27 The DNA12 Seismic Velocity Model

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27.1 Introduction

The DNA velocity models have been following the rolling USArray from west to east. The initial model, DNA07 (*Xue and Allen*, 2010), used data from the earliest USArray deployment, the BDSN, and other regional networks. *Obrebski et. al.*, (2010) continue further east for DNA09, in which the interaction of the Yellowstone Plume and Juan de Fuca plate has a prominent role in the model. DNA10 updates the body wave dataset and develops the use of a joint inversion technique which uses Rayleigh wave phase velocities to constrain the upper lithosphere where teleseismic body waves rapidly lose resolving power (*Obrebski et al.*, 2011). In this research update we discuss the most recent generation of the DNA models, DNA12, in which we extend the dataset further east and include ambient seismic noise to resolve structure within the crust.

27.2 Method

The inclusion of surface wave data in the inversion provides constraints on the lithosphere allowing interpretation of structure from the surface through the mantle transition zone. However, the S-wave body-wave data is typically measured on the tangential component as it is a cleaner signal than the radial component. Nonetheless, in the presence of large anisotropic signals, there is a chance of mixing vertical and horizontal polarizations. To overcome this problem, we implement a rotation into the P-SV-SH coordinate frame with the predicted incidence angle (*Bostock et. al.*, 2001) and measure the arrival times on the three independent components.

The SV body wave delay times are jointly inverted with Rayleigh wave phase velocities. The phase velocities are generated by two independent methods. Teleseismic phase velocities are computed by Fred Pollitz using a non-plane wave method (*Pollitz and Snoke*, 2010). The phase velocities are updated from the dataset used in *Obrebski et. al.*, (2011) by using new USArray stations. Additionally, we employ ambient seismic noise to recover relatively short period phase velocities (*Benson, et. al.*, 2007). In this case, we update the dataset used in *Porritt et. al.*, (2011) to cover the continuous United States. The two surface wave models are joined by averaging with a period specific weighting parameter. This parameter allows for more weight to be given to the ambient noise at shorter periods where the ocean microseism produces strong ambient noise signal and more weight is given to the teleseismic phase velocities at longer periods where the signal is generally stable, but ambient noise has only a weak signal.

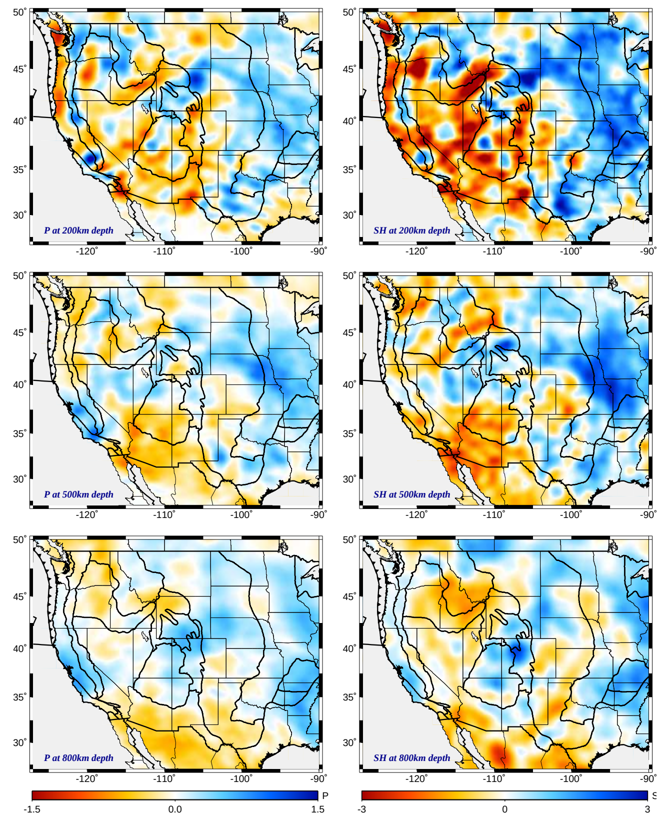

Figure 2.50: (left) Views of DNA12-P at various depths. (right) Corresponding views of DNA12-SH.

27.3 Results

We focus this discussion on the Ancestral Rocky Mountains (ARM) region where there has been little resolution in previous versions of the DNA models. The ARM is a NW-SE trending series of uplifts and basins which formed in the mid-continent around 300Ma. *Soreghan et al.*, (2012) use potential field and active source seismic data to discuss the uplift and subsidence during the Mississippian through the Permian. They model the observed uplift as a NW-SE trending Cambrian rift system (the Southern Oklahoma Alucogen - SOA) being inverted due to crustal heterogeneity and a far-field horizontal stress field causing non-linear buckling. This horizontal stress field is attributed to the Ouachita-Marathon front which runs through southern Texas and was created by the collision of Africa with North America in the formation of Pangea (*Kluth*, 1986). Other authors (*Algeo*, 1992) have

