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Earthquake News & Blog

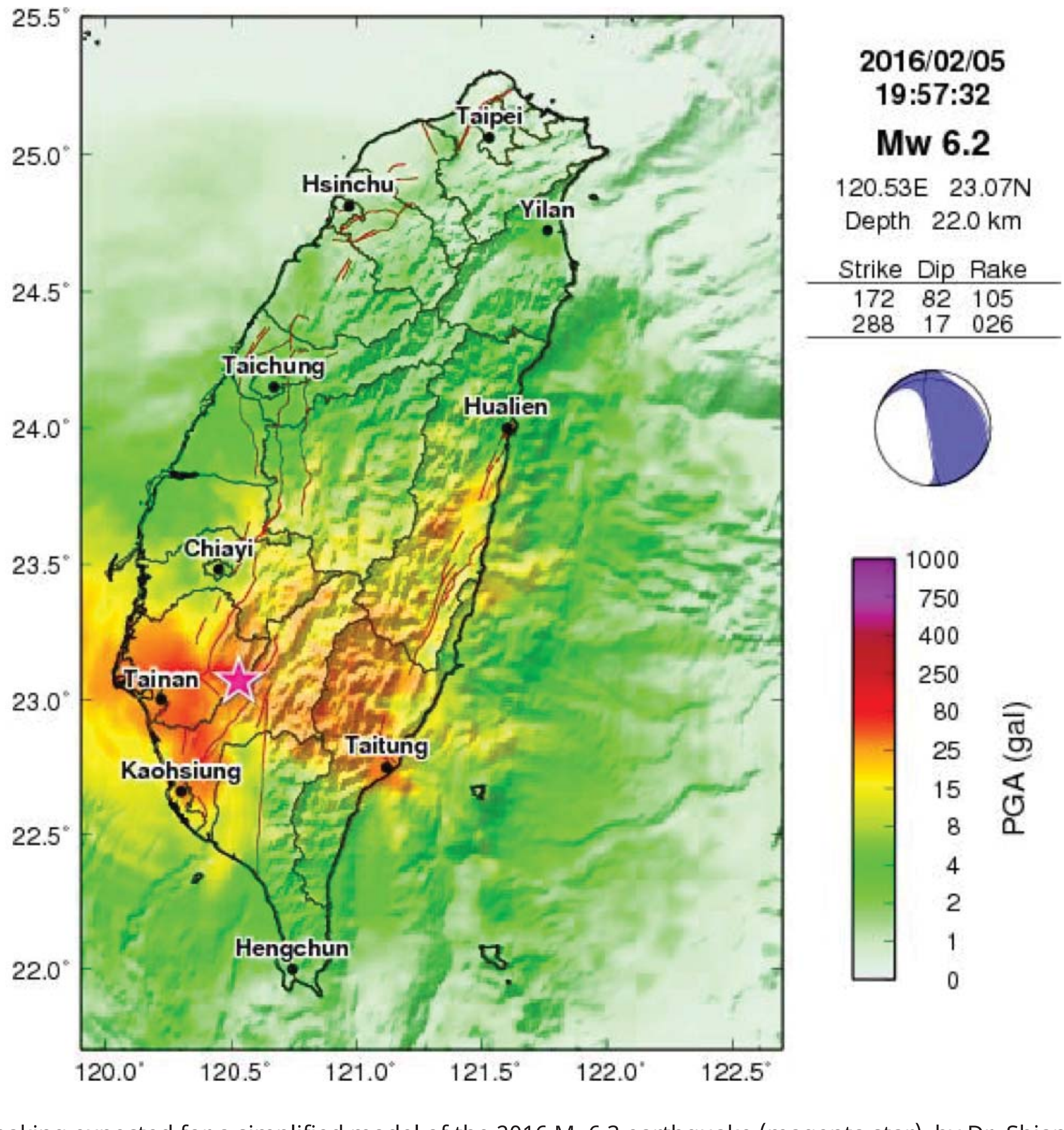
Magnitude-6.3 earthquake near Tainan, Taiwan, highlights the danger of blind thrust faults around the world

6 February 2016 | Quake Insight | **Revised**

The 5 Feb 2016 M=6.3 event struck at a depth of 20 km (12 mi) about 40 km (25 mi) east of the southern city of Tainan, with a population of 1.9 million. The earthquake was felt throughout Taiwan, and strongly shaking Tainan. A 17-story, 100-unit apartment building constructed before the strengthened building codes were imposed after the 1999 M=7.6 Chi-Chi quake, collapsed, as well as several other buildings.

