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NOTES AND CORRESPONDENCE

The 1999 Earthquake Fault and Its Repeated Occurrence at the Earthquake Museum, Central Part of Chelungpu Fault, Taiwan

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ABSTRACT

This paper reports on the trench log data covering the Chelungpu Fault preserved at the National Science Museum and 10 bore hole data across the fault. Trench log indicates the vertical offset of the 1999 displacement of terrace deposits is ca. 1.5 m and the presence of four branch faults cutting terrace deposits within 1.8 m width zone. Estimated height difference of bedrock surface based on bore hole data is more than 4.2 - 5.8 m, larger than the offset by the 1999 earthquake. These facts imply that at least one earthquake event occurred at this site before the 1999 earthquake. We also estimate the fault plane dips eastward at about 30 degrees based on the location and stratigraphy of one bore hole which penetrates the terrace gravel on the hanging wall through the bedrock.

Key words: 1999 earthquake, Chelungpu Fault, Trench, Bore hole data, Repeated fault activities

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1. INTRODUCTION

The deformed sport grounds at Wefeng, central part of the Chelungpu Fault, Taiwan, is a well known location which shows clear surface deformation by the 1999 Chi-Chi earthquake (Fig. 1) and has been cataloged in many papers (e.g., Chen et al. 2001; Angelier et al. 2003; Ota et al. 2007). The Kung-fu Middle School is truncated by the fault and is damaged severely (Fig. 2). The Earthquake Museum is established on this fault, next to the destroyed school building. The amount of vertical offset here by the Chi-Chi earthquake is measured to be 2 - 2.5 m (Fig. 2, Ota et al. 2007) with an upthrust found in the northeast. A trench wall across the surface rupture is preserved and exhibited at the museum with a simple trench log (Fig. 3). No detailed interpretation was given for the nature of faulting, however. Also no fault exposure was recorded nearby. Ten bore holes are excavated on both sides of the fault for the basic work of the construction of the Earthquake Museum. We examined the characteristics of deformation of terrace deposits recorded in this trench wall, and also examined the thickness of terrace deposits based on bore hole data, in order to verify the presence of preexisting fault prior to the Chi-Chi earthquake.

2. TRENCH LOG AND INTERPRETATION

Preserved trench wall is 9 m long and 4 m deep. The stratigraphy at this locality is divided into four units from 1 to 4 from the top to the bottom (Fig. 3). Although vertical deformation of terrace deposits is very clear, a problem remains if the terrace deposits are cut actually by the fault or only bended without faulting (see Chen et al. 2007a for this kind of discussion). We examined the facies and structure of deposits near the ruptured zone. Since we are not allowed to scrape the trench wall, and climb up the wall, we provided tentative grid strings on the trench wall surface and sketched the wall carefully. The area outlined by thick line (Fig. 3) is drawn based on our observation.

The stratigraphy is mostly based on Hou-Shu Tang who provided the trench log at the Museum: Unit 1 is an artificial

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fill with thickness of 2 - 2.5 m and includes many concrete blocks and brick fragments. Thus it is certainly artificial in origin. Unit 2 is a sand bed, 0.3 - 0.4 m thick, composed of well sorted fine sand with some stratification. It is at thickest on grid 4 - 4.5 m, reaching to 0.5 m thick. It appears to be overbank deposits, and has a sharp boundary with the underlying Unit 3, sand and gravel bed. Some concrete blocks and a sneaker were found on the boundary. Thus we assume there was some time hiatus between the deposition of Unit 2 and 3. This sand and gravel bed is composed of rounded and subrounded fluvial gravels, reaching maximum diameter of 40 cm. Its thickness is 1 - 1.2 m on the hanging wall, but no data are available for the foot wall. Unit 4 is Jin-sewi Shale and is exposed only on the hanging wall. No datable material is obtained from this trench wall, but the presence of artificial materials beneath the Unit 2 indicates that Unit 2 deposited in very recent time.

