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Study of the Relationship between Surface Rupture and Faulting in Relation to Jiashian Earthquake

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Introduction

Taiwan is located in the western margin of the circum-pacific seismic belt. There are about 1.6 earthquakes with $6 \le M_L < 7$ occurred around Taiwan every year and a number of them produced serious damage. In order to achieve seismic hazard mitigation and prevention, we must understand the reasons for disasters caused by the earthquake. **Near-surface deformation** induced by earthquake faulting is one of main causes to the damage of engineering structures during earthquakes. In return, the information of **distribution of damaged engineering structures** and **features of surface deformation** can reveal **important characteristics** of the earthquake fault. The 4 March 2010 Jiashian, southwestern Taiwan, earthquake (M_W6.4) caused moderate damage in Chiayi, Tainan and Kaohsiung including ground surface fractures, engineering s1tructure damage and soil liquefaction (Fig. 1). This study **investigated the relationship between these surface creaks and earthquake fault.** Afterward **we estimate the location and geometric morphology for the fault** further.

Study area

Figure 1 shows the all of the positions of damage which caused by Jiashian earthquake. There were dense open-type surface fractures locally distributed within an northwest-trending rupture zone at Meinong in Kaohsiung (Fig.4).

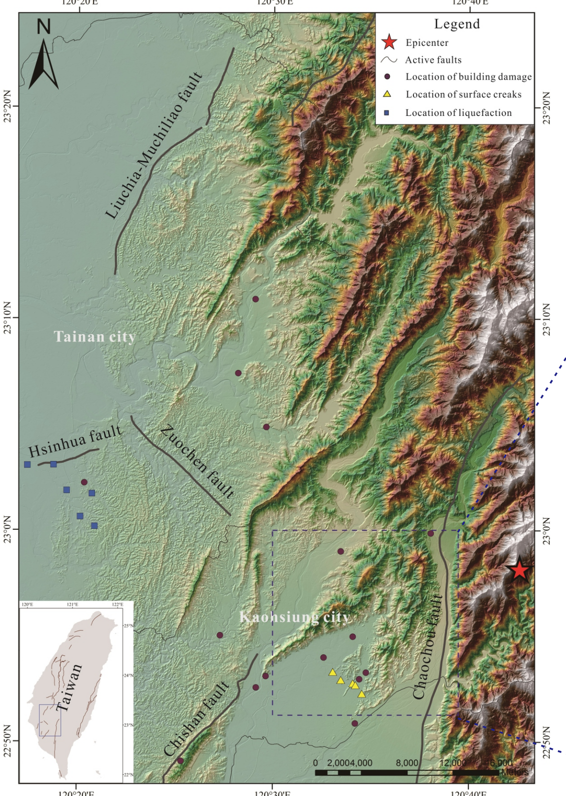


Fig. 1

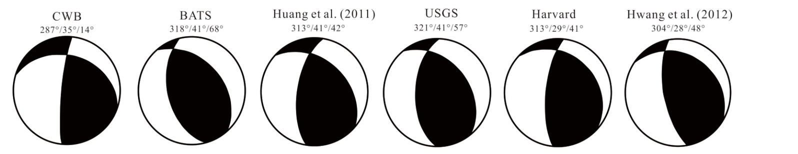
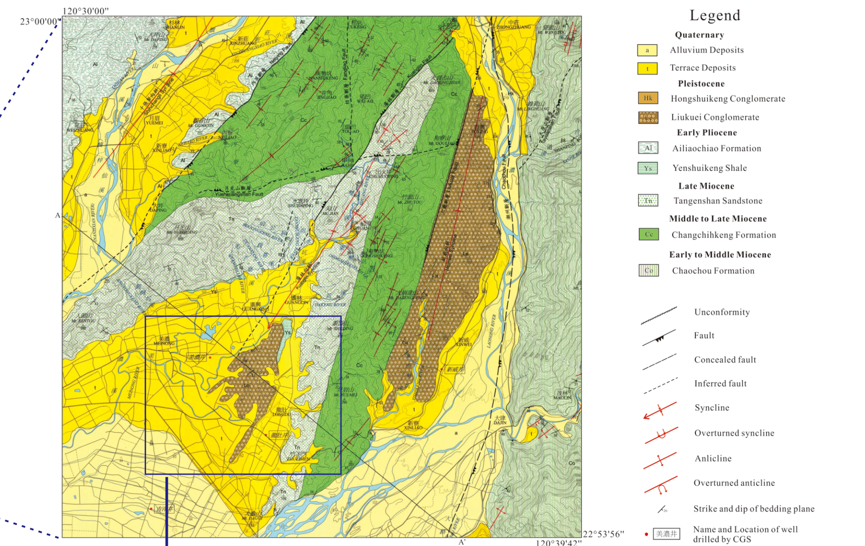


