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# EVALUATIONS OF THE EFFECTS OF THE BASIN EDGE IN H/V SPECTRAL RATIOS OF MICROTREMORS BASED ON DIFFUSE FIELD INTERPRETATION

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## *Abstract*

Based on the diffuse field assumption, the Horizontal-to-Vertical spectral ratios of microtremors (MHVR) can be derived from the ratio of the imaginary part of Green's functions of the horizontal response at the point of horizontal harmonic loading and those of the vertical component at the same point for sites with flat-layered subsurface structure as well as for 2-D and 3-D basin structures. We have shown that, by using a numerical method such as a 3-D spectral element method to calculate the Green's functions of the response at the same point of harmonic loading on the surface of a 2-D basin structure it is possible to explain the directional dependency that can be seen in the observed MHVRs at Uji campus of Kyoto University, qualitatively.

In this study, we observed microtremors in Reno, Nevada, USA, in order to observe directional dependent MHVRs and evaluate the effect of the basin edge from the observed MHVRs, as we conducted at the Uji campus. In Uji, the basin is on the footwall of a reverse fault, while in Reno it is on the hanging wall of a normal fault. In both locations, NS compnent is the fault-parallel and EW component is the fault normal direction.

We focus on the effect of the basin edge to the MHVRs and study the relationship between the basin edge shape and the difference between NS/UD and EW/UD in the observed MHVRs. At Uji, the condition of the lateral heterogeneity close to the basin edge changes the characteristics of the MHVRs. Peaks in MHVR change to higher frequency due to the change of the depth of the basin as the site gets closer to the basin edge and the amplitude of the peaks also decreases as the site gets closer to the basin edge. This can be modeled with a flat-layered velocity structure for each observation point. We can fit the peak frequency of the observed MHVRs with theoretical ones by modifying the layer thicknesses, but the amplitudes and directional dependence of theoretical MHVRs do not match as the observations.

From these results, we can see that the condition of the lateral heterogeneity close to the basin edge changes the characteristics of the MHVRs. We are comparing the MHVRs of observed microtremors in Reno to the results in Uji, and will try to determine if it is possible to identify directional effects and the basin edge shape in Reno as well based on MHVRs there.

*Keywords: Microtremor, Basin edge, Diffuse field assumption, Reno, Genoa*

## 1. Introduction

It is important to estimate the ground motion in order to prevent serious damage from earthquakes. The local subsurface structure influences the ground motion. We use spectral ratios of microtremors (MHVR) in order to model the location and shape the basin depth for estimating the ground motion. From previous studies in and around Uji Campus, Kyoto University, significant directional dependence was discovered in the observed MHVRs [1]. The cause of the directional dependence of the MHVRs were found to be the effect of the lateral heterogeneity at the basin edge from numerical calculation of MHVRs [1] considering the diffuse field assumption [2]. Also, the shape of bottom of the basin close to the basin edge was estimated by fitting the peak frequency of the NS/UD component of the observed MHVRs using the theoretical MHVRs calculated using the diffuse field assumption [3].

The Reno-Carson City urban corridor is the second most populated region in Nevada and thirteen earthquakes of Magnitude 6 or larger have occurred around Reno-Carson City since 1850 [4]. Reno is located in the Truckee Meadows basin on the western edge of the IMW and in the right-lateral transtensional shear zone of northern Walker Lane. Faults in the Walker Lane, a generally linear north-northwest-trending geologic depression extending for about 800 km, accommodate approximately 20% of the Pacific-North American plate boundary relative motion. Basins in the Walker Lane along the Sierran range front, including the Truckee Meadows, formed from active extension and right-lateral shear in roughly the last 12-3 Ma. [5].The Genoa fault, a major normal fault in west-central Nevada and eastern California, displays a prominent several-meter-high scarp with a youthful geomorphic expression. The appearance of the scrarp led early workers in the area to speculate that very recent strong earthquake had occurred on the fault [6].

In this study, we observe microtremors at the Reno and Genoa region in order to image the basin structure close to the basin edge using the same methodology used for the Uji case.