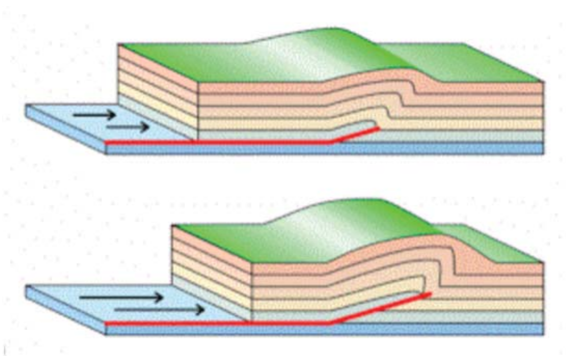
Infant rescued from a collapsed 17-story apartment building in Tainan on 6 Feb 2016 (Reuters) http://www.reuters.com/article/us-quake-taiwan-idUSKCN0VE2EO

Based on the focal mechanism, aftershocks, geology, and the distribution of shaking, the earthquake most likely involves slip on a blind thrust fault, so none of the major surface-cutting faults would appear to be involved. The most famous blind thrust events in California are the 1983 M=6.7 Coalinga, and 1994 M=6.7 Northridge, shocks. The Taiwan event is very similar in size, location, style, and shaking as the M=6.4 Jiashian earthquake in 2010; the two appear to abut, and so are almost certainly related.

