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Pg Travel Time Tomography in Eastern Asia

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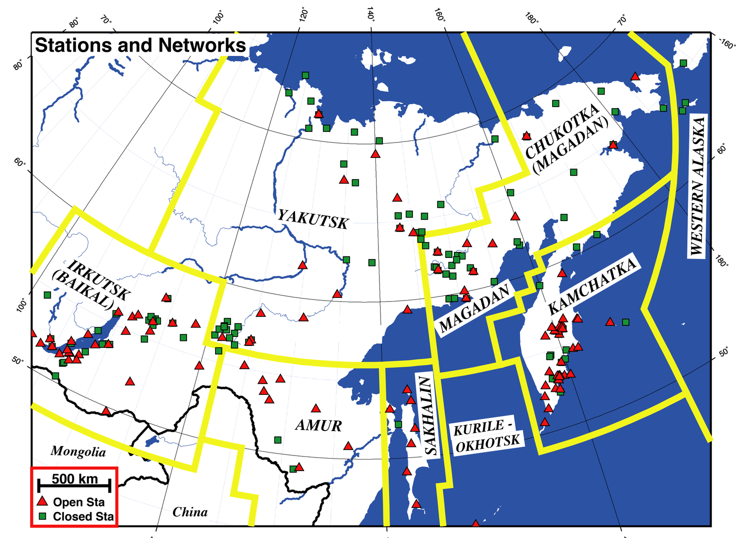
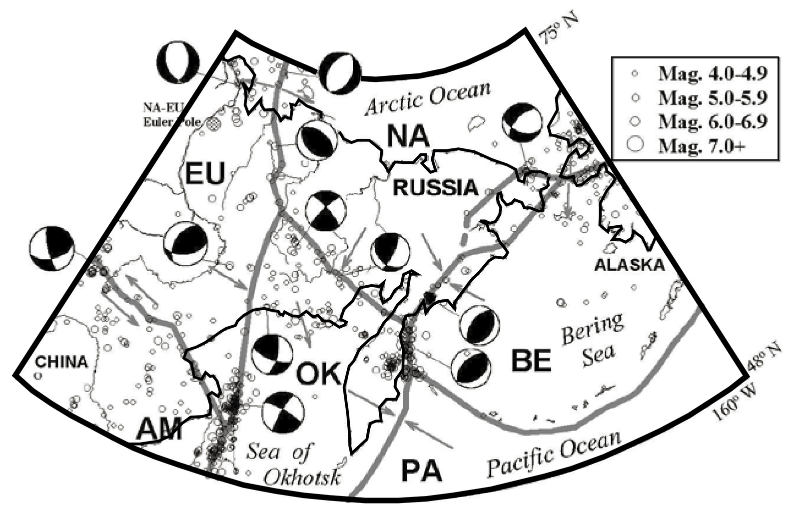
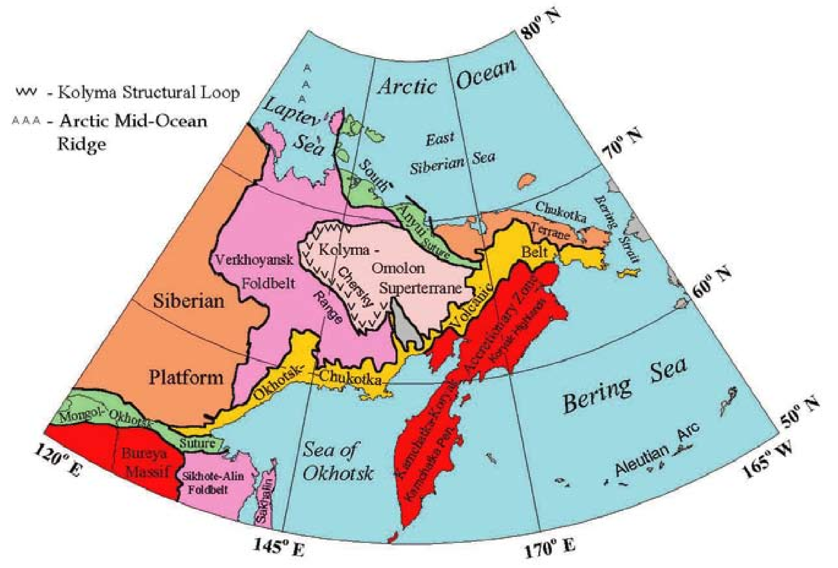
1 Introduction

