# Characterizing change of slip along plate-suture mega-thrust during earthquake cycle: a case of the Chihshang Fault in eastern Taiwan

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## Goal:

To characterize the change of slip during earthquake cycle along the Chihshang Fault, we invert geodetic data for fault slip during an interseismic period and also during the co- and post-seismic periods of the Dec. 10, 2003, Chengkung earthquake.







Ser

GPS station • Leveling benchmark

Historic earthquakes in the Taiwan region. (a) Earthquakes with a magnitude of greater than 7 and earthquake-induced surface ruptures in red. (Figure courtesy of Chen Rou-Fei) (b) Earthquakes in eastern Taiwan and 1951 earthquake-induced ground ruptures in red.

Leveling and GPS sites

## Tectonic setting

- Luzon arc of the Philippine Sea plate is colliding with the continental margin of the Eurasian plate.
- Relative convergence of the two plates occurs at a rate of about 80 mm/yr in the direction of 310°.
- Half the 80 mm/yr of convergence is being taken up on the one neotectonic belt, the
- Longitudinal Valley in eastern Taiwan considered the plate suture between the two plates.
- The valley is bounded on the east by the Longitudinal Valley fault (LVF) and on the west by the Central Range fault (CRF)
- The LVF is, in particular, highly active, with about 30% of earthquakes per year in Taiwan occurring on or near the fault.

# Chihshang fault

- South-central segment of the LVF.
- Approximate 35 km long classified as an active fault of the first category by Central
- Geological Survey of Taiwan.
- A listric shape and its dip angle decreases from 60° at depth of 5 km to 20° at depth of 20 km.
- Lichi mélange in its hanging wall and thick Holocene alluvial sediments in its foot wall. Subsequently underwent continuous surface creep.

### Data acquisition

### Vertical displacement for different periods

ni-coseisn	nic		Chengkung	Semi-coseisr	nic Displacem	nent (July∼De	c 2003)			
Vertical displacement (cm)					-		-+-L = G	eveling data PS	]	
		t.			1					
	T		1						1	
		4000			40000	10000	44000	40000	40000	

Semi-postseismic



#### Combined co- and post- seismic









# Main findings

- The derived maximum 2003 co-seismic fault slip is about 1 m located at the depth 25-35 km, however, the uncertainty is large due to poor coverage of data in the offshore.
- There showed a secondary peak of co-seismic slip at the shallow part of 60 cm located at depth of about 6 km and decreased upwards and downwards to near zero at ground surface and at depth of 16 km.
- The 1-year accumulated post-seismic fault slip also showed two-peak type of slip distribution with the shallow peak of slip up to 18 cm at depth of 4 km and 22 cm of slip at depth of 12-17 km.
- The pattern of the slip distribution of the

The two sets of leveling data for semi-co and semi-post seismic vertical displacements of Cheng-KungEQ were collected from three leveling surveys. Their starting days are June 20th of 2003, December 15th of 2003 and December 20th of 2004, respectively. Each survey took approximately two weeks. The another set of leveling data for interseismic displacement were collected from Oct., 2007 to Oct. 2009. There are five continuous GPS stations in this study area installed before 2003.

The two sets of vertical displacements are plotted with distances in reference to BM1168 in the figures at right. The **shapes** of the two curves which approximately connect the data are **quite different**. The patterns imply different locked depths of the fault for the two different periods according to the plots in the middle figure below. The tends of daily solutions for the five GPS stations show distinctly different patterns, in particular, for the post-seimic period shown in the diagrams below. In order to derive the displacements for co-

#### A. Cross-LV Plain Leveling Route At Chihshang Area



B.ChengKung EQ Co-seismic Leveling Data (July~Dec, 2003)



C.ChengKung EQ Post-seismic Leveling Data (Dec, 2003~Dec, 2004)



25

30

km

and post-seismic displacements, we took an account of the change of vertical displacements of the GPS stations and derive the newly relative displacements from the semi-co and semi-post displacements. The method illustrates Geometry of Chihshang fault in the figures below. The derived displacements for co- and post displacements are shown in the ∞°°° figures below. The leveling data for the interseismic period is shown in the figure in the 10 lower right of Column left. It displays a different 15 depth pattern from the other ones.

### inter-seismic periods and the pattern of the

sum-up slip of the co- and post- seismic periods are reciprocal.











### Interpretation

It appears that the tectonic strain in the plate suture at this latitude was mainly accumulated on the Chihshang fault during the inter-seismic period, at two particular depths: (a) 22-30 km, which we interpreted as the seismogenic zone and (b) 6-11 km, which we tentatively interpreted as the locked patch probably due to surface or shallow geological effects on the mechanical property along the fault.