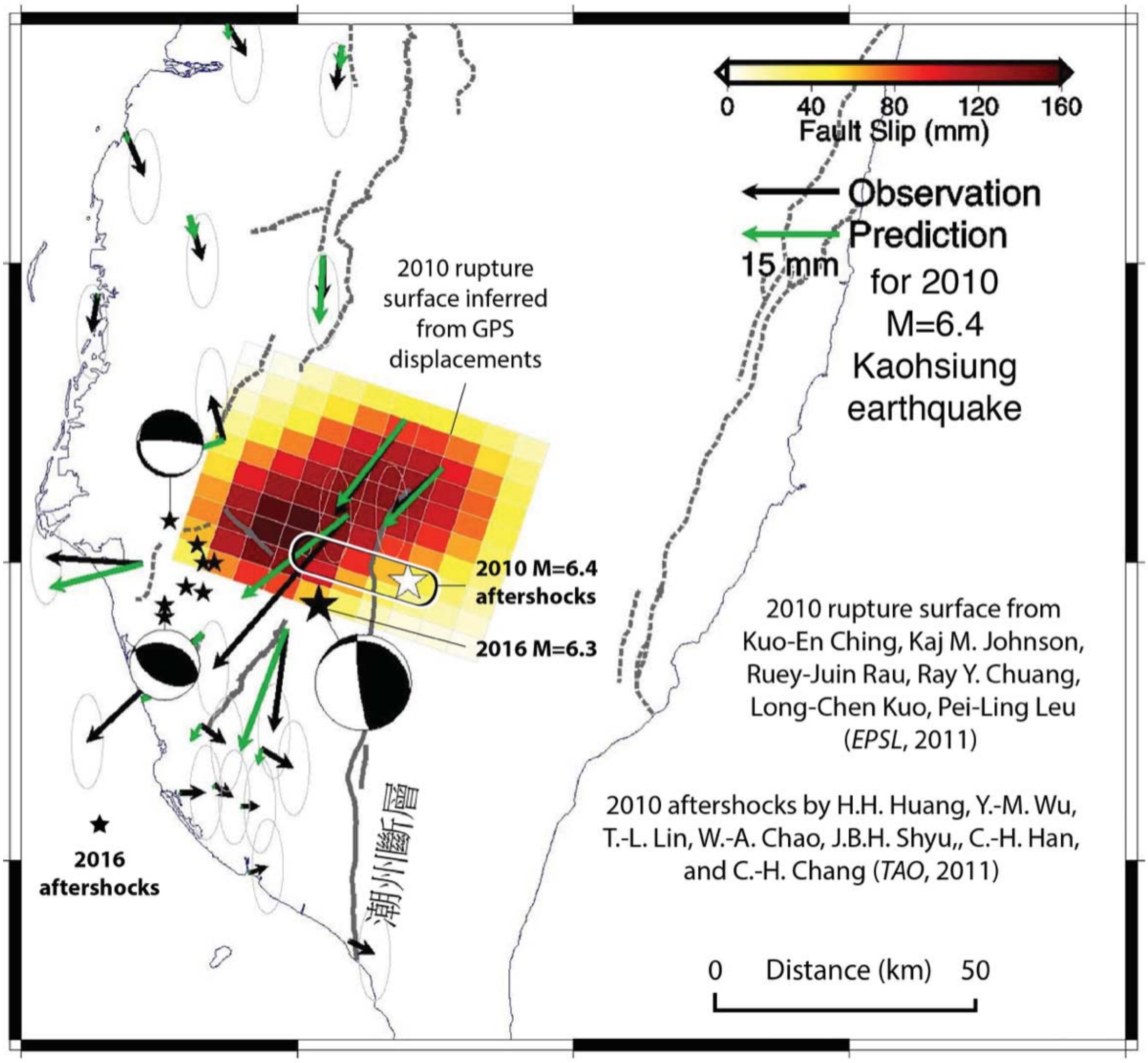


Shaking expected for a simplified model of the 2016 M=6.3 earthquake (magenta star) by Dr. Shiann-Jong Lee suggests very strong amplification at large distances from the mainshock, with values of almost 1.0 g in Tainan, and 0.3 g in Taitung and Kaohsiung
(Abbreviations: PGA = Peak Ground Acceleration, 980 gal = 1.0 g)

A 'blind thrust fault' is one that does not cut the earth's surface, and therefore is 'blind' to geologists. The fault (*red at left*) causes the overlying strata to be uplifted and warped into a fold, and so blind thrusts are often inferred from