We are performing Pg tomography of central and eastern Asia, including eastern Russia, Mongolia, China, Japan, India, and Indochina. Our goal is to improve travel time calibration of Pg to reduce seismic event mislocations when secondary phases are used. In our study we have placed particular emphasis on data acquisition in Northeastern Russia. This region covers an area roughly equivalent to the United States, with seven seismic networks operating independently [see figure immediately below]. Together, Michigan State University and Los Alamos National Laboratory researchers have merged catalogs from the Yakutsk, Magadan, Sakhalin, Kamchatka, and Irkutsk networks along with global bulletins and special studies to produce a unified Eastern Siberia Database with about 250,000 events recorded between 1964 and 2004. Associated with these events are 1,300,000 arrivals from about 500 stations. The Eastern Siberia Database has been merged with our regional and global assets to form a comprehensive Asian dataset. To invert the data, we use a first-difference smoothed least squares inversion similar to Pn tomography. The inversion is performed with an LSQR conjugate gradient method, and we solve for velocities, site terms, and event terms. We assume a great circle path between event and station and at this point do not take into account depth, though we restrict event depths to be shallower than 33km. In eastern Russia we observe unexpectedly slow crustal velocity at Sakhalin Island and the foldbelt to its west and in the eastern half of Mongolia. High velocities are found in the forearc sections of Pacific subduction zones. The Baikal rift shows moderate velocities with higher Pg velocities in the Siberian Platform and Aldan Shield. These results agree well with previous Pg work by Mackey and with Pn velocity and Lg attenuation results by Rowe et al. Although anomalously low Pg velocities are observed in India and Iran we feel further research is required to interpret this finding. Data coverage for these areas is less dense,however it is possible that anomalous low velocities reflect inconsistencies in Pg treatment by regional station operators rather than data coverage or true structural variation.