## 2. Microtremor Observation

We observed microtremors at Reno and Genoa in September 2015. Fig.1 shows the location of the observation sites at Reno and Fig.2 shows that at Genoa. As for the observation lines in Reno, i.e. path1 to path4, the separation of the observation points are about 1 km. As for the observation lines in Genoa, i.e. path5 and path6, the separation of the observation points are about few hundreds of meters to 1 km, according to the distance from the fault scarp. We selected observation points that would be least affected by the traffic, but since we selected points as we drove along the roads, some observation points we somewhat close to heavy traffic. Photo 1 shows an example of the observation points. We used a portable SMAR-6A3P accelerometer made by Mitsutoyo (formerly Akashi Corporation) combined with data logger DATAMARK LS8800 by Hakusan Corporation. We made observations for 30 minutes at each site with the following conditions: 200 Hz sampling, a 500 times analog amplifier, a 50-Hz low-pass filter, time correction by Global Positioning System. We made consecutive observation of microtremors with time duration of 30 minutes along the six observation lines shown in Figs. 1 and 2.

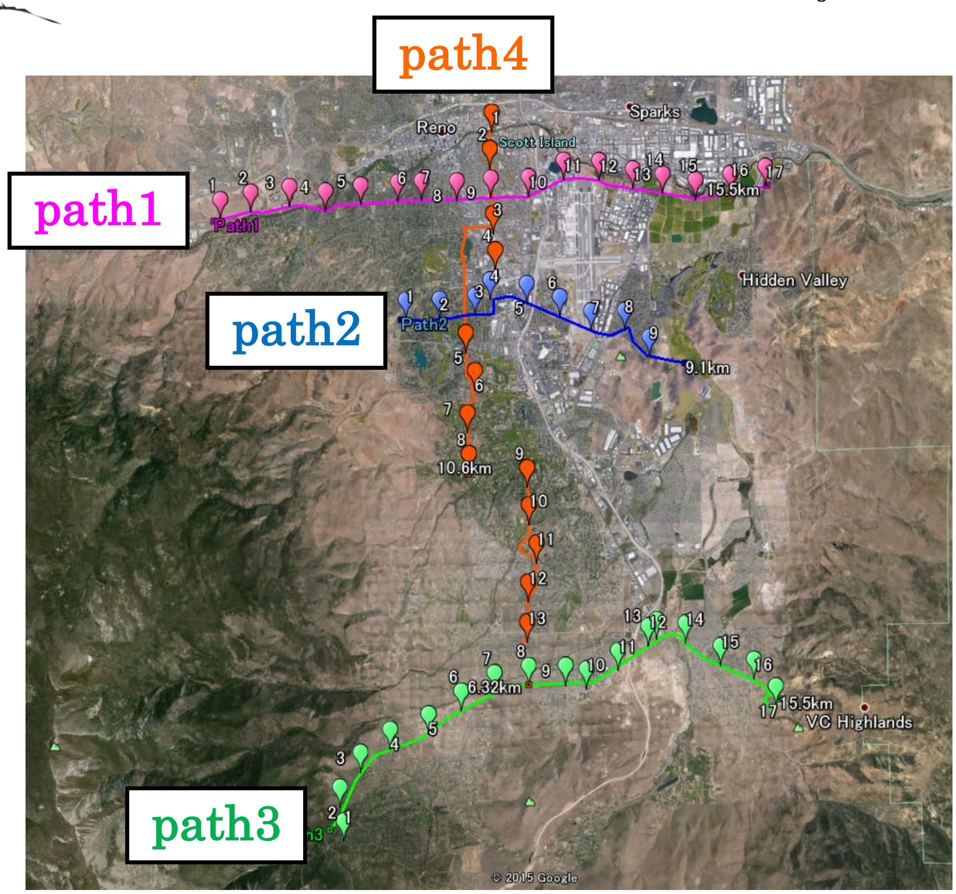


Fig. 1 Observation sites at Reno (path1-4)