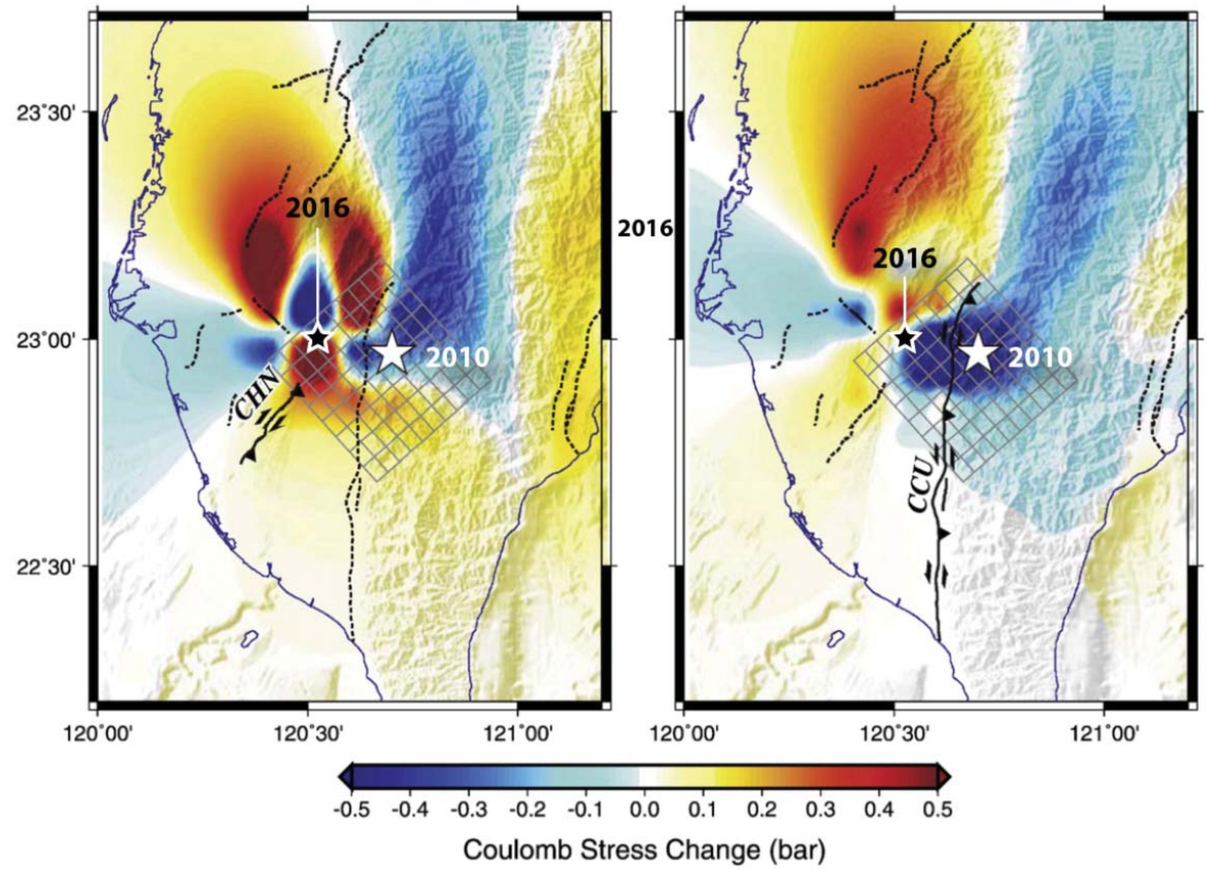


surface folds. Blind thrusts can produce M<7.5 quakes, and are a threat in southern and central California.