Tectonic plates and motions in northeastern Russia

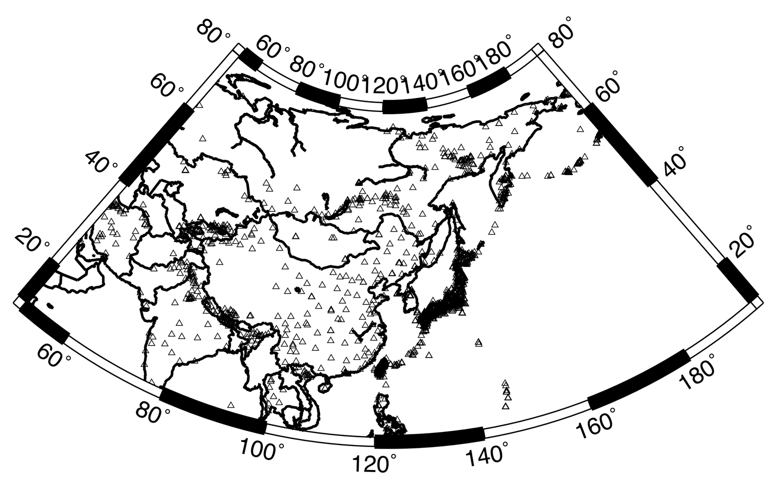


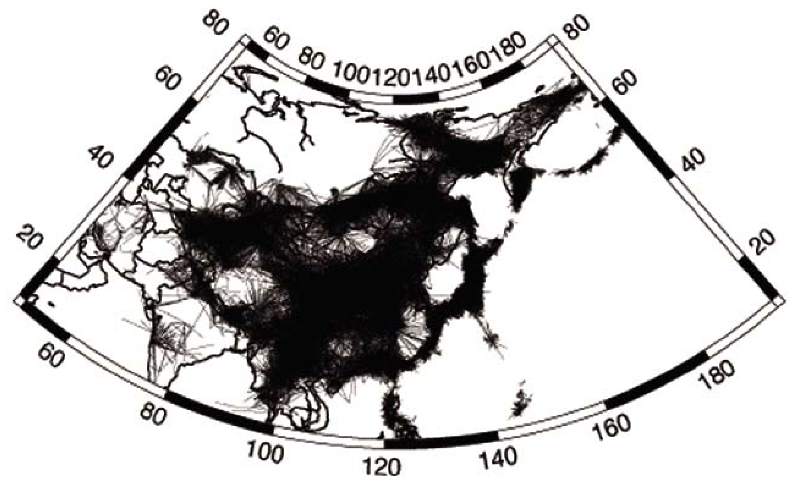
Geologic/tectonic terranes in northeastern Russia

2 Pg Tomography of Eastern Eurasia

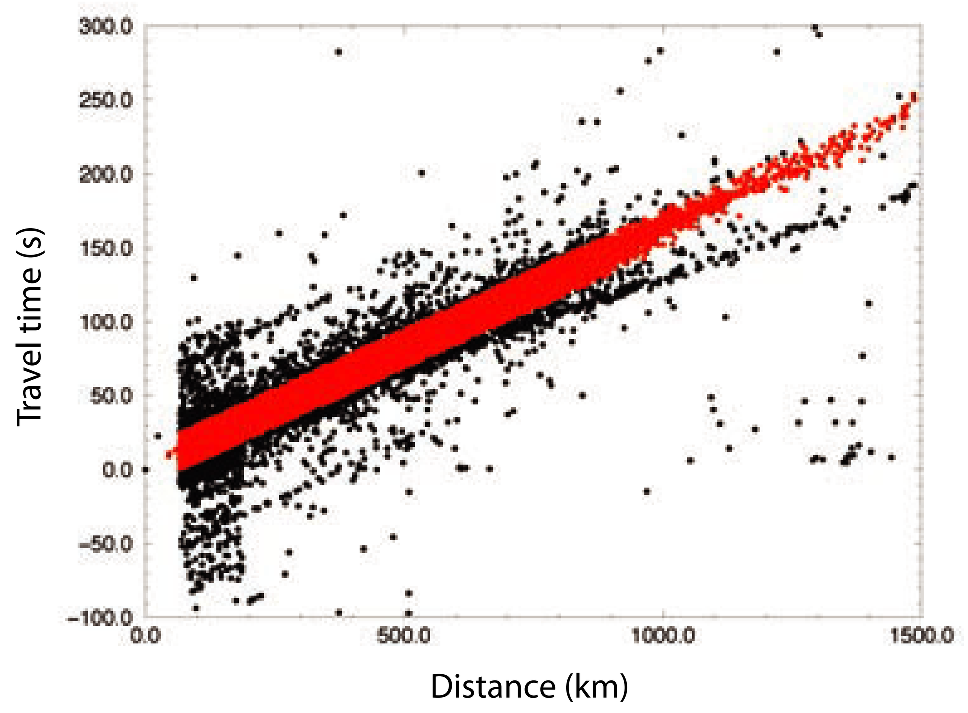
Dataset

The dataset for this study is comprised of Pg arrivals from 1344 seismic stations and 174,501 events, for a total of 515,140 arrivals. Data are only used for events shallower than 33 km and for epicentral distance between .6 and 14 degrees. Below left shows the station locations while below right shows the event/station path coverage.





The time-distance plot below illustrates quality control performed on the catalog data. Data were excluded if they fell outside adhoc upper and lower bounds or if the travel time was negative. Pn contamination is clear from this figure, as are timing errors of +/- 60 seconds. Timing errors of 30 and 60 minutes are also present, but not shown here.