Fig. 2 The focal mechanisms of Jiashian earthquake



(Modified from CGS)

Fig. 3 Regional geological map

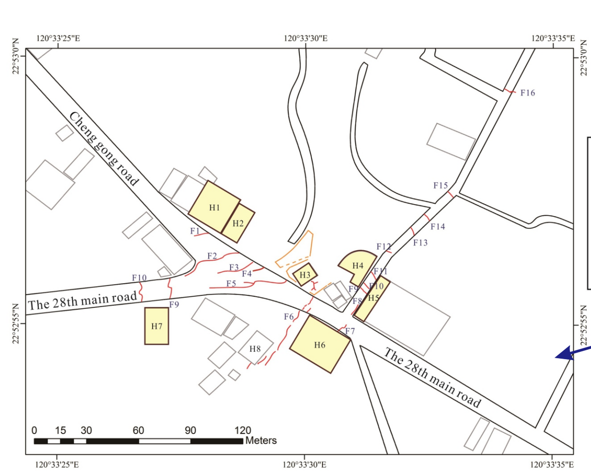


Fig. 5 The surface repture at Siao shan community

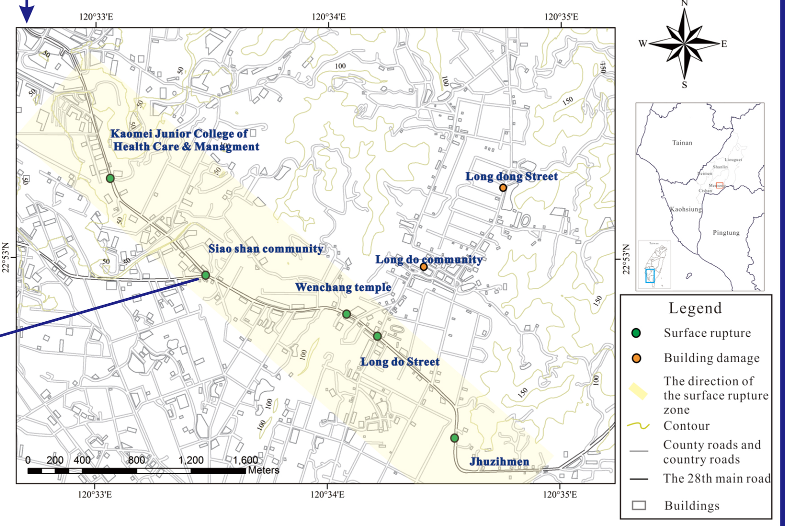


Fig. 4 The distribution of surface rupture and damaged engineering structures at Meinong.

Conception

- To estimate the direction of the stress of surface fractures in the ideal case (Fig. 6).
- In general, the larger damage was caused by the larger surface strain.
- This study used **dynamic and static strain** to explore the relationship between surface rupture and earthquake fault.

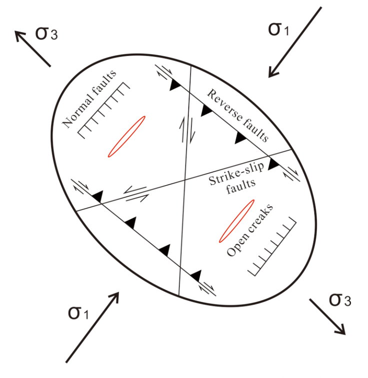


Fig. 6 Diagram of strain ellipse

10^{-}[illegible]	The surface will produce obvious rupture and damage.
10^{-}[illegible]	The surface will produce rupture and damage but they are not clear.
10^{-}[illegible]	The surface appear rupture is impossible.