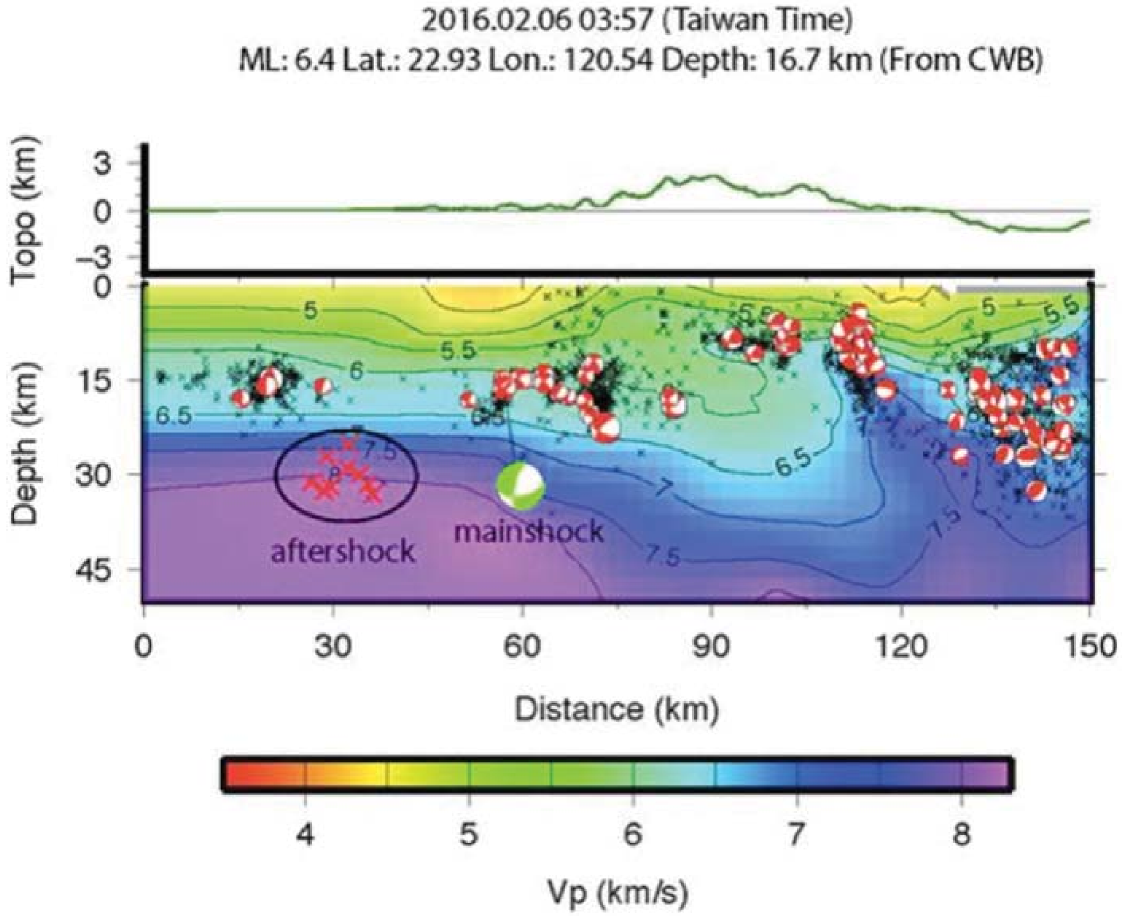


A slip model by Ching et al (2011) for the 2010 quake colored squares) shows slip on a blind thrust fault. This is a large area and a small slip for a M=6.3 shock, and so perhaps the actual rupture was more compact. Nevertheless, the 2016 M=6.3 shock strikes at the periphery of the 2010 rupture, which was likely brought closer to failure.

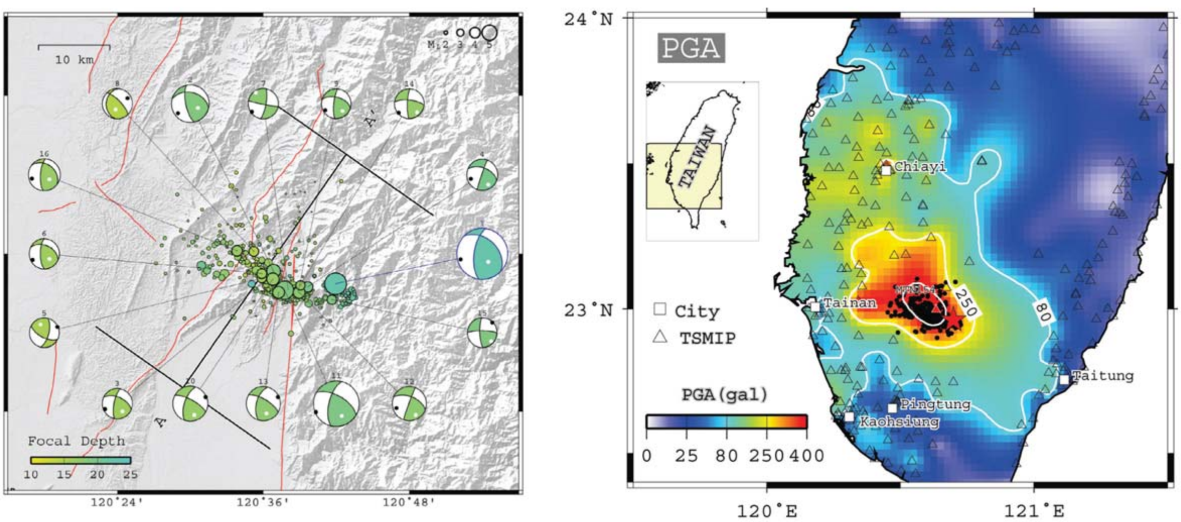
One can see the site of the 2010 M=6.4 shock in the same figure (from H. H. Huang, Y.-M. Wu, T.-L. Lin, W.-A. Chao, J. B. H. Shyu, C.-H. Han, and C.-H. Chang, TAO, 2011), with its approximate rupture area based on the extent of its aftershocks. The mainshocks are only 15 km (9 mi) apart, with the 2016 mainshock on the edge of the 2010 rupture, suggesting that the 2010 shock brought the site of the 2016 rupture closer to failure.