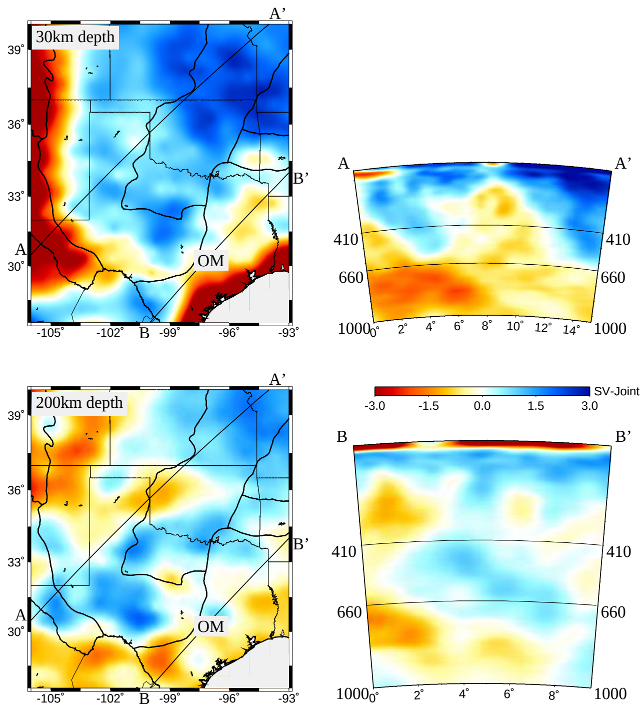

Figure 2.51: Views of the DNA12 model focused on the ARM. Maps at 30km and 200km depth are shown on the left with cross-section locations, physiographic boundaries, and state lines overlain. The Marathon-Ouachita Front (OM) is in southeast Texas near section B-B'.

suggested southward dipping subduction or wrenching of the Laurentia craton as the source of horizontal stress.

In Figure 2.51 we illustrate the velocity structure in the ARM region. The first feature we notice is the Ouachita-Marathon front in the 30km depth slice. The front is seen as a region of velocity contrasts where the generally high velocity cratonic lithosphere to the NW meets the area where the Pangean breakup occurred. In the asthenosphere, a high velocity body is imaged SW of the main uplifts dipping roughly to the NE and striking NW-SE. This high velocity body is distinct from the North American craton and the deeper Farallon slab system. One possible explanation is an independent subduction system which collided from the SW. Dating of igneous rocks in the ARM shows primarily Cambrian ages (*Hogan and Gilbert*, 1997) meaning any subduction in the region must have occurred 200 million years before the ARM uplift. Therefore we cannot conclude that subduction was the main force of ARM uplift, but a relic slab in the lithosphere could provide a buttress during the Pangean-forming orogeny, further forcing the stress into the SOA and resulting in the observed buckling.

27.4 Acknowledgements

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27.5 References

Algeo, T.J., Continental-scale wrenching of south-western Laurussia during the Ouachita-Marathon orogeny and tectonic escape of the Llano block, *West Texas Geological Society Guidebook*, v. 9292, p. 115131, 1992.

Bensen, G.D., M.H. Ritzwoller, M.P. Barmin, A.L. Levshin, F. Lin, M.P. Moschetti, N.M. Shapiro, and Y. Yang, Processing seismic ambient noise data to obtain reliable broadband surface wave dispersion measurements, *Geophys. J. Int., 169*, 1239-1260, doi: 10.1111/j.1365-246X.2007.03374.x, 2007.

Bostock, M. G., Rondenay, S., Schragge, D.S., Multiparameter two-dimensional version of scattered teleseismic body waves, 1. Theory for oblique incidence: *J. Geophys. Res,* 106, 30,771-30,782, 2001.

Hogan, J.P., and Gilbert, M.C., Intrusive style of A-type sheet granites in a rift environment: The Southern Oklahoma aulacogen, in Ojakangas, R.W., et al., eds., Middle Proterozoic to Cambrian rifting, central North America, *Geological Society of America Special Paper 312*, p. 299311, doi: 10.1130/0-8137-2312-4.299, 1997.

Kluth, C.F., Plate tectonics of the Ancestral Rocky Mountains, in Peterson, J.A., ed., Paleotectonics and sedimentation in the Rocky Mountain region, United States, *American Association of Petroleum Geologists Memoir 41*, p. 353369, 1986.

Obrebski, M., Allen, R.M., Xue, M., Hung S.H., Slab-plume interaction beneath the Pacific Northwest, *Geophys. Res. Lett. 37*, L14305, doi:10.1029/2010GL043489, 2010.

Obrebski, M., Allen, R.M., Pollitz, F.F., Hung, S.H., Lithosphere-asthenosphere interaction beneath the western United States from the joint inversion of body-wave traveltimes and surface-wave phase velocities, *Geophys. J. Int. 185*, 1003-1021, doi:10.1111/j.1365-246X.2011.04990.x, 2011.

Pollitz, F.F. and Snoke, J.A., Rayleigh-wave phase-velocity maps and three-dimensional shear-velocity structure of the western US from local non-plane surface-wave tomography, *Geophys. J. Int., 180*, 1153-1169, 2010.

Porritt, R.W., Allen, R.M., Boyarko, D.C., Brudzinski, M.R., Investigation of Cascadia Segmentation with Ambient Noise Tomography, *Earth Planet. Sci. Lett. 185*, 67-76, doi:10.1016/j.epsl.2011.06.026, 2011

Soreghan, G.S., Keller, G.R., Gilbert, M.C., Chase, C.G., Sweet, D.E., Load-induced subsidence of the Ancestral Rocky Mountains recorded by preservation of Permian landscapes, *Geosphere*, 10.1130/GES00681.1, 2012

Xue, M. and R.M. Allen, Mantle Structure Beneath the Western US and its Implications for Convection Processes, *J. Geophys. Res., 115*, B07303, doi:10.1029/2008JB006079, 2010