We can identify the deformed zone of 1.8 m width at grid 3.5 - 5.3. We can see four subparallel faults (F1 - F4) within this deformation zone, the location of which corresponds to the distinctive scarp expressed by the upper and lower boundary of Unit 2. We placed dashed lines for these proposed faults, based on the presence of linear arrangement of the long axis of rotated gravels (Figs. 3 and 4). F1 probably coincides with the western margin of Jin-swei Shale. Other three faults seem to converge downward, making a fault zone. There are complex displacements of lamination within Unit 2 on the upward extension of the four faults (Figs. 3 and 4). We assume that the Jin-swei Shale is thrust over into alluvial deposits along the fault as seen in many trenching walls across the Chelungpu Fault (e.g., Chen et al. 2007b) and then the fault diverges into four branches within unconsolidated Unit 3. However, we still can trace the faults within Unit 3 by the linear arrangement of gravels. We also can see the effect of faulting from the displacement of lamination within Unit 2. The shortening as the resulting strain for reverse faulting is expressed as the thickening of Unit 2.

3. EXAMINATION OF BORING DATA ACROSS THE FAULT

Among ten bore holes drilled by the Cung-chi Technical Consultant Co. Ltd. six bore holes are excavated on the

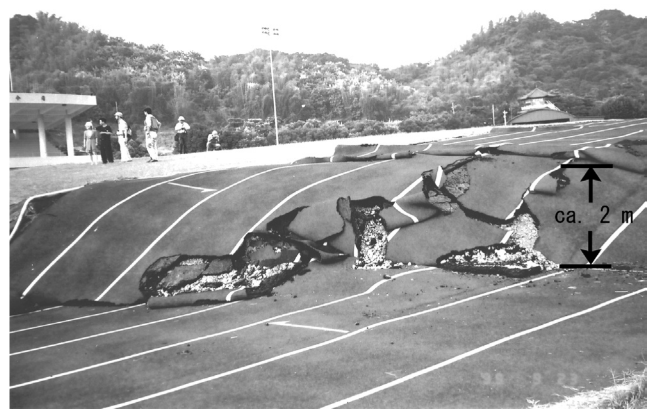

Fig. 1. Surface deformation on the sport grounds at Wefen (photo by Ota, 23 September 1999). Convex profile of the scarp and overriding hanging wall on the foot wall are clearly visible.

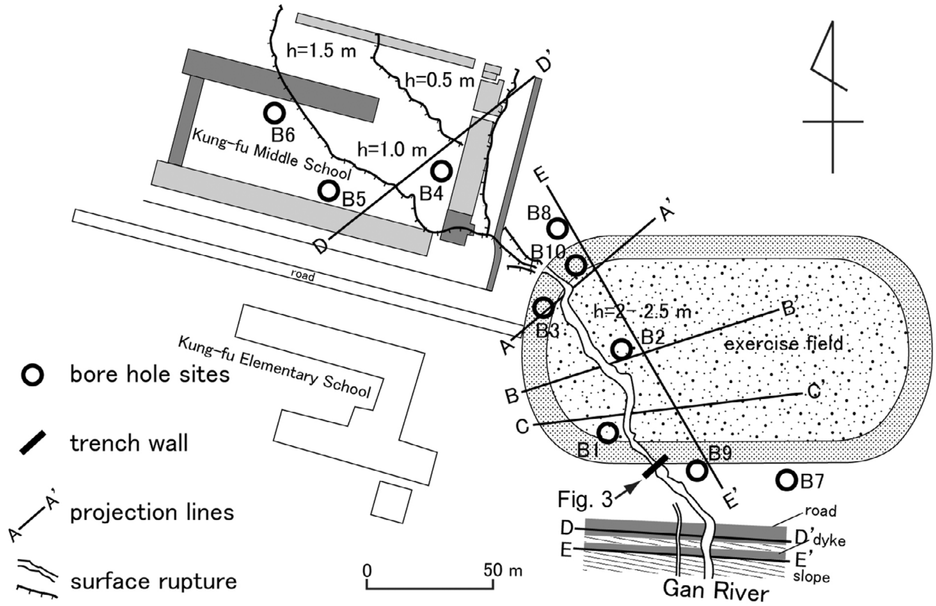

Fig. 2. Map showing the location of the surface rupture truncating the sport grounds (Ota et al. 2007). Trench site and drilling sites are shown on this map.

