# Determination of the Bedrock Structure of Plain in the Central Part of Shan'in District, the West Japan Based on Observation Data of Microtremor and Gravity

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**SUMMARY:**
Microtremor observations and gravity surveys' data of Izumo Plain, Matsue Plain and Yumigahama Peninsula, the eastern Shimane Prefecture and the western Tottori Prefecture in the central part of San'in district, the west Japan were analysed to determine the underground structures. The result is as follows. The S-wave velocity structure models were determined from the results of microtremor array observations data. A 3D model of density bedrock was obtained from the gravity anomaly data. The S-wave velocity structure models were used in the 3D gravity model of the depth to bedrock. A 3D configuration of bedrock was determined in the whole area and it was found from the obtained bedrock structure that there are steeply dipping structures in the south part of Shimane peninsula.

*Keywords: bedrock structure, plain, microtremor, gravity anomaly, San'in district*

## 1. INTRODUCTION

The target area of this study is Izumo Plain, Matsue Plain and Yumigahama Peninsula, the eastern Shimane Prefecture and the western Tottori Prefecture in the San'in district, the west Japan. Damaging earthquakes; the 1854 Ansei-Nankai earthquake, the 1872 Hamada earthquake, the 1946 Nankaido earthquake and the 2000 Western Tottori prefecture earthquake occurred in the area. The severely damaged area was concentrated on some parts of the plains. It is thought that this concentration of damage was caused by the characteristics of the strong earthquake motion, which is given by the local site effects of the area. We need to investigate the causes of the local site effects for the prevention or mitigation of earthquake disasters in the area. The purpose of our study was to determine the bedrock structures of the area by using microtremor and gravity observational records.

## 2. MICROTREMORS AND GRAVITY DATA

To determined S-wave structure models, microtremor arrays observational data at 12 sites were used for analysis. The array observation was executed by using many kinds of radii within the range from 3m to be 2000m for each site according to the situation of the site. For the analysis, the spatial autocorrelation (SPAC) method (Aki, 1957) is applied and phase velocities are estimated. The SPAC method is a technique of geophysical exploration that is used to infer phase velocities of surface waves using records of microtremors from a circular array of seismic sensors deployed on the ground surface. The frequency range of the dispersion curves of phase velocity are 0.3 -10Hz. The minimum and maximum values of phase velocity are 150m/s and 2500m/s, respectively. The velocity structures were determined by using a heuristic approach based on forward calculations by using fundamental mode of Rayleigh wave in the frequency range of 0.3 - 2Hz (Adachi et al., 2008 and Sakai et al., 2006).

The gravity observational data were existence data which the gravity survey was carried out at about 500m - 1km intervals in the central part of San'in district (Adachi et al., 2008 and Sakai et al., 2006)