Method

The method we use is a first-difference regularized least squares inversion, similar to Pn tomograpy. Total travel time is inverted for absolute slowness, where times are written as:

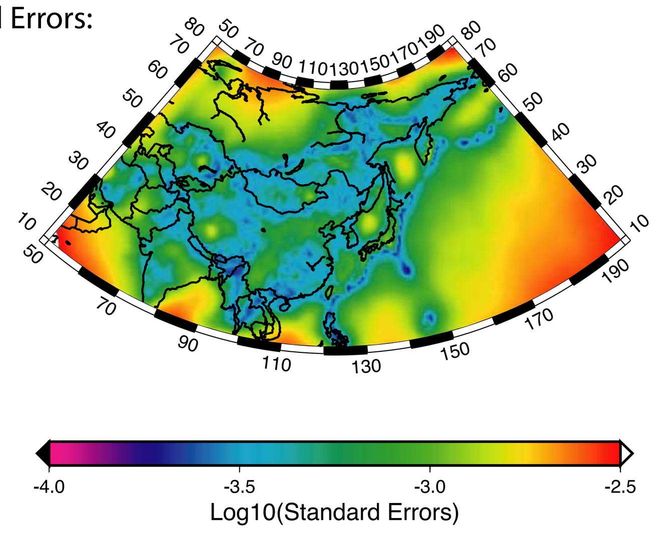
$$t_{ij} = \sum \delta x_{ij} s_{ij} + e_i + s_j,$$

where i and j are event and station indices, the δx are path segments, and the s are slowness. The summation is performed over the N segments of the given path. The inversion is performed using an LSQR conjugate gradient method, and we solve for slowness, station terms and event terms. The station term sum is damped to zero while event terms are unconstrained. We assume a great circle path between the epicenter and the station. In the next panel we present results for a run in which we choose a 1^o grid for a lat/lon box spanning 10-80^o N and 50-195^o E. A smoothing parameter of 400 was used, resulting in a 30 % reduction in RMS residuals with respect to IASPEI91 (from 1.7 sec to 1.2 sec).

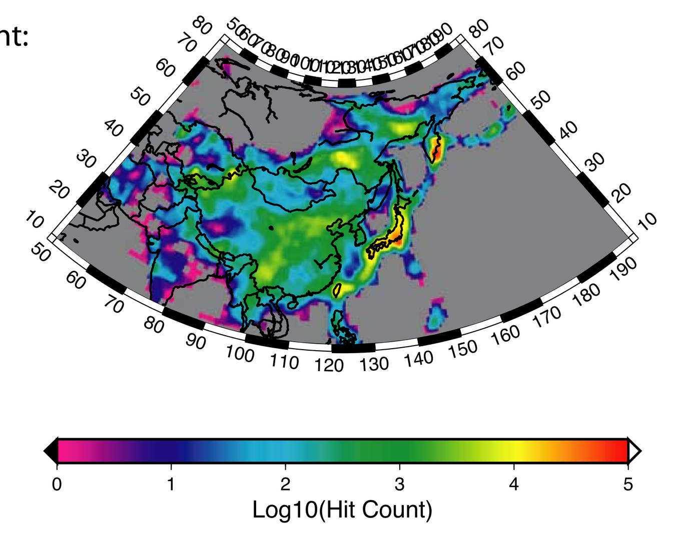
3 Pg Tomography Results

Results

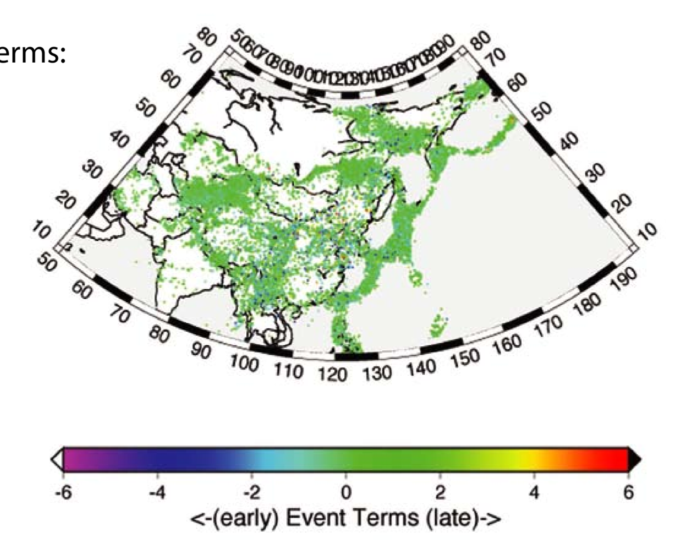
Standard Errors:



