AMBIENT NOISE TOMOGRAPHY FOR A HIGH SPATIAL-RESOLUTION 3D S-WAVE VELOCITY AND AZIMUTHAL ANISOTROPY MODEL OF THE KINKI REGION, SOUTHWEST JAPAN, USING DENSE SEISMIC ARRAY DATA

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論　文　名　：AMBIENT NOISE TOMOGRAPHY FOR A HIGH SPATIAL -RESOLUTION 3D S-WAVE VELOCITY AND AZIMUTHAL ANISOTROPY MODEL OF THE KINKI REGION, SOUTHWEST JAPAN, USING DENSE SEISMIC ARRAY DATA
（高密度地震計を用いた近畿地方の高空間分解能3次元S波速度・方位異方性の推定に向けた微動ノイズトモグラフィ）

区　　分　：甲

論文内容の要旨

The interactions among the subducting Philippine Sea Plate (PSP), the overriding Eurasian or Amurian (Amur) plate and the Pacific Oceanic Plate continually deform the crust and produces major tectonic structures in the Kinki region, southwest Japan. In this region, there is an apparent inconsistency between earthquake hypocenters and the location of documented active faults. Some of these earthquake hypocenters either occur between known fault locations or are aligned in the same direction as documented active faults, suggesting a possible existence of concealed faults or other deformational structures. Previous studies that sought to unravel the geological heterogeneities in the Kinki region focused mainly on deep, large-scale structures and could not resolve fine-scale (~13 km) shallow crustal structures. Therefore, there is a need to characterize the upper crustal structure of this region at an improved spatial resolution. The fundamental aim of this study is to estimate and characterize the shallow crustal structure of the Kinki region at an improved spatial resolution using the ever-present ambient seismic noise. In Chapter 1, I provide the background information, justification and the aims of this study. A detailed description of the geologic setting of the Kinki area is given in Chapter 2.

In Chapter 3, I provide a detailed description of the data and methods used in this study. Firstly, I pre-processed the continuous seismic waveforms recorded over a period of six months by the densely distributed 221 permanent and temporary seismic stations. Then, I derived the empirical Green’s functions from the cross-correlations of the vertical component of ambient seismic noise data, from which Rayleigh wave phase velocities were estimated using a frequency domain method (Zero-crossing). Using the estimated phase velocity dispersion data, I constructed high-resolution 3D S-wave velocity and azimuthal anisotropy models of the Kinki region based on ambient noise tomography (ANT) method, a form of interferometry. To construct the 3D S-wave velocity model, I applied a direct surface wave tomographic method (DSurfTomo), which is based on frequency-dependent ray-tracing inversion. This inversion approach is well-suited to determining the complex shallow crustal structure of the Kinki region using the short-period surface waves dispersion

data.

To further construct the 3D azimuthal anisotropy model, I applied a direct joint inversion (DAzimSurfTomo) method. Here, the inversion workflow was implemented in two steps. Firstly, I obtained the 3D isotropic S-wave model by inverting the measured Rayleigh wave phase velocity dispersion data using a 3D direct inversion method. Secondly, the isotropic S-wave model obtained from the initial step was then used as the 3D reference model to perform a joint inversion for both 3D isotropic S-wave velocity perturbation and azimuthal anisotropy.

In Chapters 4 and 5, I presented the results of this study and their interpretations. Here, the 3D isotropic S-wave velocity model constructed in Chapter 3 revealed a NE-SW trending low-velocity structure coinciding with the location of the Niigata-Kobe Tectonic Zone (NKTZ) and the active Biwako-seigan Fault Zone (BSFZ). Also, I identified fine-scale low-velocity structures coinciding with known active faults on the eastern side of the NKTZ, as well as sets of low-velocity structures on the northern side of the Arima-Takatsuki Tectonic Line (ATTL). Moreover, sedimentary basins manifest as low-velocity zones extending to depths ranging from ~1.5 to 2 km, correlating well with those reported in previous studies.

The resolved 3D azimuthal anisotropy reveals significant contrasts of anisotropy across the Kinki region. The southern part shows predominantly NE-SW- and near E-W- trending fast axes in the central part and the western part of the Kii Mountainland, respectively, which are attributable to stress-induced anisotropy. In the northwestern portion, the observed fast axes direction is consistent with that of the maximum horizontal compressional stress and the principal strain rate axes, suggesting that the observed anisotropy in the northwestern part of the Kinki region is influenced by both the stress field and strain rate. On the depth profiles of anisotropy, I observed depth-dependent variation of azimuthal anisotropy. Furthermore, my model revealed a significant consistency between azimuthal anisotropy and seismicity beneath a depth of 3 km. This interrelationship between anisotropy and seismicity demonstrates that the observed anisotropy could be linked to local crustal stress or fractures relevant to earthquake ruptures. The high-spatial resolution 3D anisotropy model obtained in this study therefore contributes towards understanding the locations and features of seismicity region. Most importantly, the results of this study contribute towards understanding the complex shallow crustal structure, earthquake faulting, the dominant deformation mechanisms in the tectonically active Kinki area, and will be useful for hazard assessment and disaster mitigation. The main findings of this study are summarized in Chapter 6.