1041-1044, doi:10.1038/Ngeo1982.

Savage, B., and Silver, P. G., 2008. Evidence for a compositional boundary within the lithospheric mantle beneath the Kalahari craton from S receiver functions. Earth Planet. Sci. Lett. 272, 600-609.

Schaeffer, A. J., and Lebedev, S., 2013. Global shear speed structure of the upper mantle and transition zone, Geophys. J. Int. 194, 417–449.

Schaeffer, A. J., and Lebedev, S., 2014. Imaging the North American continent using waveform inversion of global and USArray, Earth Planet. Sci. Lett. 402, doi: 10.1016/j.epsl.2014.05.014.

Schaeffer, A. J., and Lebedev, S., 2015. Global heterogeneity of the lithosphere and underlying mantle: a seismological appraisal based on multimode surface-wave dispersion analysis, shear-velocity tomography, and tectonic regionalization, in The Earth's Heterogeneous Mantle, Springer International Publishing, pp. 3-46.

Schmandt, B., Lin, F.-C., and Karlstrom, K. E., 2015. Distinct crustal isostasy trends east and west of the Rocky Mountain Front, Geophys. Res. Lett. 42, doi:10.1002/2015GL066593.

Schmerr, N., 2012. The Gutenberg Discontinuity: Melt at the lithosphere-asthenosphere boundary, Science 335, 1480-1483.

Schulte-Pelkum, V., and Mahan, K. H., 2014. A method for mapping crustal deformation and anisotropy with receiver functions and first results from USArray, Earth Planet. Sci. Lett. 402, 221-233.

Schutt, D. L., and Lesher, C. E., 2006. Effects of melt depletion on the density and seismic velocity of garnet and spinel lherzolite, J. Geophys. Res. 111, B05401, doi:10.1029/2003JB002950.

Selway, K., Ford, H., and Kelemen, P., 2015.. The seismic mid-lithosphere discontinuity. Earth Planet. Sci. Lett. 414, 45-57.

Selway, K., 2019. Electrical discontinuities in the continental lithosphere imaged with magnetotellurics, In Lithospheric Discontinuities, ed. Yuan, H., and Romanowicz, B.A., AGU Geophysical Monograph 239, 89-110.<https://doi.org/10.1002/9781119249740.ch8>.

Shapiro, S. S., Hager, B. H., and Jordan, T. H., 1999. The continental tectosphere and Earth's long-wavelength gravity field, Lithos 48, 135-152.

Shapiro, N. M. and Ritzwoller, M. H., 2002. Monte-Carlo inversion for a global shear-velocity model of the crust and upper mantle, Geophys. J. Int. 151, 88–105.

Shearer, P. M., and Buehler, J., 2019. Imaging upper‐mantle structure under USArray using long‐period reflection seismology. J. Geophys. Res. 124, 9638-9652.

Shen, W., and Ritzwoller, M. H., 2016. Crustal and uppermost mantle structure beneath the United States, J. Geophys. Res. 121, 4306–4342, doi:10.1002/2016JB012887.

Shito, A., Suetsugu, D., Furumura, T., Sugioka, H., and Ito, A., 2013. Small-scale heterogeneities in the oceanic lithosphere inferred from guided waves. Geophys. Res. Lett. 40, 1708-1712.

Sim, S. J., Spiegelman, M., Stegman, D. R., and Wilson, C., 2020. The influence of spreading rate and permeability on melt focusing beneath mid-ocean ridges. *Physics of the Earth and Planetary Interiors*, 106486.

Simmons, N. A., Forte, A. M., Boschi, L., and Grand, S. P., 2010. GyPSuM: a joint tomographic model of mantle density and seismic wave speeds. J. Geophys. Res. 115, B12310. doi:10.1029/2010JB007631.

Sleep, N. H., 2005. Evolution of the continental lithosphere, Annu. Rev. Earth Planet. Sci. 33, 369-393.

Snyder, D. B., Humphreys, E., & Pearson, D. G., 2017. Construction and destruction of some North American cratons. Tectonophys. 694, 464-485.

Sodoudi, F., Yuan, X., Kind, R., Lebedev, S., Adam, J. M. C., Kastle, E., and Tilmann, F., 2013. Seismic evidence for stratification in composition and anisotropic fabric within the thick lithosphere of Kalahari Craton, Geochem., Geophys. Geosys., 14, 5393-5412, doi:10.1002/2013GC004955.

Stein, C. A., and Stein, S., 1992. A model for the global variation in oceanic depth and heat-flow with lithospheric age, Nature 359, 123-129.

Steinberger, B., and Becker, T. W., 2018. A comparison of lithospheric thickness models. Tectonophysics 746, 325-338, [doi: 10.1016/j.tecto.2016.08.001](https://doi.org/10.1016/j.tecto.2016.08.001).

Stern, T.A., Henrys, S.A., Okaya, D., Louie, J.N., Savage, M.K., Lamb, S., Sato, H., Sutherland, R. and Iwasaki, T., 2015. A seismic reflection image for the base of a tectonic plate. Nature 518, 85-88, doi:10.1038/nature14146.