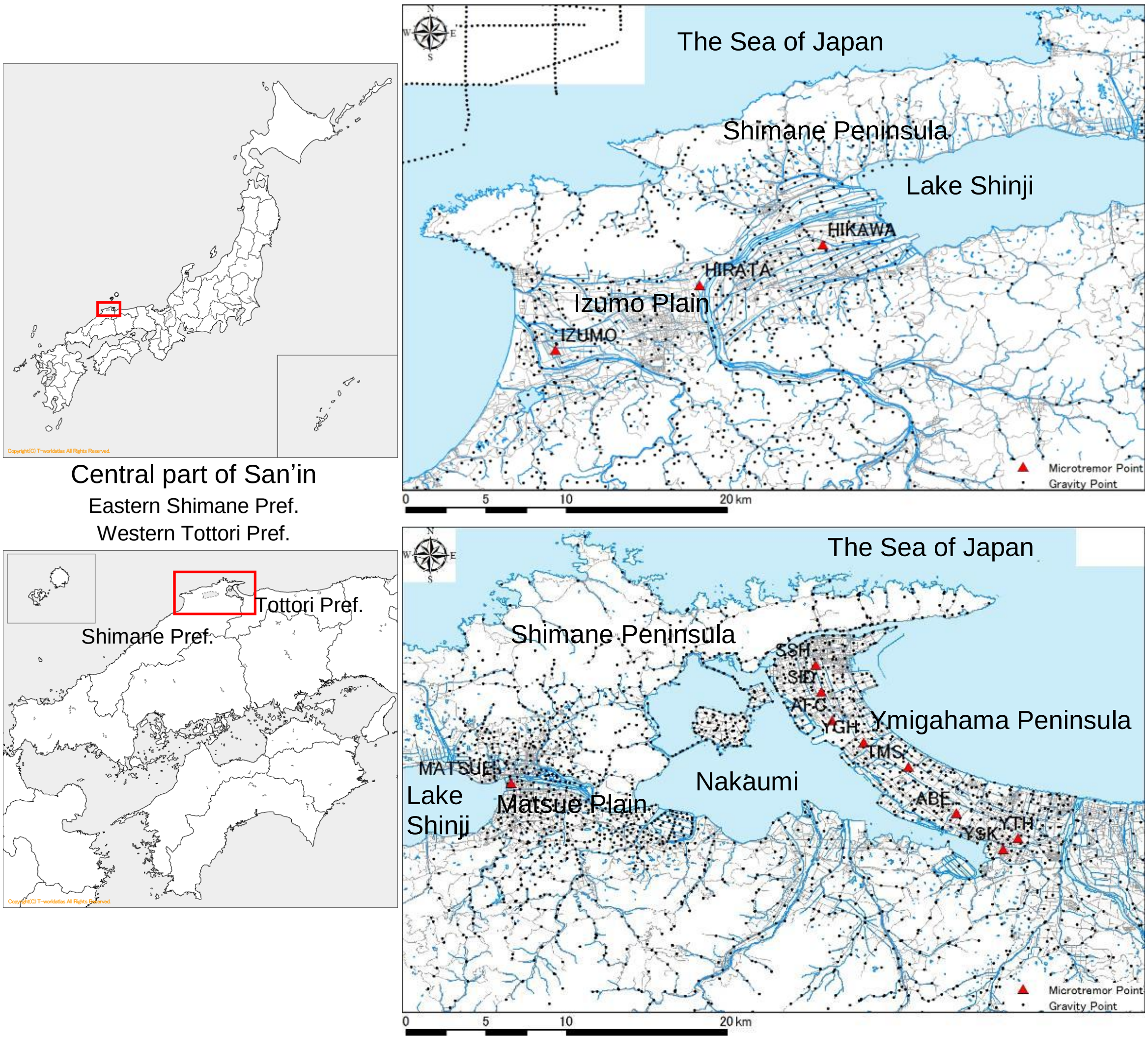


**Figure 1.** Location of microtremor array observation sites (triangles) and gravity observation points (circles)

**Table 1.** Final subsurface structure models at the microtremor array observation sites

| $\rho$ (t/m$^3$) | Vp (m/s) | Vs (m/s) | Thickness (m) | | | |
|---|---|---|---|---|---|---|
| | | | IZUMO | HIRATA | HIKAWA | MATUSE |
| 1.7～2.0 | 1450～1850 | 150～600 | 200 | 250 | 240 | 110 |
| 2.2～2.3 | 2730～2900 | 1300～1500 | 900 | 300 | 90 | 560 |
| 2.4～2.5 | 3500～3800 | 2000～2500 | 1200 | 1100 | 1100 | 630 |
| 2.6 | 5000～5100 | 3000～3400 | ∞ | ∞ | ∞ | ∞ |

| Thickness (m) | | | | | | | |
|---|---|---|---|---|---|---|---|
| SSH | SID | AFC | YGH | TMS | ABE | YSK | YTH |
| 176 | 255 | 252 | 230 | 221 | 123 | 126 | 162 |
| 890 | 550 | 800 | 500 | 600 | 150 | 100 | 150 |
| 1150 | 1130 | 1000 | 500 | 800 | 180 | 250 | 200 |
| ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ |

and published data from gravity database CD-ROM (Gravity Research Group, 2001 and AIST, 2004). The terrain correlation was made with a topographic 50 m and 250 m mesh digital data to obtain the gravity anomaly. An adequate setting of the densities is vital to estimate the subsurface profile appropriately. Locations of the observation points are shown in Fig. 1.

