P-37 六甲山地、五助橋断層の地中レーダ探査

近藤 大輔（神戸大）、田中 健一（神戸大）、宮田 隆夫（神戸大）

GPR survey for the Gosukebashi fault zone in the Rokko Mountains, SW Japan

Daisuke KONDO (1), Ken-ichi Tanaka (1), Takao MIYATA (2)
(1) Department of Earth and Planetary Science, Graduate School of Science and Technology, Kobe University
(2) Department of Earth and Planetary Science, Kobe University

Introduction

Ground-penetrating radar (GPR) survey was conducted across the well-known Gosukebashi fault zone in the Rokko Mountains in order to investigate the shallow fault structures in granites. The fracture zones contain a lot of water, based on observation and the report of a tunnel construction.

The purpose of this study is
(1) to investigate fracture zones along the faults in massive granites using GPR,
(2) to obtain the deeper subsurface structures than around 30m in depth of the GPR investigation until now, and
(3) to survey the inside structure of the fracture zone.

GPR Technique

GPR is an investigational method to know the subsurface structure by electromagnetic wave. We used a SIR-2 system with 35MHz and 100MHz frequency antennas.

The GPR data were processed. We could get the velocity of electromagnetic wave in the granites to detect an underground object.

We executed the overgain processing in order to investigate the inner structure, and carried out the migration processing for them if necessary.

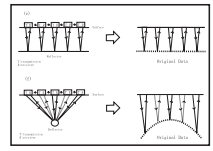


Fig.4.Measuring Methods of ground-penetrating radar.
(e) The mesurement of a sediment with a layer.
(f) The mesurement of a object: In this case, we have to carry out a migration procedure.

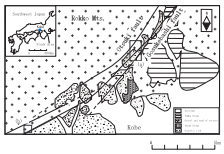


Fig.1. Geological map of the east Kobe (Simplified from Fujita･Kasama, 1982)
(a) and (b) are measurement area. The enlargements are Fig.3.

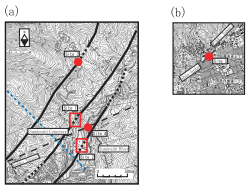


Fig.3. Location map of GPR survey lines. This area is located to the east of Kobe. The GPR surveys were carried out at five sites across the Gosukebashi fault and above the Rokko tunnel. The blue dotted line shows a cross section (Fig.2).

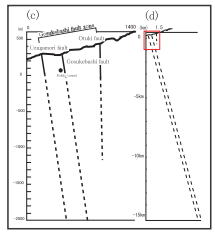


Fig.2. Schematic illustration of the Gosukebashi fault zone (c). The Gosukebashi fault zone is composed mainly of the Otuki, Gosukebashi, and Uzugamori faults near the ground surface (The fault spacing is 200～400m) . (d) Even if the faults are separated from each other on the ground surface, we could image that the faults gather to narrow zone at the deep part, at which the Kobe Earthquake occured.

Photo.A. Photograph showing the locating of the Gosukebashi fault and the Uzugamori fault from east to west (Sumiyoshi Cemetery).

Fig.5.Photograph showing the measurement way of 35MHz antenna across the Uzugamori fault (Site 2).

Fig.6. Map of the site 5. Red line is the GPR survey line. Blue dotted line is the Rokko tunnel. We investigated this line for information about a velocity in the granite.

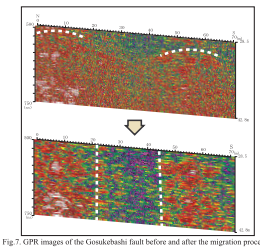


Fig.7. GPR images of the Gosukebashi fault before and after the migration processing.

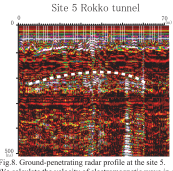
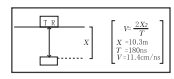


Fig.8. Ground-penetrating radar profile at the site 5. We calculate the velocity of electromagnetic wave in granite zone by detecting the underground object. This value is similar to the velocity of granite, so we adapt this value in the depth.

Material	Velocity (m/ns)
Air	30
Granite,dry	13
Granite,wet	11
Sand,dry	12~15
Sand,wet	5~9
Fresh,water	3.3

Fig.9. Velocity of electromagnetic wave of rock and soil. (After Uchida, 1984 and Daniels, D.J., 1996)



Range (ns)	100	150	200	250	500	750	1000	1250
Depth (m)	5.7	8.6	11.4	14.3	28.5	42.8	57.0	71.3

Fig.10. The depth of each range

Fig.11. Map of the Sites 1 and 2. Red lines are the GPR survey lines. Black dotted lines are the Gosukebashi and Uzugamori faults.