Stixrude, L. and Lithgow-Bertelloni, C., 2011. Thermodynamics of mantle minerals – II. Phase equilibria. Geophys. J. Int. 184, 1180–1213, doi: 10.1111/j.1365-246X.2010.04890.x

Sun, D., Miller, M.S., Piana Agostinetti, N., Asimow, P.D., Li, D., 2014. High frequency seismic waves and slab structures beneath Italy. Earth Planet. Sci. Lett. 391, 212-223.

Sun, W., and Kennett, B.L.N., 2017. Mid-lithosphere discontinuities beneath the western and central North China Craton, Geophys. Res. Lett. 44, 1302–1310, doi:10.1002/2016GL071840.

Takei, Y., and Holtzman, B. K., 2009. Viscous constitutive relations of solid‐liquid composites in terms of grain boundary contiguity: 1. Grain boundary diffusion control model. J. Geophys. Res. 114.

Takeo, A., Nishida, K., Isse, T., Kawakatsu, H., Shiobara, H., Sugioka, H., and Kanazawa, T., 2013. Radially anisotropic structure beneath the Shikoku Basin from broadband surface wave analysis of ocean bottom seismometer records, J. Geophys. Res. 118, 2878–2892. doi:10.1002/jgrb.50219.

Tan, Y., and Helmberger, D. V., 2007. Trans‐Pacific upper mantle shear velocity structure, J. Geophys. Res. 112.

Tharimena, S., Rychert, C., Harmon, N., and White, P., 2017a. Imaging Pacific lithosphere seismic discontinuities—Insights from SS precursor modeling. J. Geophys. Res. 122, 2131-2152.

Tharimena, S., Rychert, C., and Harmon, N., 2017b. A unified continental thickness from seismology and diamonds suggests a melt-defined plate. Science 357, 580-583.

Thybo, H., and Perchuc, E., 1997. The seismic 8˚ discontinuity and partial melting in the continental mantle, Science 275, 1626-1629.

Tonegawa, T., and Helffrich, G., 2012. Basal reflector under the Philippine Sea plate. Geophys. J. Int. 189, 659-668.

Turcotte, D., and Oxburgh, E. R., 1967. Finite amplitude convective cells and continental drift, J. Fluid Mech. 28, 29-42.

Wagner, L.S., Fischer, K.M., Hawman, R., Hopper, E. and Howell, D., 2018. The relative roles of inheritance and long-term passive margin lithospheric evolution on the modern structure and tectonic activity in the southeastern United States. Geosphere 14, 1385-1410.

Weeraratne, D. S., Forsyth, D. W., K. M. Fischer, and Nyblade, A. A., 2003. Evidence for an upper mantle plume beneath the Tanzanian craton from Rayleigh wave tomography, J. Geophys. Res. 108, 2427, doi:10.1029/2002JB002273.

Wirth, E. A., and Long, M. D., 2014. A contrast in anisotropy across mid-lithospheric discontinuities beneath the central United States—A relic of craton formation. Geology 42, 851-854.

Wittlinger, G., and Farra, V., 2007. Converted waves reveal a thick and layered tectosphere beneath the Kalahari super-craton, Earth Planet. Sci. Lett. 254, 404–415, doi:10.1016/j.epsl.2006.11.048.

Wölbern, I., Rumpker, G., Link, K., and Sodoudi, F., 2012. Melt infiltration of the lower lithosphere beneath the Tanzania craton and the Albertine rift inferred from S receiver functions, Geochem., Geophys. Geosys. 13, 1-20, doi:10.1029/2012GC004167.

Wu, F. Y., Yang, J. H., Xu, Y. G., Wilde, S. A., and Walker, R. J., 2019. Destruction of the North China craton in the Mesozoic. Ann. Rev. Earth Planet. Sci. 47, 173-195.

Xu, P. and Zhao, D., 2009. Upper-mantle velocity structure beneath the North China Craton: implications for lithospheric thinning. Geophys. J. Int. 177, 1279–1283. doi:10.1111/j.1365-246X.2009.04120.x.

Yamauchi, H., and Takei, Y., 2016. Polycrystal anelasticity at near-solidus temperatures, J. Geophys. Res. 121, 7790-7820, doi:10.1002/2016jb013316.

Yuan, X., Kind, R., Li, X., and Wang, R., 2006. The S receiver functions: synthetics and data example, Geophys. J. Int. 165, 555–564.

Yuan, K. and Beghein, C., 2013. Seismic anisotropy changes across upper mantle phase transitions, Earth. Planet. Sci. Lett. 374, 132-144.

Yuan, K., and Beghein, C., 2014. Three‐dimensional variations in Love and Rayleigh wave azimuthal anisotropy for the upper 800 km of the mantle. J. Geophys. Res. 119, 3232-3255.

Yuan, H., and Romanowicz, B., 2010. Lithospheric layering in the North American craton, Nature 466, 1063–1069.

Yuan, H., and Levin, V., 2014. Stratified seismic anisotropy and the lithosphere‐asthenosphere boundary beneath eastern North America. J. Geophys. Res. 119, 3096-3114.

Yuan, H., Romanowicz, B., Fischer, K. M., and Abt, D., 2011. 3-D shear wave radially and azimuthally anisotropic velocity model of the North American upper mantle. Geophys. J. Int. 184, 1237-1260.