PASSIVE AND ACTIVE SEISMIC DATA ANALYSES FOR HIGH TEMPORAL-RESOLUTION MONITORING AND HIGH SPATIAL-RESOLUTION IMAGING OF THE EARTH

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論 文 名 : PASSIVE AND ACTIVE SEISMIC DATA ANALYSES FOR HIGH TEMPORAL-RESOLUTION MONITORING AND HIGH SPATIAL-RESOLUTION IMAGING OF THE EARTH
（高い時間解像度のモニタリングと高い空間解像度のイメージングに向けたパッシブ地震探査とアクティブ地震探査手法の開発）

区　　分　: 甲

論　文　内　容　の　要　旨

In seismic exploration, seismic source can be divided into two categories: active source and passive source. Active source refers to the artificial/man-made source. The examples of active source, that is related to seismic exploration, are dynamite, hammer, vibroseis, sparker and water gun. Passive source refers to the seismic source generated from natural phenomena. The examples of passive source related to seismic exploration are earthquake and ambient noise (e.g., wind and traffic noise). In general, the active source seismic exploration has higher spatial resolution image in comparison to passive source exploration. On the other hand, the active source exploration requires high cost, especially for long-term operation (i.e., time-lapse monitoring) with high temporal resolution. In this study, (1) the passive source was used for constructing real-time monitoring system with “high temporal resolution” and (2) the active source was used for constructing “high spatial resolution” profiles for hydrocarbon exploration. This dissertation contains four chapters, and the description for all chapters are shown below:

In Chapter 1, research objectives, background, and motivation are described. In this study, the ambient noise data was used for passive source exploration and deeply-towed multi-channel seismic data was used for active source exploration. In this chapter, some previous studies related to the utilization of ambient noise and the exploration using deep-towed data are introduced.

In Chapter 2, the ambient noise data was used for developing a spatio-temporal monitoring system in Japanese islands. This monitoring system with high temporal resolution is useful to continuously monitor crustal behavior. Since the monitoring results are associated with earthquakes, magmatic activities, and several environmental effects (e.g. tides and rain precipitation), it can be utilized for disaster mitigation. Several sophisticated methods were used for processing of ambient noise data, such as seismic interferometry, stretching interpolation and temporal normalization. For estimating temporal velocity variation with high accuracy, the coda wave was used rather than direct wave. To improve the stability in real-time monitoring, Sliding Reference Method (SRM) was developed in this study. By using SRM, temporal velocity variation with high temporal resolution and stability can be obtained. There is also a module for removing the glitch/spike in temporal velocity variation automatically, based on Median Absolute Deviation (MAD) and median filter. Moreover, I described how to select an optimum parameter to achieve high temporal resolution result while keeping the stability. By using high parallel computation approach, this system can process huge data in short time. The temporal velocity variation derived from this continuous monitoring system is open through Kyushu University website.

In Chapter 3, the deep-towed Autonomous Cable Seismic (ACS) data was processed for finding hydrocarbon (e.g., free gas, gas chimney and gas hydrate) on Joetsu Basin, Japan. In this ACS, high spatial resolution imaging can be achieved by generating high-frequency signal close to the seafloor. The common problem that occurred on deep-towed ACS acquisition is the unstable depth position of source-receiver. The unstable depth of source-receiver caused an inaccurate reflection signal on pre-stack data. Moreover, the source signature of ACS data has sidelobes signal. The existence of sidelobes will decrease the frequency content on pre-stack data. It is crucial to remove the effect on unstable depth of source-receiver and sidelobes to make the stack image of subsurface result more obvious. Therefore, I developed a method to correct the unstable source-receiver depth, and the reflection signal can be accurately recovered. In order to suppress the sidelobes, a filter was designed so that the source signature becomes more focused. The result of data processing showed significant improvements of results (i.e., reflection profiles): the velocity semblance more focused and the frequency content became wider. In order to characterize the gas chimney, gas hydrate and free-gas, seismic attributes were calculated. From the seismic attributes, the hydrate area is shown as high reflection amplitude on the seafloor, and the gas area is shown by a low amplitude signal and frequency fluctuation.

In Chapter 4, the result and key findings of this thesis are summarized, and future visions are described. The results derived from the proposed methods demonstrate that the ambient noise can be available for real-time (high temporal resolution) monitoring of velocity variation, and the deep-towed ACS data acquisition can be beneficial to construct high spatial resolution profile for exploring the hydrocarbon distribution. The interferometry and several other sophisticated computation technologies for ambient noise data have been used for developing an accurate, stable, and fast velocity monitoring system, hence this monitoring system has been currently operated for long term monitoring. In the future, not only the speed of computation performance will be faster, but also the number of observation locations that can record ambient noise will be larger using either conventional seismometer or fiber optic sensor. By applying this monitoring system for such huge data, monitoring of velocity variation on a larger scale (worldwide) and with more detailed spatial result can be achieved. Moreover, it can contribute for understanding the newest global earth phenomena and disaster mitigation. Applying the proposed data processing schemes for the deep-towed acquisition has given a promising result for high spatial resolution exploration. The deep-towed system is not only for exploring the hydrocarbon, but also for imaging other geological features, such as deep-sea ore deposits and slumping features.