Result

Site 1 Gosukebashi fault　　Site 2 Uzugamori fault

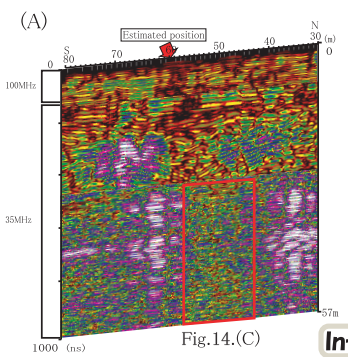


Fig.14.(C)

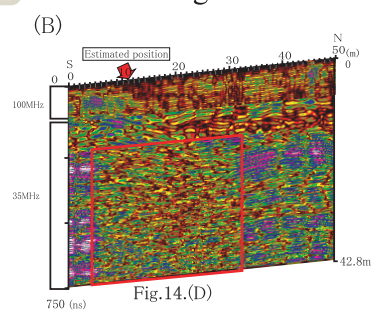
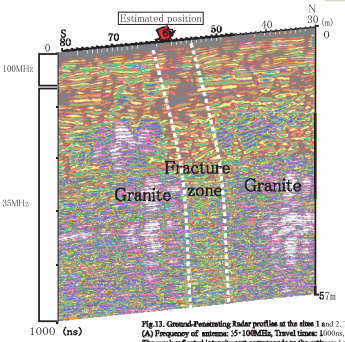


Fig.14.(D)

Interpretation



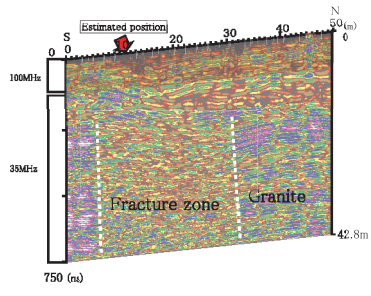


Fig.13. Ground-Penetrating Radar profiles at the sites 1 and 2. The upper figures are GPR results, and the lower figures are their interpretations.
(A) Frequency of antenna: 35+100MHz, Travel times: 1000ns, Distance: 50m, Depth: 57m, (B) Frequency of antenna: 35+100MHz, Travel times: 750ns, Distance: 50m, Depth: 42.8m.
The weak reflected intensity part corresponds to the estimated position of a fault. The width of the fracture zone coincides with that of geological observation and the Sanyo-Shinkansen Work Records

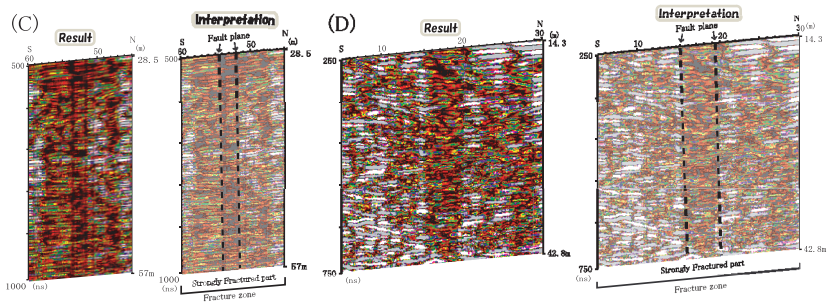


Fig.14. The results of overgain processing at the site 1 and 2. The left figures are the results, and right figures are their interpretation.
I selected the lower part of fracture zone of Fig.13.'s results, and overgained the parts.

We selected five GPR- survey sites along the Gosukebashi fault zone and the Rokko tunnel, of which its depth is already known. The results of the Sites 1 and 2 are shown in Fig.13, except for a GPR profile obtained from 500 ns at the Site 3. The GPR result at Site 4 caught a reflected signal from the Rokko tunnel, but could not catch it at the Site 5.

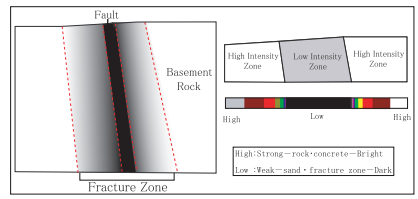


Fig.12. The image of fracture zone by ground-penetrating radar (GPR) exploration. Low intensity part from GPR image corresponds to a fracture zone. The reflective intensity pattern of this part is disclosed by dull color image. For this study, although it is difficult to specify the position of faults, it is not difficult to show the fracture zone. Therefore we think the fault plane exists in somewhere of the fracture zone.

Results and Interpretations

We obtained for the first time the favorable GPR images which were over 50 m deep. The obtained GPR data (upper figures in Fig. 13 are interpreted as follows : (See the lower figures)

(1) The strong reflected pattern on the GPR profile means granite, while the weak reflected pattern means weathered and fractured parts.
(2) The weak reflected part extended beneath can be regarded as the fracture zone of the Gosukebashi fault or Uzugamori fault, respectively.
(3) The fracture zone width (~20m) of the Uzugamori fault at the Site 2 is lager than that (~10m) of the Gosukebashi fault at the Site 1.
(4) We obtained the linear structures,interpreted as fault planes within the fracture zone, using the overgain processing.

Conclusions

The following results were obtained:

(1) The wide fracture zone of the Gosukebashi fault zone was found as the detected anomalies on GPR images.
(2) The GPR with a 35 MHz antenna allowed for favorable imaging until a range of 1000 ns at the test sites of the Rokko Mountains.
(3) When the condition of the GPR survey is favorable as a case of the test sites, we found GPR with the 35MHz antenna to be very useful in understanding the subsurface fault structures over the depth of 50 m.
(4) We obtained the inner structures within the broad fracture zone on the GPR images, using the overgain processing.