

Measuring ground deformation across the Chegualin fault and Chishan fault, Southwestern Taiwan, using aerial image correlation and DSM time series

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Tectonic setting of Taiwan (Strain rate map from Hsu et al., 2009) N26.5 E124 Eurasian Plate

Tectonic Setting:

- The Chishan fault and the Chegualin fault locate in the foothills of southwestern Taiwan, where rapid shortening is occurring.
- The present deformation at the Zhongliao tunnel area results from fault creeping according to ground-based geodetic observations, and severely damages the architectures along the Freeway No. 3.

Our Goals:

- Complement existing geodetic data with aerial image correlation, which provides moderate spatial resolution but higher spatial coverage.
- Understand the regional tectonics and the mechanism behind these phenomena.







Chishan fault).

(Left) The damaged tunnel and the corresponding cracks (red arrows) exposed after the excavation at Freeway No.3.



Aerial image correlation

Processed with MicMac, an open-source software suite.

- 1. Collect aerial images.
- 3. Extract DSM and orthorectify the aerial images.
- 5. Measure vertical displacement via DSM.

Horizontal displacement field



- 2. Reconstruct 3D model by SfM. Estimating the 3-D structure from a set of 2-D images.
- 4. Measure 2D horizontal displacement. Using orthoimage pairs from 2008 and 2015.



Comparison between our image correlation results and ground-based geodetic network (Yang et al. 2018) nearby the Zhongliao tunnel.

Geological Field Survey





(A) Black shear bands with C-S fabric indicate reverse faulting. (B) Overview of the shear zone. Compressional displacement gradient occurs across a significant SE-dipping shear zone. The attitude of the shear zone is N40°E/33°SE and the slip sense is reverse.



→ 25 cm of displacemen



自瓜林斷層帶邊引 (虛線表推測)

- During 2008-2015, shortening across the Chegualin fault is ranging from 17 to 44 cm, with 13-42 cm of right-lateral offset south of the freeway but slightly left-lateral offset north of the freeway.
- The displacement field shows clockwise rotation northeast of the freeway and a counter-clockwise rotation southwest of it.



Black vectors: Our measurements. Red vectors: Geodetic network measurements.

Chegualin fault Chishan fault

et = 38.5 cm

SE B

-50

1250

Extension across he Chishan fault?

625

Vertical displacement

offset 🖻 35 cm

Fault perpendicular

Fault parallel

B NW

-1250

NW

Artifact due to

Right lateral offset = 13 cn

Horizontal Distance (m)

-625

Chequalin fault

repavement the freeway





(C) We observed an up-dip shear sense there. (D) Overview of the Chegualin fault shear zone.

SE-dipping shear zones of Chegualin fault. Displacement field also shows a slightly compressional gradient across these shear zones. Attitude of the shear zone is N39°E/32°SE at site C.







(E) (F-1) Slickenlines on SE-dipping shear planes indicate normal faulting. (F-2) Black shear bands with clear C-S fabric showing NW side is uplifting.

We found shear zones that are close to Chishan fault, with high density of brittle cracks and ductile sheared mudstone with clear C-S fabric. They indicate normal faulting, with right lateral component.



Freeway No. 3

→ 25 cm of displacement

Map of active structures

Shear zone (Dash where inferred)

Chegualin Fault







- Aerial image correlation helps widen the observations on ground deformation along the fault strike, and has good consistency with ground-based geodetic network.
- The compression across the Chegualin fault extends at least 2 km along the fault strike.
- However, the strike-slip component on the Chegualin fault is not the same along different segments, and active deformation in the southern part of the study do not follow the Chegualin fault trace.
- Geological evidence suggested that the normal faulting across the Chishan fault can extend about 2 km.
- With a better mapping of actively creeping structures, we propose a half-doming model, which is possibly driven by mud piercement.