Table 1

Collects and collates surface fractures

↓

To judge whether the surface fractures related to earthquake faulting

↓

Elastic half-space dislocation model (static strain) | Analyzing peak ground strain (PGS) (dynamic strain)

↓

To presume the location of earthquake fault and extent of near-surface deformation

Fig.7 Flowchart

Results

- The formation of one group of the **open-type fractures at Meinong** which oriented in azimuth of **230°± 30°** likely resulted from the earthquake faulting because of no evidence connected with the weakness of engineering structures (Fig. 8).
- The result of the dynamic strain analysis show that the cause of fracturing due to the seismic shaking can't be ruled out because the magnitude of the strains could reach the threshold of ground failure (10^{-}[illegible]) but there is no evidence for the directional characteristic.
- The main variables for this study are the fault dip angles, fault slip and the depth of the fault tip. We referred to the references of previous studies for modeling. The preliminary simulation result show at Fig. 9. The maximum strain could reach the threshold of ground failure (10^{-}[illegible]). Besides, the open- type fractures and their orientation of 230°± 30° in azimuth produced from the near-surface modeled static strains are consistent with those discovered in field investigations. Then, we used this result to project the fault location to the surface (Fig. 10).

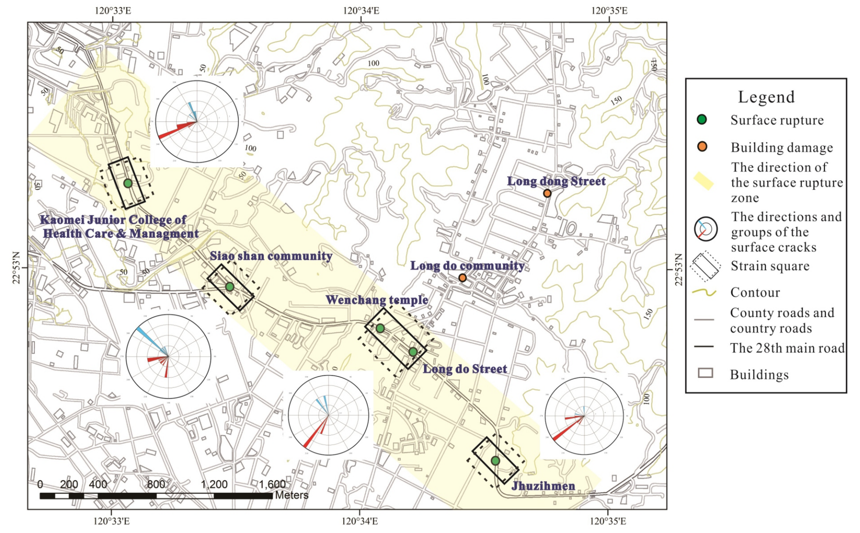


Fig. 8 This shows the orientations of surface fractures at Meinong. The orientation of red group is 230°± 30° which likely resulted from the earthquake faulting. The orientation of blue group is 330°± 30° which is associated with the weakness of engineering structures, for this reason, this study don't discuss them. We inferred that the strain direction according to the orientation of surface fractures. The size of strain squares in this figure don't represent the values of the strain.