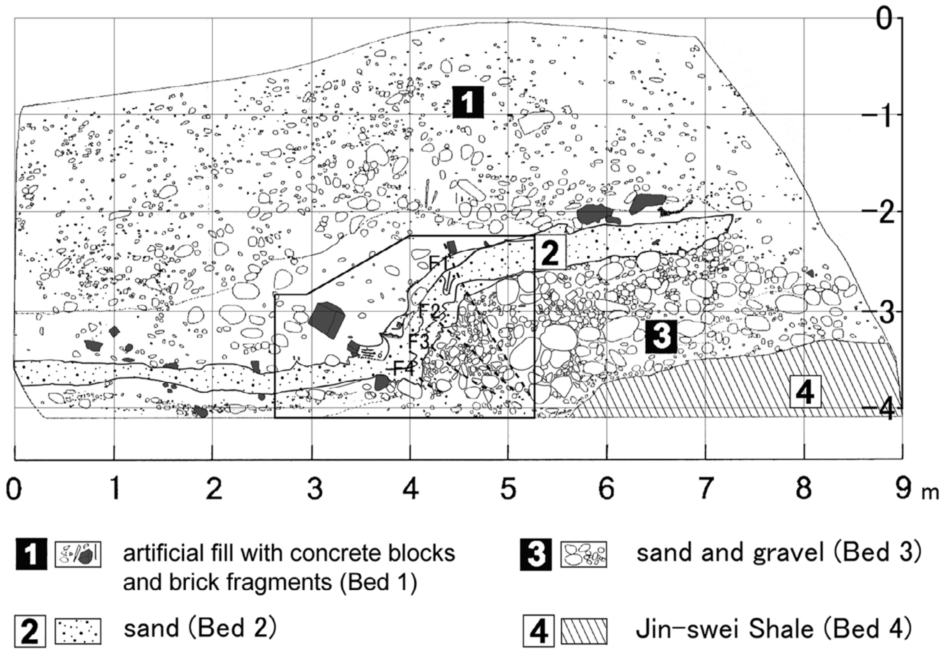

Fig. 3. Trench log across the 1999 surface rupture, preserved at the Earthquake Museum (drawn by Tung). Sketch within the section outlined by thick line is by our observation (on 18 June 2008). Four faults, F1 to F4, are seen in the deformation zone of 1.8 m in width.

hanging wall of the fault and four on the foot wall (Fig. 2). Gravel bed, shown in the stratigraphic columns corresponds to Units 2 and 3 at the trench wall. All of bore holes on the hanging wall reach to the bedrock (Jin-swei Shale) at 4 - 6 m below the ground surface. In contrast, no sites reach to the bedrock on the foot wall (Fig. 5). Although thickness of the gravel bed on the foot wall is not confirmed, the bedrock surface is surely more than 6 - 7 m below the surface. Therefore, we can assume that height difference of bedrock surface is larger than that of the surface rupture (2 - 2.5 m) associated with the 1999 Chi-Chi earthquake and that there was a fault scarp before the deposition of terrace deposits. Thus, at least two faulting events including 1999 event are estimated in this area.

The bore hole B4 reaches to the bedrock at 5.2 m depth, and then reaches to the terrace gravel again at 11.7 m deep. This site is located 18 m east from of a branched fault (Fig. 2). These data indicate that the fault plane dips eastward with a dip of 30 degree. This dip is nearly equivalent to the dips at Chushan trench site (Chen et al. 2007b). B4 hole also shows that the amount of total shortening along the fault is at least 18 m and this is too large to interpret by only two faulting events, thus it is very likely that more events have occurred.

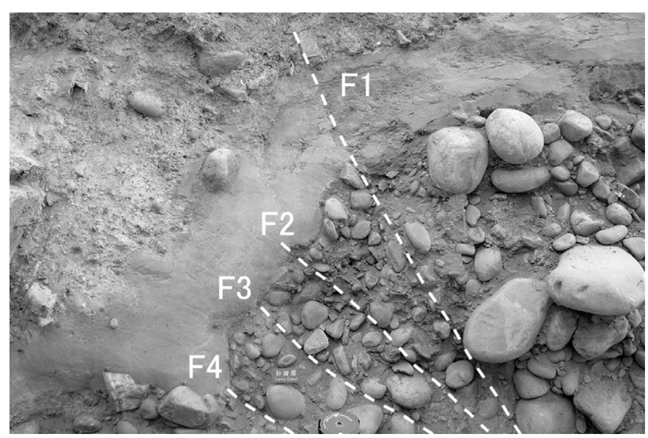

Fig. 4. Photo showing the feature of deformation zone (Photo by Ota, April 2008).

4. SUMMARY AND CONCLUSION

1. We examined the trench wall preserved at the Earthquake Museum and found four branch reverse faults in a 1.8 m wide zone within the terrace deposits. They may converge into one fault when they reach to the bedrock.
2. We compared the thickness of terrace deposits and height of bedrock surface using 10 bore hole data across the earthquake fault at Earthquake Museum. Bedrock is exposed at the hanging wall but not in the foot wall and the elevation difference of bedrock surface across the fault is greater than the offset of the 1999 earthquake, suggesting the presence of penultimate event.
3. Based on bore hole B4, we can estimate the fault dips 30 degree eastward. The 18 m shortening at this site implies the presence of multiple previous events.