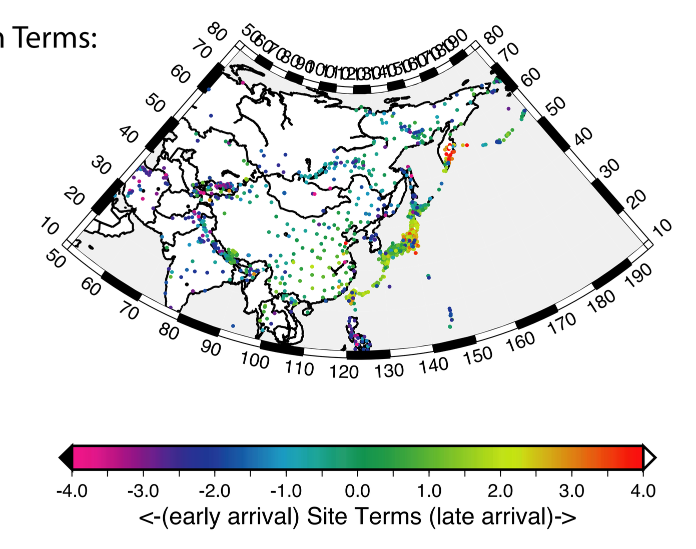
Hit Count:



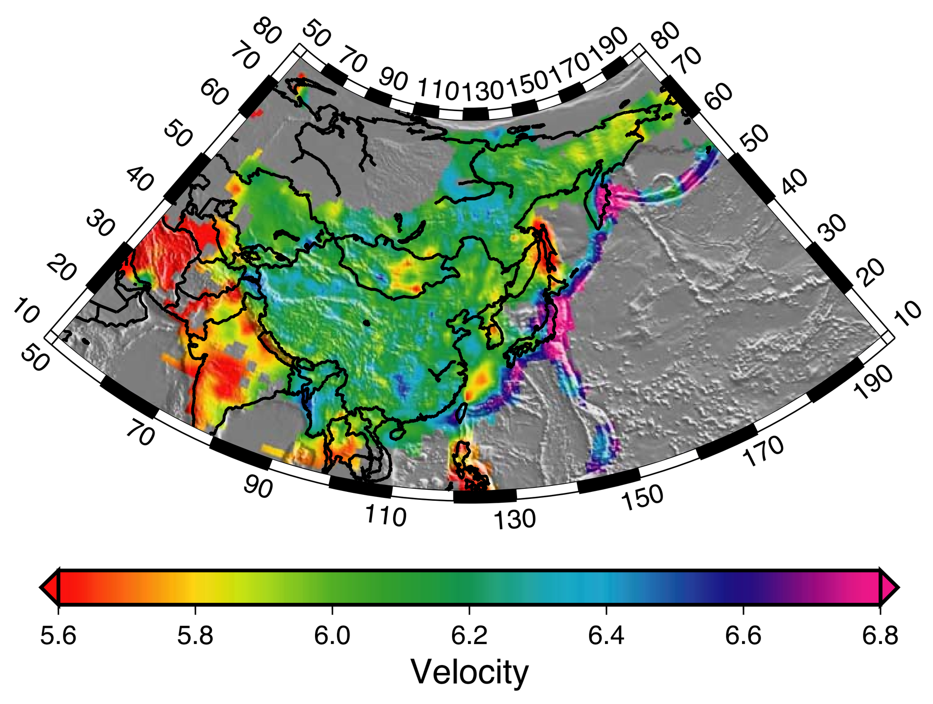
Event Terms:



