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Lateral heterogeneities and microtremors: Limitations of HVSR and SPAC based studies for site response

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A B S T R A C T

We report a site effect study carried out in a small alluvial valley, Nari basin, in Ulleung island, Republic of Korea. In that small valley a permanent, broad-band array of five stations records ground motion continuously. In addition, we performed microtremor measurements using two arrays of stations; a small aperture array (60 m) and a medium aperture one (500 m). Ambient vibration was also recorded at 38 points inside the basin. The records were analyzed using horizontal-to-vertical spectral ratios (HVSR), to estimate dominant frequency and maximum amplification, and the spatial autocorrelation (SPAC) method, to estimate the subsoil structure via phase velocity dispersion curves. Nari basin is clearly a 3D structure but it was expected that a laterally irregular model might be built from the interpolation of several 1D models. Dominant frequency maps based on results from HVSR suggest a simple sedimentary structure with mostly smooth lateral variations. In contrast, maximum amplification distribution is very irregular and shows no correlation with dominant frequency. In the case of Nari, it seems that the complexity of the basin structure cancels the usefulness of HVSR. We could estimate a phase velocity dispersion curve for 81% of the station pairs recording simultaneously ambient vibration in our arrays. In all the cases, the resulting dispersion curve had a simple shape, suggesting that the subsoil structure consists of a single layer over a half space. However, the dispersion curves are incompatible among them, even for different station pairs covering the same path, something impossible if the subsoil structure were 1D. It seems that the passive methods we have used in Nari basin are not adapted to its structure. This makes a tomography unfeasible and we are unable to propose a subsoil structure for Nari basin. Our results show that surface wave dispersion may be estimated using the SPAC method even when the medium is far from 1D. We believe that this problem is enhanced by the small size of this basin, which amplifies the effect of lateral heterogeneities.

1. Introduction

Site effects are arguably the most easily predicted factor of strong ground motion (Chávez-García, 2011). Amplification caused by soft soil layers close to the surface will affect future earthquakes in the same way it has affected past earthquakes. That amplification may be identified in ambient vibration measurements because seismic noise propagates with the same waves and through the same subsoil structure as earthquake waves. Seismic local amplification has been determined from horizontal-to-vertical spectral ratios (HVSR) for many years now (see, for example, Nakamura, 1989; Bard, 1999). Another possibility is to determine the subsoil structure at the origin of the local amplification and use it to compute expected amplification.

The Korean Peninsula has not been recently subjected to large earthquakes. However, during its long history, a few tens of destructive earthquakes have occurred since 2 AD (Baag et al., 1998). The amount of exposed infrastructure makes for a large seismic risk even if the likelihood of a very large event is low. The Korean government operates an Earthquake Research Center within the Korean Institute of Geoscience and Mineral Resources. This center is the national agency in charge of evaluating seismic hazard in Korea. A recent result is an updated version of the national seismic hazard map (Choi et al., 2012) which predicts expected ground motions on bedrock but does not consider site effects. The Korean peninsula consists mainly of volcanic and metamorphic rocks. Sedimentary basins are of recent origin and mostly shallow. In order to approach site effect evaluation and ground motion simulation including those effects, a small basin was selected for a pilot study in Ulleung island, East Sea. The selected basin is located in the caldera of a volcano in that island. Its geological history and small size suggested that its subsoil structure would be simple. Noise excitation is expected to be isotropic and due to wave action along the coast, given the small human activity in the basin (used mainly for agriculture, and inactive at the period chosen for the experiment). Because of the geology of Korea, it was deemed useful to study a volcanic basin, as there are

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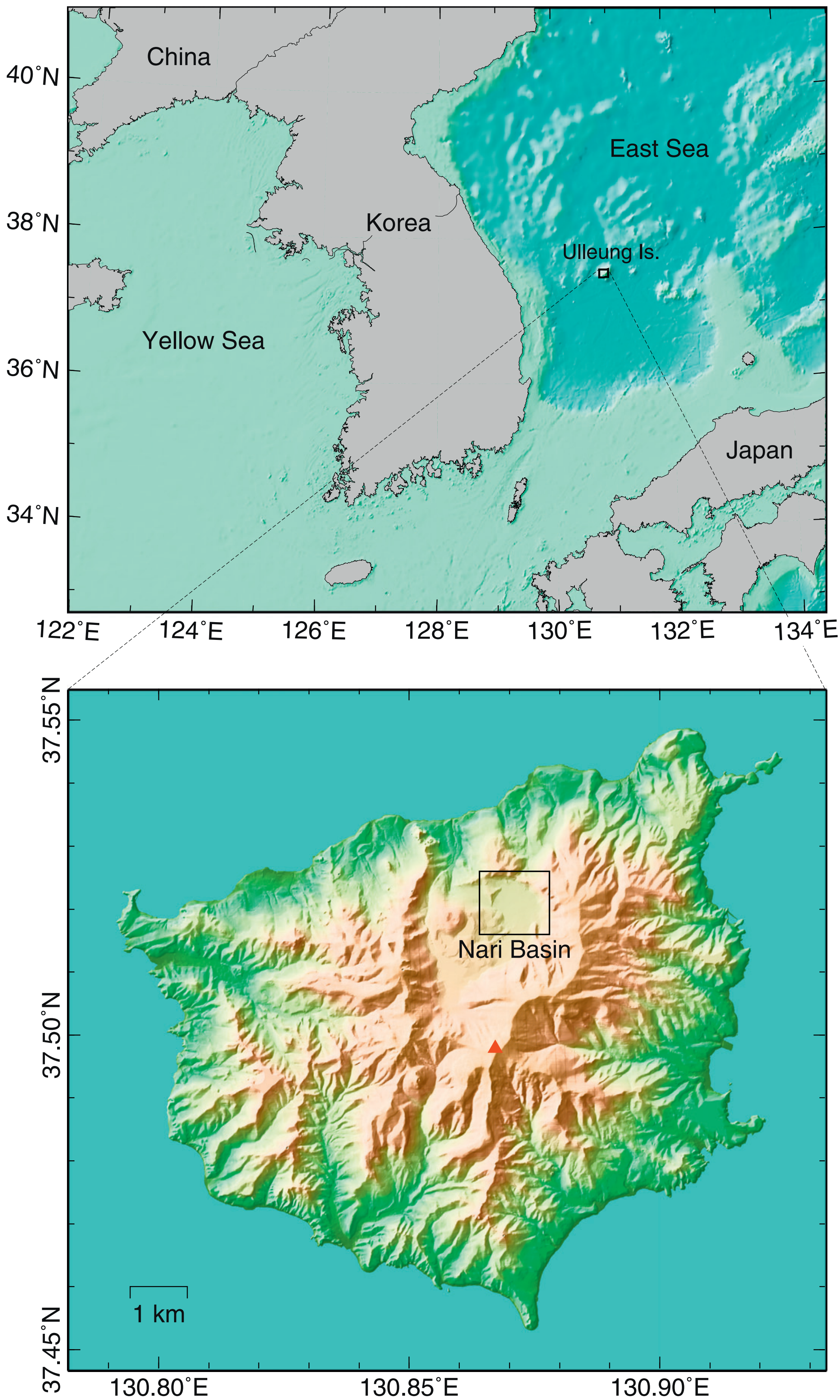
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East Sea
Korea
38°N
Ulleung Is.
Yellow Sea
36°N
Japan
34°N
122°E
124°E
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130°E
132°E
134°E
37.55°N
Nari Basin
37.50°N
1 km
37.45°N
130.80°E
130.85°E
130.90°E