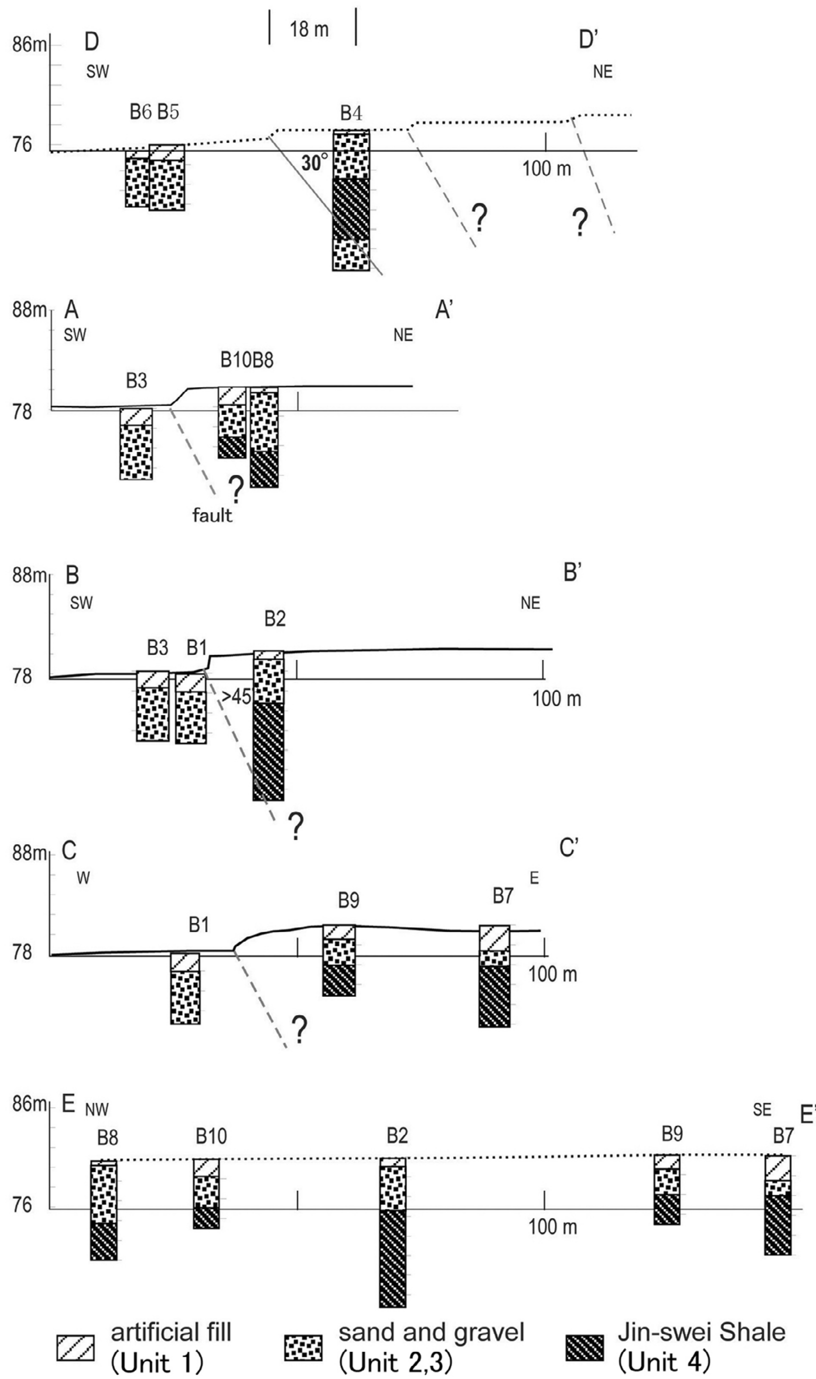

Fig. 5. Columnar sections (after Chung-chi Technical Consultant Co. Ltd.), projected onto the topographic profiles across the 1999 surface rupture. Profiles are after Ota et al. 2007). In contrast to six sites reaching to the unconformity between terrace deposits and bedrock, foot wall do not reach to the bedrock surface.

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