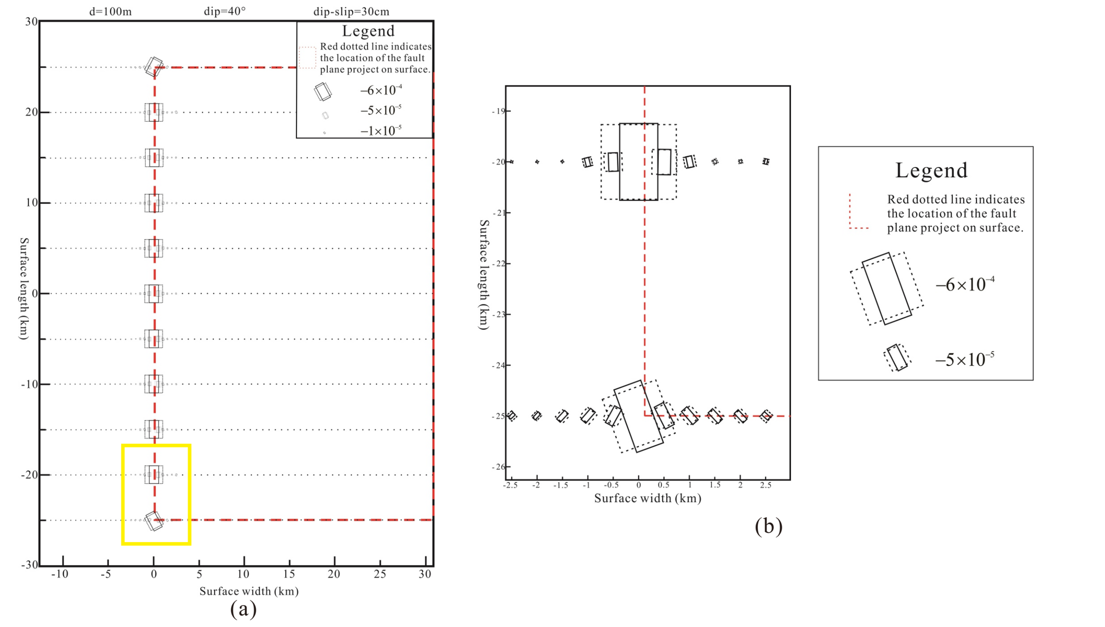


Fig. 9 (a) The preliminary simulation result (b) Yellow partial enlarge view of the preliminary simulation results. The ground position that the upper part of the fault extended to the surface have maximum strain. Besides, there are significant changes in the strain direction on the most southern surface position.

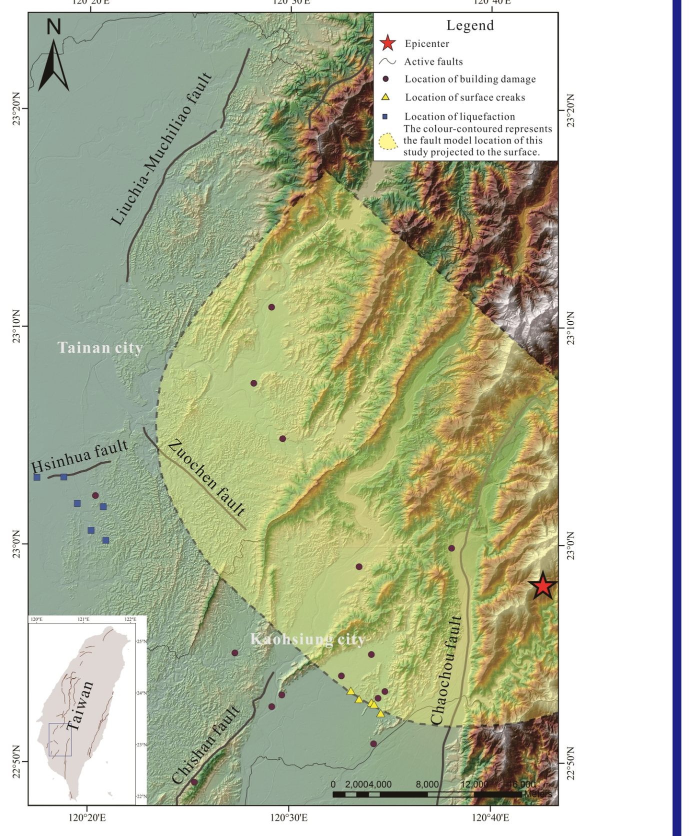


Fig. 10 The fault plane of this study inferred that projected to the surface without considering the topography.

Discussion and conclusion

- To compare with previous studies : There are some differences on the surface location that the fault projected to between by using the GPS observations and surface rupture (Fig.11).
- To compare the unity with seismic catalog : The fault plane don't mesh vary well with the aftershock distribution (Fig 12).
- The initial simulate results are consistent with that discovered in field. However, the model in this study is too simple because we only used the surface fractures as references to infer the fault location. We considered the factors are too less so that the fault plane can't mesh very well with the aftershock distribution.
- Although the results are not ideal, this study provides a simple method to determine the relationship between the surface fractures and earthquake fault.

