CHARACTERIZATION OF THE SHALLOW STRUCTURES OF THE DEREN FAULT BY GROUND PENETRATING RADAR

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1. INTRODUCTION

Mongolia often experiences earthquakes due to the collision of the Indian-Australian plate with the Eurasian Plate, as well as the extension of the tectonic structure associated with the Baykal rift system [1]. As a result, several new faults are emerging near Ulaanbaatar city, the capital of Mongolia. The city is exposed to a high earthquake risk.

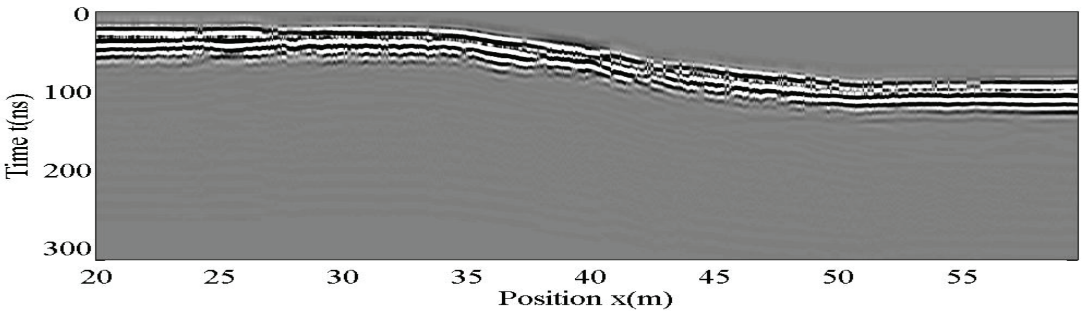
Ground penetrating radar (GPR) has been widely used in geologic, hydrogeologic, and civil engineering purposes. Correlated with geological exposures and trenches, GPR data can offer detail subsurface information to past earthquakes investigation. McClymont et al. [2][3] show very good performance of GPR for fault characterization. In this paper, we show an example of practical application of GPR to fault detection. Based on the processed data information, we interpret the data in terms of a simple structural model.

2. GPR DATA ACQUISTION AND PROCESSING

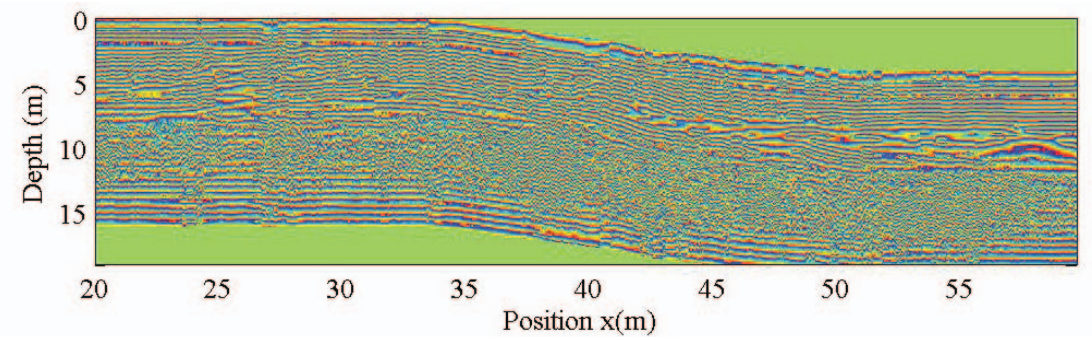
The field experiment by GPR was carried out in the Deren Fault about 200 Kilometers south of Ulaanbaatar city. RAMAC GPR system (MALA Geoscience, Sweden) with 100MHz antennas was used in the study. The RAMAC system employs physically separable transmitter and receiver antennas with 1.0 m offset. The experiment field is shown in Figure 1. The survey line is parallel and 35 m far away to the trench. The GPR traces were recorded at 0.05 m intervals along 100 m-long line.

After applying a cross correlation technique to align the airwave arrivals, a mean trace removal was used to suppress the strong directly coupled signal. Instantaneous attributes can be obtained by expressing the GPR trace as a complex function by Hilbert transform [4]. The instantaneous phase emphasizes the continuity of events independent on the reflection strength. The velocity of the electromagnetic wave in the subsurface was measured by Common-mid-point (CMP) data and yielded velocity of 0.12 m/ns. The GPR profiles after topographic correction and depth conversion are shown in Figure 2.

Fig.1 The experiment field in the Deren fault, 200 km south of the Ulaanbaatar city, Mongolia.



(a)



(b)

Fig.2 GPR data (a) before processed by Instantaneous phase (b).

3. DATA INTERPRETATION AND DISCUSSION

The sketch of the trench walls is shown in Figure 3. It shows very hard sand stone with cracks. The cracks are filled by soil, carbonate, gravels, coarse sand, mud volcano and animal bones. Figure 4 shows the correlation between the trench structures with GPR data. The GPR data show the phase change around 45 m marked by an arrow in Figure 4. It corresponds to the trench observation where the cracks filled by the sand stone, white carbonate, gravels and coarse sand. It can be caused by the tectonic movement. There is a crack around 38 m in the trench filled with soil, gravels and animal bones, marked by an arrow, and it corresponds to the discontinuities of the reflection event in the GPR profile. The similar discontinuities can also be obvious around 27 m and 33 m. Based on above observations, we estimate the locations of faults, marked by white lines in Figure 4. We observe a phase change around 51-59 m (10 m depth) and it is estimated as the crack fillings. This kind of structure can help to define the fault.