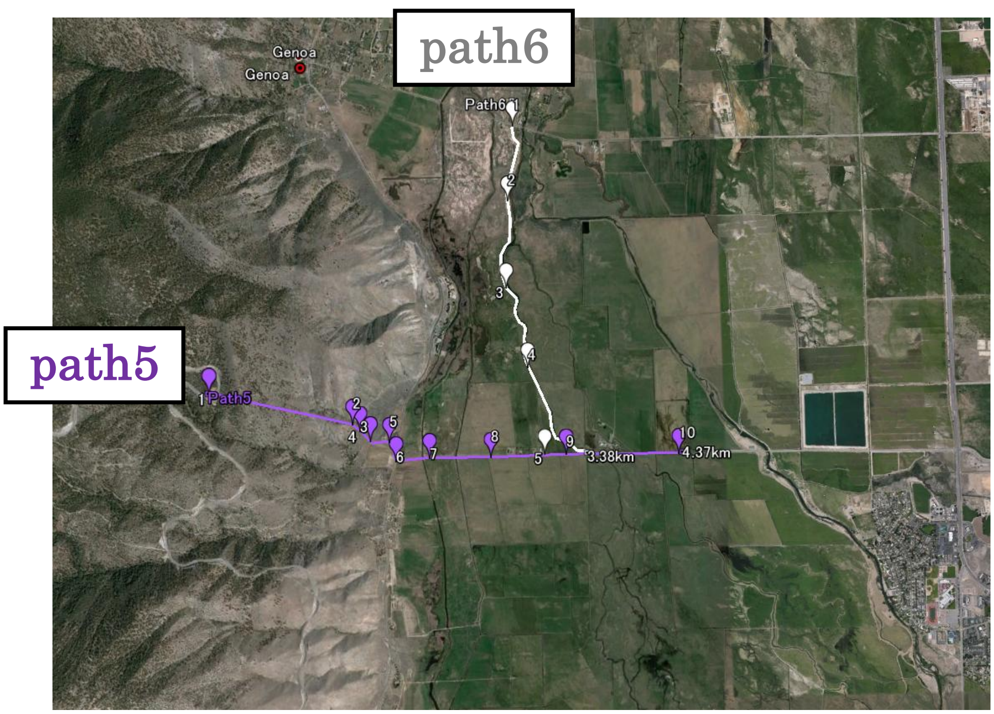


Fig. 2 Observation sites at Genoa (path5-6)

Photo 1 An example of the microtremor observation points

## 3. Observed MHVRs

For the analysis of the MHVRs, we took out 40.96 second time window sections overlapping half of the time window. We did not average the two horizontal components as done in conventional MHVR studies, but calculated the average MHVRs for each time section for NS and EW components separately. For each segment, the power spectrums $S_{NS}$, $S_{EW}$, and $S_{UD}$ were calculated and smoothed by Parzen window with a width of 0.1 Hz. The MHVRs were calculated using $S_{NS}$, $S_{EW}$, and $S_{UD}$ as shown in Eq. (1).

$$MHVR_{NS} = \frac{NS}{UD} = \sqrt{\frac{S_{NS}}{S_{UD}}},$$
$$MHVR_{EW} = \frac{EW}{UD} = \sqrt{\frac{S_{EW}}{S_{UD}}} \quad (1)$$

Fig. 3 shows the examples of observed MHVRs for sites along path1 (site1-15 to 17). There is a common peak at around 5 Hz, which can be assumed to be associated with the shallow structure at the east end of path1 and the difference between NS/UD and EW/UD is limited. For the peak in low frequency of site1-17, it shows a broad peak that may have information about the deep velocity structure, but since it is the only site with a peak in this frequency range it is difficult to claim that it is. Also, the EW/UD has higher amplitude than the NS/UD, but the strike of the assumed fault in this region is north-south, so the amplitude difference of the two components should be opposite according to the results of Uji. Fig. 4 shows those along path2 (site2-4 to 6). The MHVRs do not have clear peaks for frequency range of 0.5 to 20 Hz and the NS/UD and EW/UD look very similar, which infers that there are small impedance contrast in the shallow velocity structure. In the low frequency range, the

EW/UD is commonly larger than NS/UD for the three sites, but from the precision of the instruments, it is difficult to conclude that it is the effect of the deep basin structure. Fig 5 shows those along path3 (site3-5 to 7) and we can see that there are small impedance contrast in these areas. The low frequency range peaks needs to be checked thoroughly before we can decide if it contains information about the deep basin structure. Fig 6 shows those along path4 (site4-1, site4-5, site4-13). Theses MHVRs also show the low impedance contrast in the shallow subsurface structure. Fig. 7 shows those along path5 (site5-1, site5-3, site5-4, site5-6 to 5-8). For observation points site5-7 and site5-8, there are peaks around 0.2 to 0.3 Hz and it looks as if it is shifting to the higher frequency as the point is going away from the fault, inferring that the subsurface structure is getting shallower as it gets further from the fault scarp.