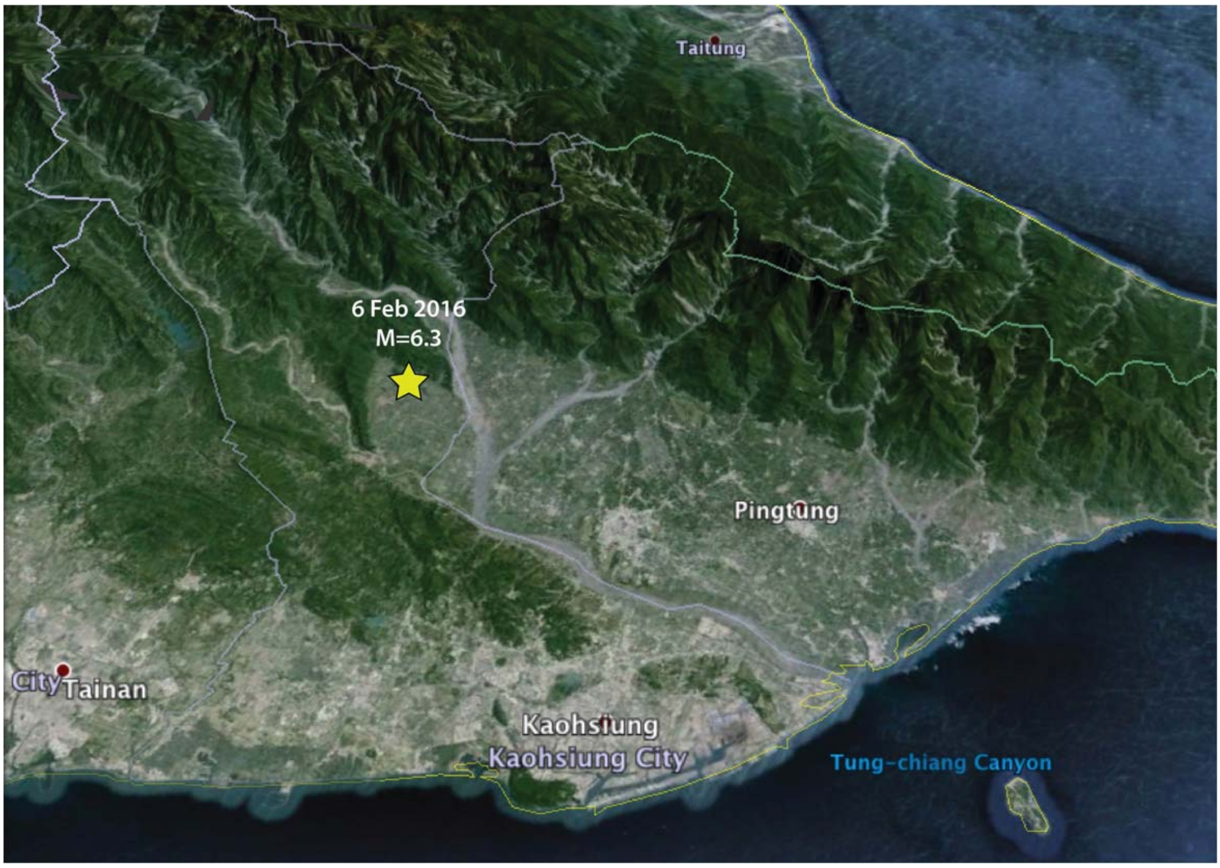
Here, Ching et al (2011) calculated the stress imparted by the 2010 quake to surrounding faults, also known as 'receiver faults,' because they receive the stress. The left panel is for thrust receivers striking NE, as in the Chishan fault (CHN); the right panel is for left lateral-thrust faults striking N-S, as in the Chaochou fault (CCU). So, the 2010 quake could have brought the site of the 2016 quake as much as 0.5 bar closer to failure, which is significant if it proves correct.



In this cross-section, W is on the left and E is on the right. The topography is in green at top, and the seismic wave speed, Vp, is at bottom Francis T. Wu. The 6 Feb 2016 (Taiwan time) M=6.4 mainshock is the green 'beach ball' (focal mechanism). Taiwanese seismologists suspect that the rupture aligns with the small red beachballs on a gently inclined 'blind' thrust fault.