Although the trench reveals more structures than can be observed in the corresponding GPR profile, the main information correlate with the fault locations. We use a simple geological model (Figure 5) inferred from GPR data to interpret the subsurface structures. The weathering rock layer is 4-6 m thick lying under the topsoil with soft sand and a relatively stable structure, the bedrock, underlying it.

4. CONCLUSIONS

We have demonstrated the applicability of GPR technique for characterization of the shallow structures of the fault. The processed GPR data showed details of subsurface information correlated to the fault. Many of the identified structures ranging from a few tens of centimeters to depths >10 m were not evident at the surface. Using surface-based observations from the geological trench, GPR data can reveal complicated fault zone information such as location, dip and azimuth.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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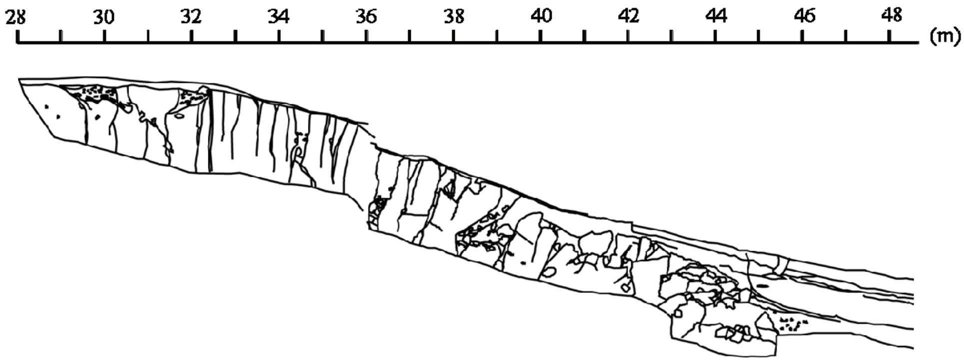

Fig.3 The sketch of the trench walls with corresponding position to the survey line.

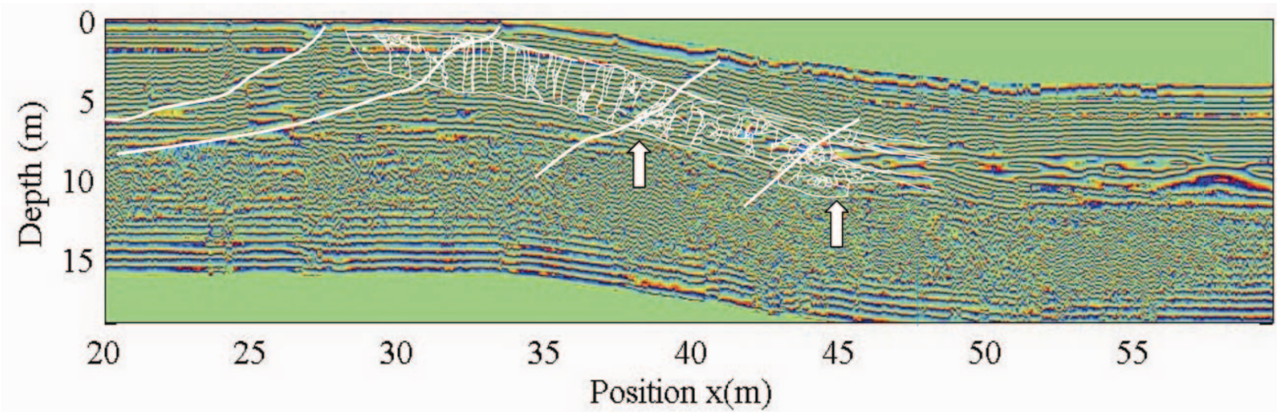

Fig.4 Correlation of GPR data with trench observations.

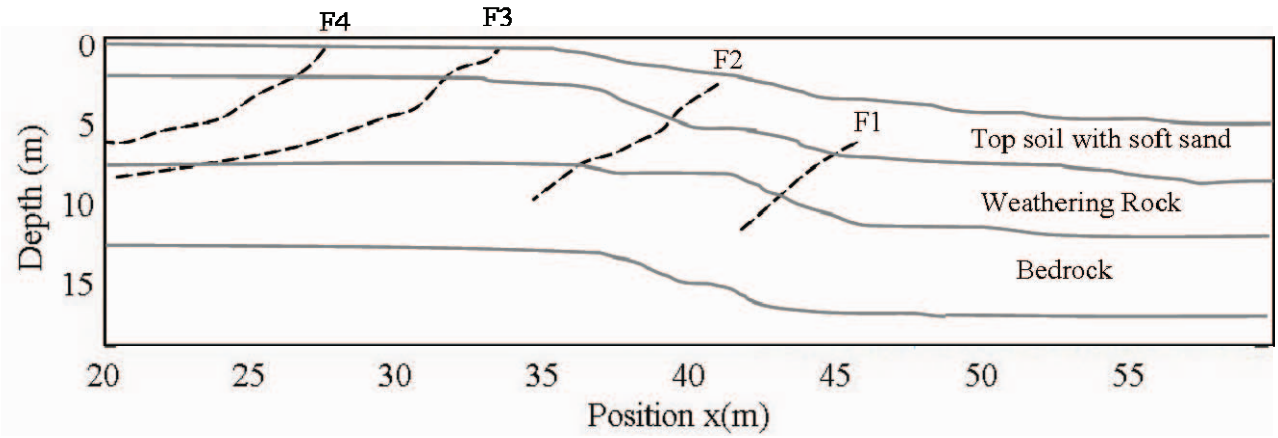

Fig.5 Simple geological model interpreted from Figure 4.