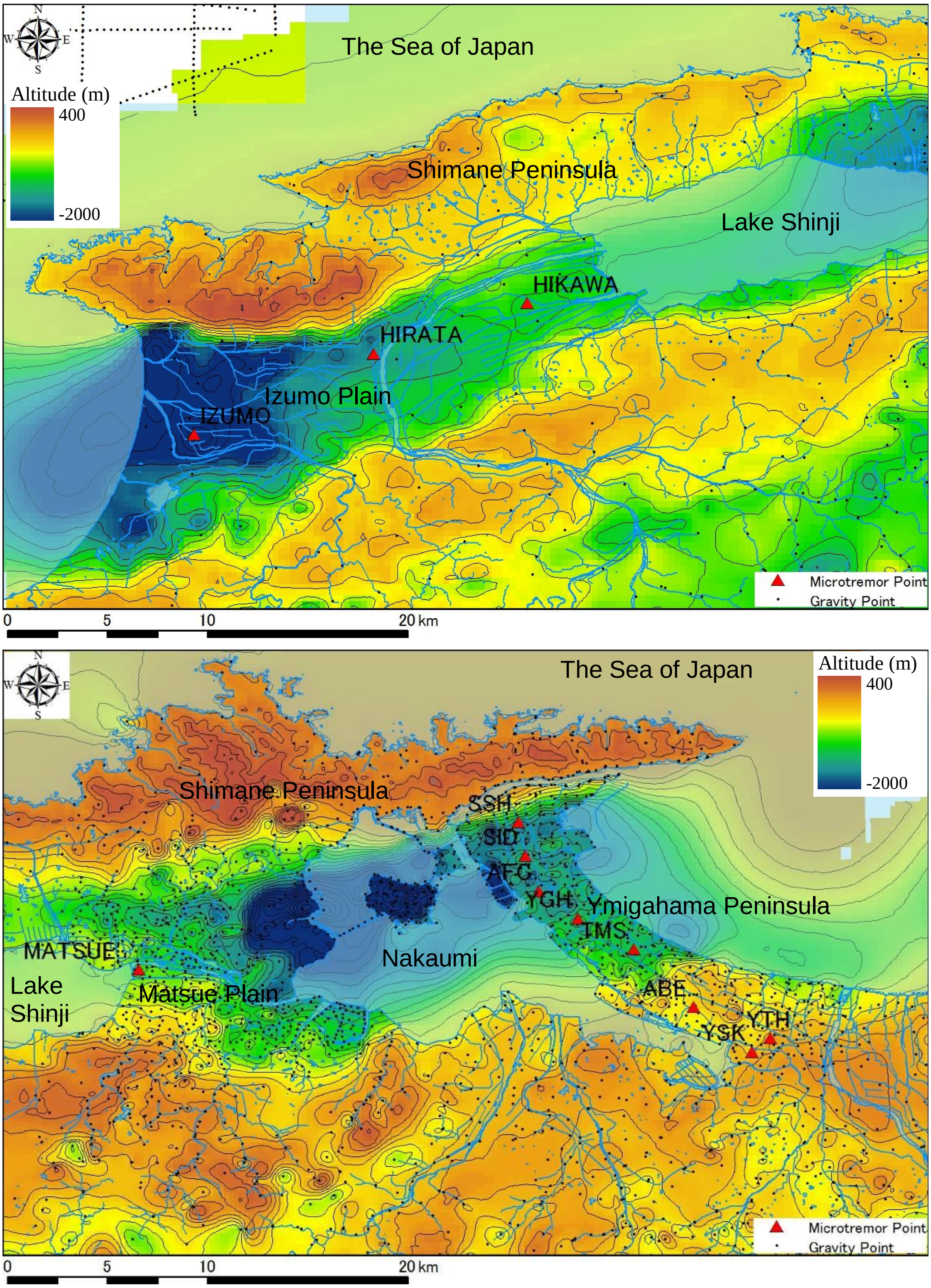


**Figure 2.** Contour map of the 3D density structure model. The interval between the contour lines is 100m.

## 3. DETERMINATION OF BEDROCK STRUCTURES

Subsurface structure models were determined by trial and error based on the forward calculations (Adachi et al., 2009 and Sakai et al., 2006). As a result, the layers with some different velocities structure are determined. Parameters of the subsurface structure models are number of layers, density, P-wave velocity; [Vp], S-wave velocity; [Vs] and layers thickness. The final subsurface structure model is shown in Table 1.

A 3D density structure was automatically calculated from the observed gravity anomaly. A suitable assumed density of gravity anomaly was determined to be 2.5g/cm$^3$ as a bedrock layer. Program codes of a 3D analysis method (Komazawa, 1995) were used to determine 3D density structures. This method uses the automatic forwarding method of underground structure. The parameters required are density differences between surface and bedrock layers of two homogeneous layers and a control point for bedrock depth. In addition, the depth to the bedrock layer in the 2-layer model was restricted to the outcrop point and the depth to the bedrock layer of S-wave velocity structural models in the array observation. We thought the density difference between the sediments and the bedrock layers was optimized to be 0.4 g/cm$^3$ in the case of 2-layer model. To remove the structure effect of the part deeper than 5km, a band pass filter that combines two upward continuation filters of 50 m and 5000 m was used. The 3D bedrock structure is shown in Fig. 2.

An overview of 3D bedrock structure is as follows. Deep bedrock areas whose depth is approximately 1000m to 2000m are found in the north part of Izumo Plain, Matsue Plain and Yumigahama Peninsula. Shallow area whose depth to bedrock is approximately 200m to 500m is found between Izumo Plain and Matsue Plain. The maximum depth to bedrock is approximately 2000m. There is a steeply slope topography and the deepest parts exit in a south part of Shimane Peninsula.

## 4. CONCLUSION

In this study, the bedrock structure of plains in the central part of the Shan'in district, the west Japan was determine based on the microtremor observations and gravity surveys data. As the results, the 3D bedrock model was obtained by a 3D gravity analysis using the results of S-wave velocity from microtremor data as for the bedrock depth as control points. It was found that there are steeply dipping structures in the south part of Shimane peninsula and the maximum depth to bedrock was approximately 2000m.

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