Abstract of Doctoral Dissertation

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Upper Mantle Structure Beneath Mongolia with Surface Wave Tomography

（表面波トモグラフィーによるモンゴル地域の上部マントル構造）

Investigations of seismic structures of the upper mantle based on surface wave analysis can be useful for clarifying the regional tectonics and mantle dynamics, but such studies have still been limited in the Mongolian region. Although some local areas in Mongolia have been the targets of several earlier seismological studies, surface-wave tomography across the nationwide areas of Mongolia with the enhanced coverage of seismic stations has yet to be investigated.

Over the past decade, a number of seismic stations have been installed in Mongolia. Between 2011 and 2013, 69 temporary broadband seismic stations were installed in central-south Mongolia as a part of a collaborative project between China and Mongolia. From 2012 to 2016, several temporary broadband networks of IRIS-PASSCAL (Incorporated Research Institutions for Seismology – Program for the Array Seismic Studies of the Continental Lithosphere) were sporadically installed in western Mongolia. Since 2015, the nationwide regional broadband seismic network in Mongolia has also been in operation. These seismic networks have enabled us to carry out surface-wave dispersion measurements, which can be the basis for the construction of a 3-D S-wave model of the entire Mongolian region.

In this study, we employ the three-stage inversion technique of multimode surface waves. In the initial stage, we measured multimode phase speeds of Love and Rayleigh waves for a number of source-receiver pairs by using a fully nonlinear waveform fitting for individual seismograms based on the Neighborhood Algorithm. In the second stage, we retrieved multimode phase speed maps using the linearized inversions based on the method of surface-wave tomography incorporating approximate effects of finite frequency. In the third stage, localized multimode dispersion curves derived from the sets of multimode phase speed maps were used to construct local 1-D S-wave profiles, including radial anisotropy, which formed a final 3-D S-wave speed model beneath Eastern Eurasia including Mongolia.

The dataset utilized in this study consists of seismic waveforms from over 1655 teleseismic events ($Mw \geq 5.8$) that were recorded at permanent and temporary stations in and around Mongolia between 2009 and 2021. We reconstructed phase speed maps with $2.0^0 \times 2.^0$ grids (or greater size, depending on path coverage for each period) by covering the study region with many ray paths; e.g., about 70,000 paths for the fundamental-mode Rayleigh waves, 40,000 paths for the fundamental-mode Love waves at a period of 100 s, and about 5,000 - 40,000 paths for higher modes of both Rayleigh and Love waves. Broadband seismograms from the permanent and temporary seismic networks in Mongolia, as well as nearby stations of the Global Seismograph Network and temporary regional networks in Eurasia, were combined to retrieve a high-resolution S-wave model covering entire Mongolia. The new 3-D model gave us new insight into the large-scale tectonics of the Mongolian region, including the western margin of the Amurian plate.

The obtained 3-D S-wave model shows significant lateral variations of S-wave speeds in the uppermost mantle beneath Mongolia, indicating the structural differences between western and eastern Mongolia. In the radial anisotropy model, SH waves tend to be faster than SV waves in most areas of the Mongolian upper mantle above 100 km depth, except for the northeast of the Altay Mountains.

The low-velocity anomalies are seen in western Mongolia beneath the Hangay Dome and the northern Altay Mountains. The low-velocity anomaly in the Altay Mountains persists to a depth of about 100 km, which may be linked to the northern extension of the collision tectonics between Asia and India. A large-scale low velocity beneath the northeast of the Hangay Dome persists to around 150 km depth, accompanied by significant radial anisotropy with slower SV velocity than SH in the top 100 km that may result from finely layered or laminated heterogeneity, possibly including partially molten layers. High-velocity anomalies corresponding to the lithosphere can be seen in the uppermost mantle of eastern Mongolia, reflecting the relatively stable tectonics in this region, in contrast to the tectonically active regions of central-western Mongolia. The differential motion between eastern and western Mongolia may be related to such regional variations of the upper mantle structure and dynamics beneath the Eurasian and Amurian plates.