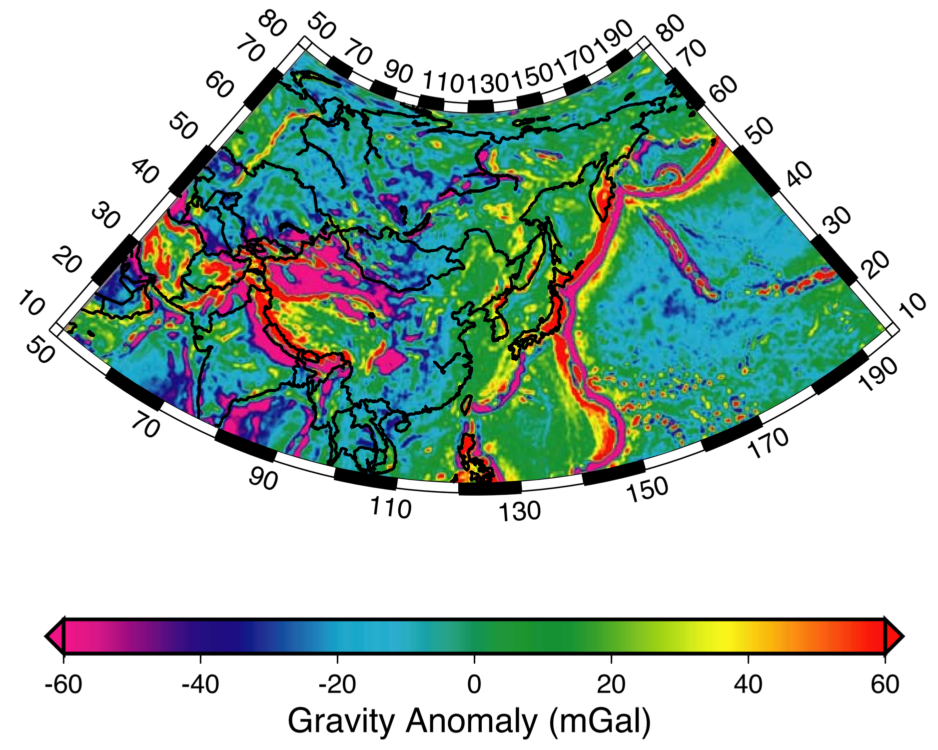
Station Terms:



Pg Velocities:



GRACE Gravity Anomalies (Tapley et al.,2004):

