論文の内容の要旨

Detection and Quantification of Pre-P Gravity Signals from the 2011 Tohoku-Oki Earthquake

–Proposal of Pre-P Gravity Seismology through Observation and Theoretical Modeling–

（2011年東北沖地震からのP波前重力信号の検出と定量化

–観測および理論モデリング研究を通したP波前重力地震学の提案–）

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Dynamic earthquake rupture causes a mass redistribution around the fault, and the emitted propagating seismic waves are accompanied by bulk density perturbations. Both processes are thought to cause a transient gravity change prior to the arrival of P-waves. The first theoretical model showed an expression of this pre-P gravity signal, providing the first target for signal detection. Then, the pre-P signal from the 2011 Tohoku-Oki earthquake was reported, but the statistical significance of the signal was not enough to be considered as a discovery of a new physical phenomenon. The second detection was reported as an agreement between observed waveforms and synthetics calculated using an improved model. However, the signal significance was not discussed, and the employed signal processing method included an acausal process, which may cause artifacts in the original records. In this thesis, we first aimed to identify the pre-P gravity signal with a sufficient statistical significance. Using an artifact-free signal processing method, we detected the signal from the 2011 event with a 7σ significance. We then examined the previous acausal signal processing method and showed that the

resultant artifacts were sufficiently small not to deny the second detection report. These two studies of ours confirmed the existence of pre-P gravity signals and established a basis for the quantitative comparison between observation and theoretical modeling. In the third study, we proceeded to the use of the pre-P gravity signal to estimate the source parameters of the 2011 event. We conducted a waveform inversion analysis for the identified three-component pre-P signal from the event, combined with synthetics calculated using the simulation approach which solves the fully coupled elasto-gravity equations for a realistic Earth structure. The pre-P gravity signal gave a constraint on the dip angle of the source, which is not well determined from long-period seismic waves. Through our studies, the research field that deals with pre-P gravity signals has progressed from the phase of discussing the signal existence to the next stage where quantitative comparison between observation and theoretical modeling provides a new seismological implication. Finally, we proposed that the usage of the three-component pre-P gravity signal waveforms was essential for providing the new constraint on the source parameters beyond the limitation of the seismic wave observations.