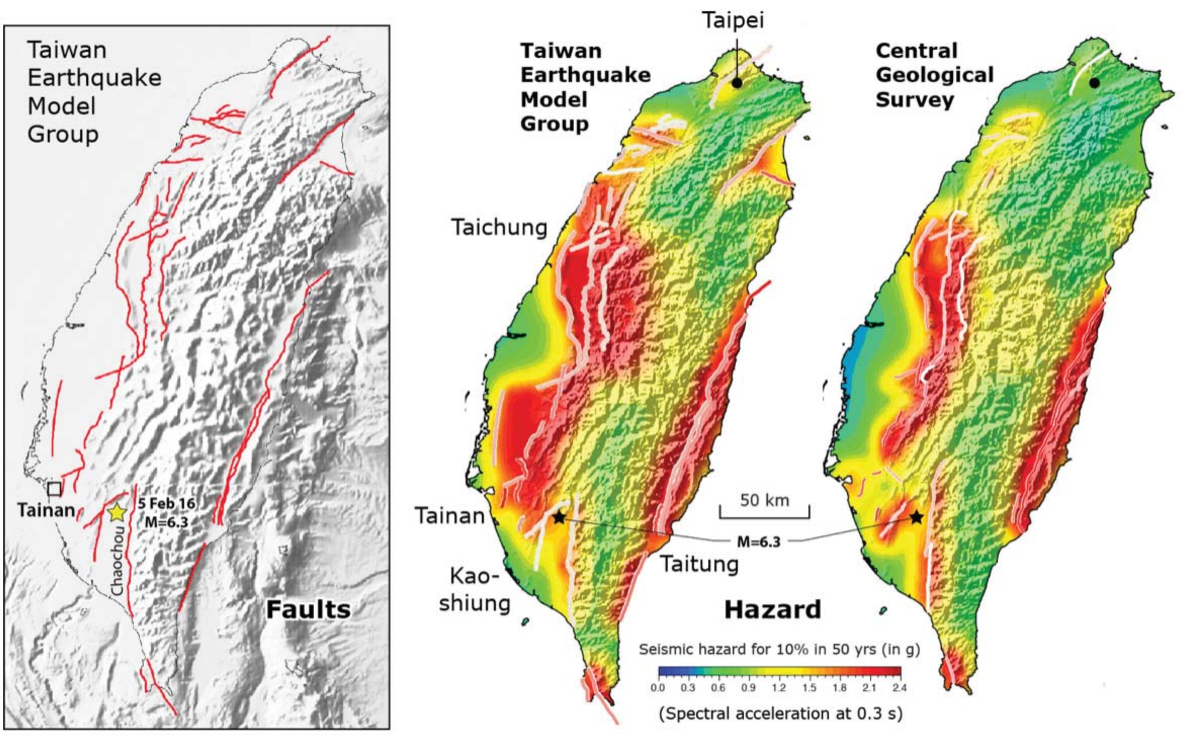
The 4 March 2010 M=6.4 Jiashian earthquake shows a location and rupture style similar to the 6 February 2016 quake (left). The distribution of shaking is also very similar (right). From Huang et al., (2011).



The Chaochou fault marks the razor-sharp boundary between the Central Ranges at the top of this oblique Google Earth image from the Pingtung Plain in the center. Because the fault is almost 100 km (60 mi) long, it is likely capable of a M=7.2 earthquake. The image is oriented with North to the upper left. The city of Tainan is in the lower left. The fault was elucidated in the landmark study of J. Bruce H. Shyu, Kerry Sieh, Yue-Gau Chen, and Char-Shine Liu, 'Neotectonic architecture of Taiwan and its implications for future large earthquakes,' J. Geophys. Res., doi:10.1029/2004JB003251 (2005).

Today's earthquake presages modifications to the seismic hazard map for Taiwan now underway by the Taiwan Earthquake Model group (TEM), an interdisciplinary community of earth scientists and engineers drawn from academia and industry. TEM is using the state-of-the-art open source modeling tool, Open Quake, developed by the Global Earthquake Model (GEM Foundation). TEM not only uses GEM's tools, but has been a leading contributor to GEM science. Crucially, the TEM geologists have found new faults, re-evaluated older ones, and reassessed the amplification of seismic waves in the basins along western Taiwan.

One can see that the hazard in Tainan in the TEM map is much higher than in the preceding national map developed by the Central Geological Survey. The TEM map is preliminary, and no map or hazard model can forecast earthquake occurrence, and so the M=6.3 quake does not allow one to assess which model is best. But because the new model doubles the hazard in Tainan, and raises the hazard slightly at the M=6.3 epicenter, the 6 February 2016 earthquake lends support to its fidelity and utility.



Comparison of the active fault map (left) and probabilistic hazard model (center) of Taiwan proposed by the Taiwan Earthquake Model Group, and that by the Central Geological Survey (right), with the site of the M=6.3 earthquake marked.

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My friends should know this

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