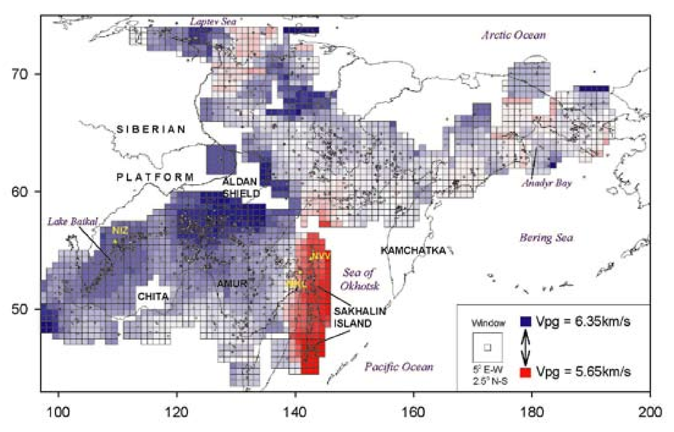


Discussion

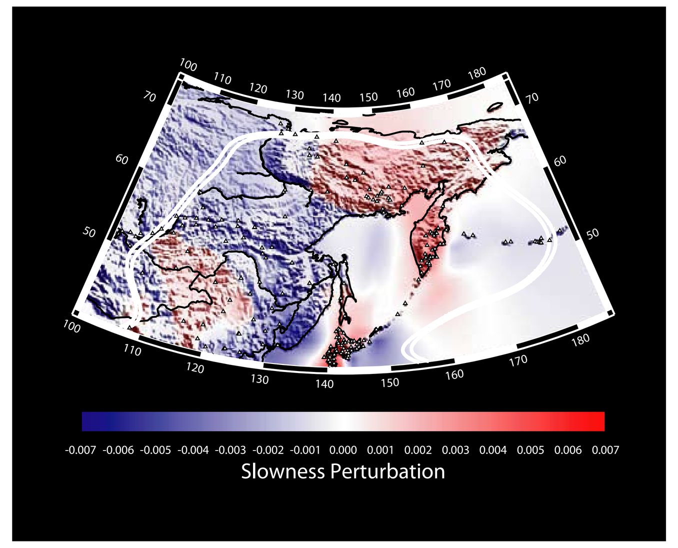
Inversion results show very slow crustal velocities at Sakhalin Island, the eastern half of Mongolia, as well as India, Iran, the Phillipines and Thailand. Very high velocities are found in the forearc sections of Pacific subduction zones. The Baikal rift shows moderate velocities with higher Pg velocities in the Siberian Platform and Aldan Shield. Results in Siberia agree well with previous Pg work by Mackey and with Pn velocity and Lg attenuation results by Rowe et al. (see figures on the right-hand side of this panel). The very low velocities may be due to inconsistancies in Pg identification across station operators.

Previous/Related Work in Siberia

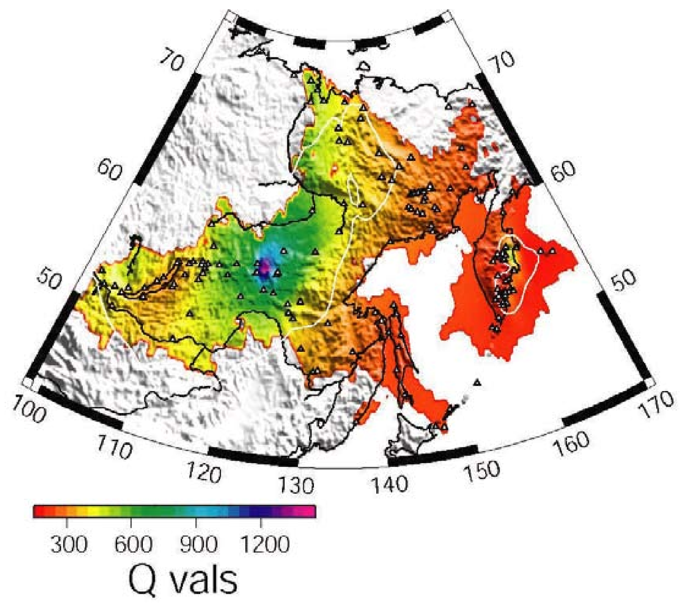
Pg velocity from moving window relocations (Mackey 1999 and Mackey et al. 2003)



Pn velocity results from differential Pn tomography (Rowe et al. 2005; Phillips et al., 2005)



Lg attenuation (Rowe et al. Fall AGU 2006)



References

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Mackey, K. G., Fujita, K., Steck, L. K., and Hartse, H. E., 2003, Seismic regionalization in eastern Russia, in Proceedings of the 25th Seismic Research review - Nuclear Explosion Monitoring: Building the Knowledge Base: National Nuclear Security Administration, U.S. Department of Energy, LA-UR-03-6029, p. 73-82.

Phillips, W. S., C. A. Rowe, and L. K. Steck, 2005, The Use of Interstation Arrival Time Differences to Account for Regional Path Variability, Geophys. Res. Letts., 32, L11301, doi:10.1029/2005GL022558.

Rowe, C, Steck, L.K., W. S. Phillips, M. Begnaud, R. Stead and H. Hartse, 2005, Pn Tomography and Location in Eurasia, 2005 IASPEI Meeting, Santiago Chile.

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