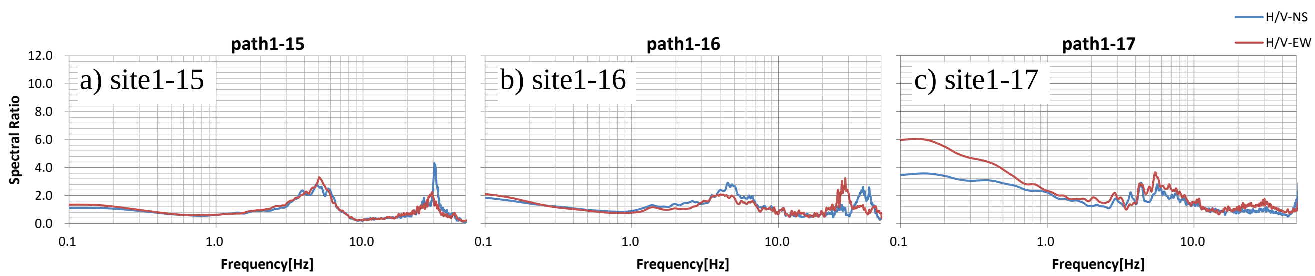


Fig. 3 MHVRs for sites a) site1-15, b) site1-16, c) site1-17 along path1

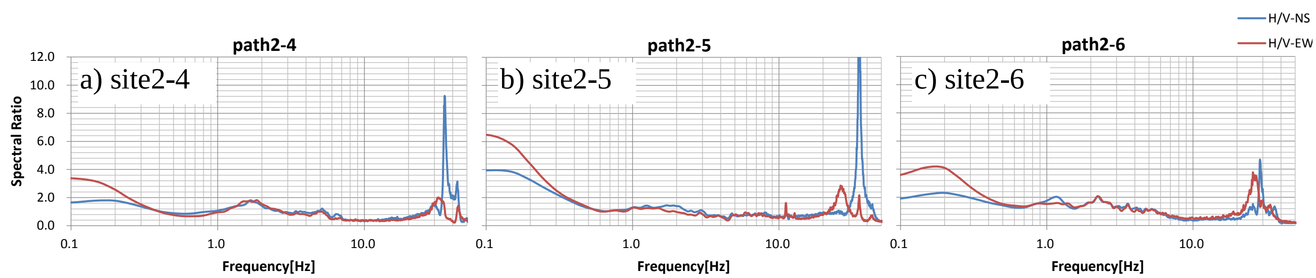


Fig. 4 MHVRs for sites a) site2-4, b) site2-5, c) site2-6 along path2

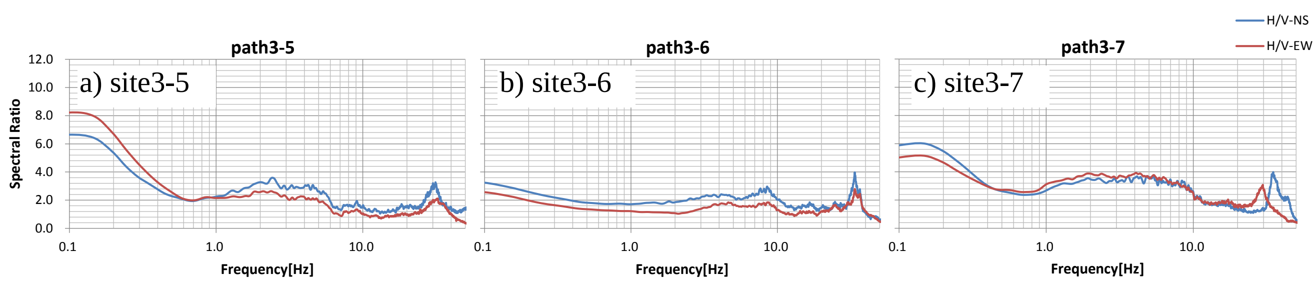


Fig. 5 MHVRs for sites a) site3-5, b) site3-6, c) site3-7 along path3

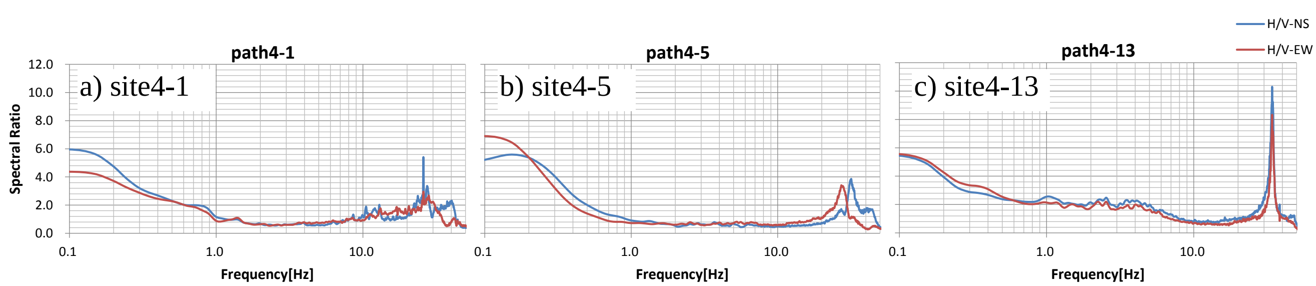


Fig. 6 MHVRs for sites a) site4-1, b) site4-5, c) site4-13 along path4

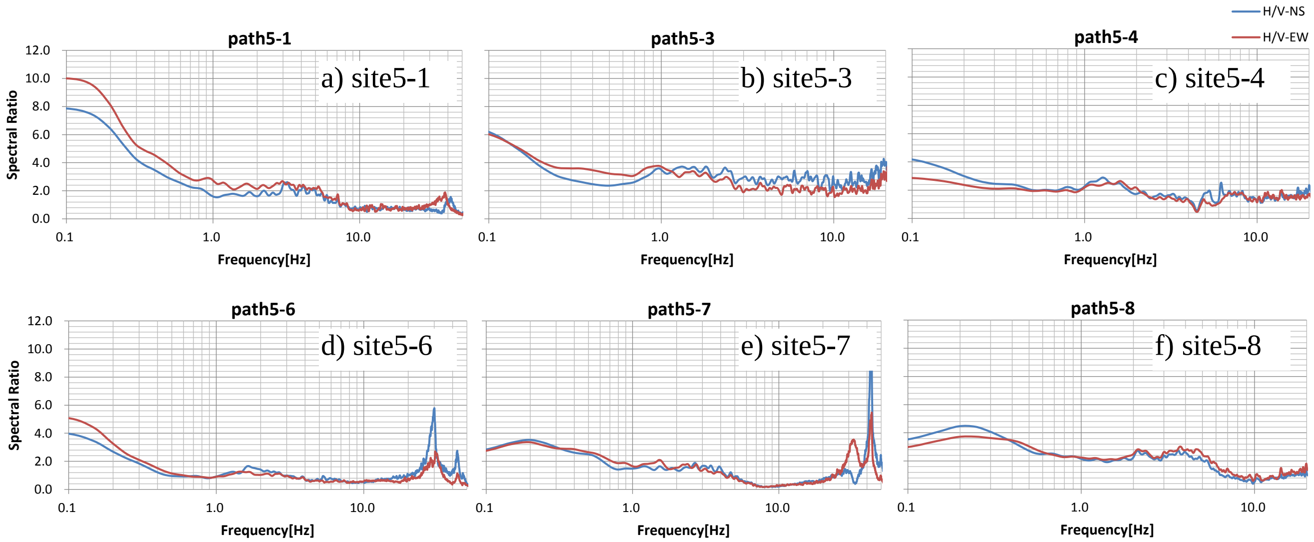


Fig. 7 MHVRs for sites a) site5-1, b) site5-3, c) site5-4, d) site5-6, e) site5-7, f) site5-8 along path5

## 4. Conclusion and Future Tasks

In previous studies in Uji Campus, Kyoto University, it was shown that the MHVRs have information about the heterogeneous subsurface structure close to the basin edge. The studies showed that the structure of the basin edge makes large difference to MHVRs. In this study, we observed microtremors at Reno and Genoa, Nevada, USA, in an attempt to estimate the depth of the basin and the shape of the basin edge from directional dependent MHVRs that is expected to be observed in the target area. We focused on the effect of the basin edge to the MHVRs and tried to study the relationship between the basin edge shape and the difference between NS/UD and EW/UD in the observed MHVRs.

The observed MHVRs at Reno and Genoa shows some peaks that seems to correspond to the basin depth, but most of the observed MHVRs shows that there are small impedance contrast in the area. From the observed MHVRs, it is difficult to derive information to estimate the velocity structure. In order to investigate the conditions of the basin structure in the Reno and Genoa regions, we need to try to observe microtremor with instruments that allows us to catch the signal in the low frequency range.

For this purpose, we will conduct microtremor observations in Reno and Genoa again, and get detailed information about the basins in Reno and Genoa. We will also use strong motion data to extract the necessary information to estimate the basin structure.

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