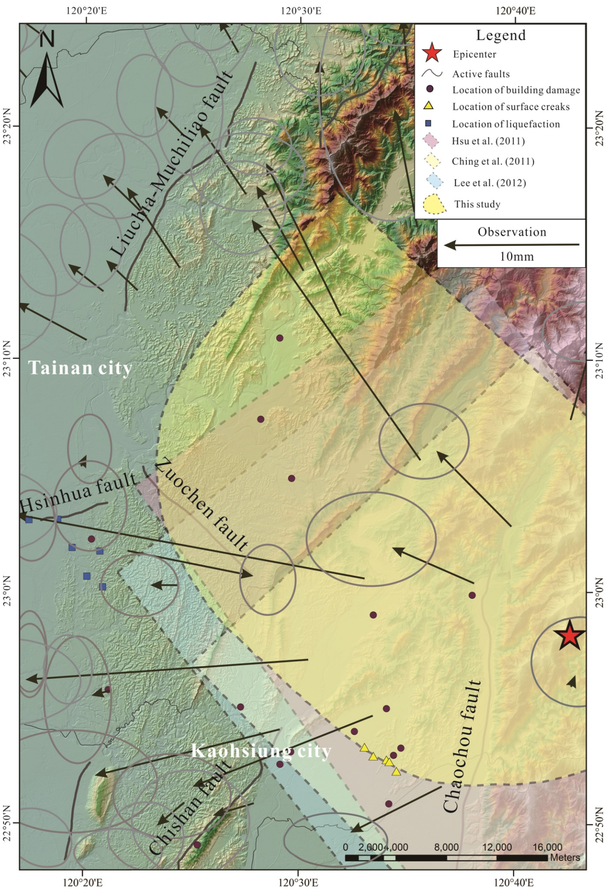


Fig. 11

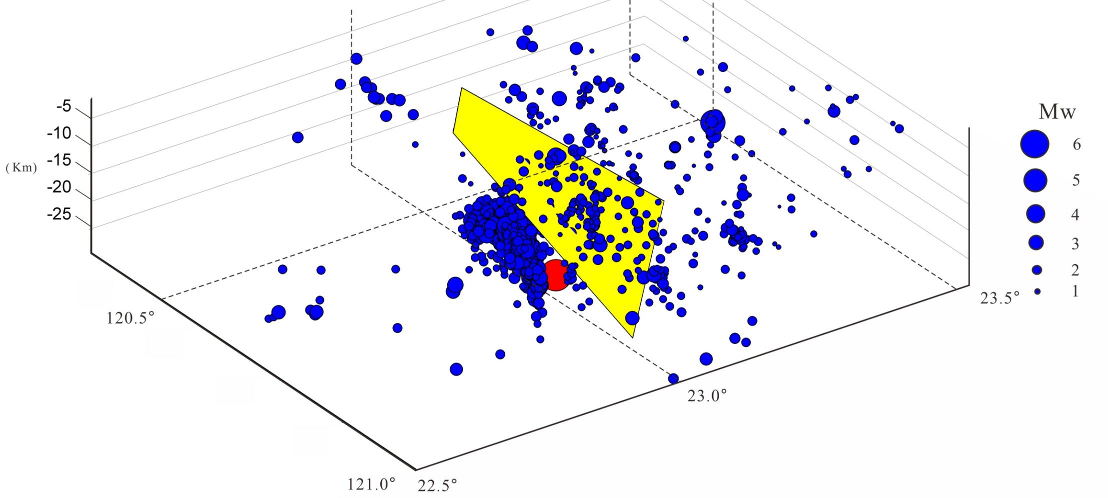


Fig. 12 It's seismic distribution within seven days after Jiashian earthquake. The red point is Jiashian mainshock and the blue points are aftershocks. The yellow rectangle is fault plane of this study inferred.

Future work

- To relocate the seismic data and re-analyze the GPS data.
- We can make use of the surface fractures as the main evidence for simulation. At the same time, using the results which re-analyzed as references to invert the fault geometry.

References

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