

# Estimated pressure source and vertical deformation in Tatun volcano group, Taiwan, detected by precise leveling in June 2006-August 2007

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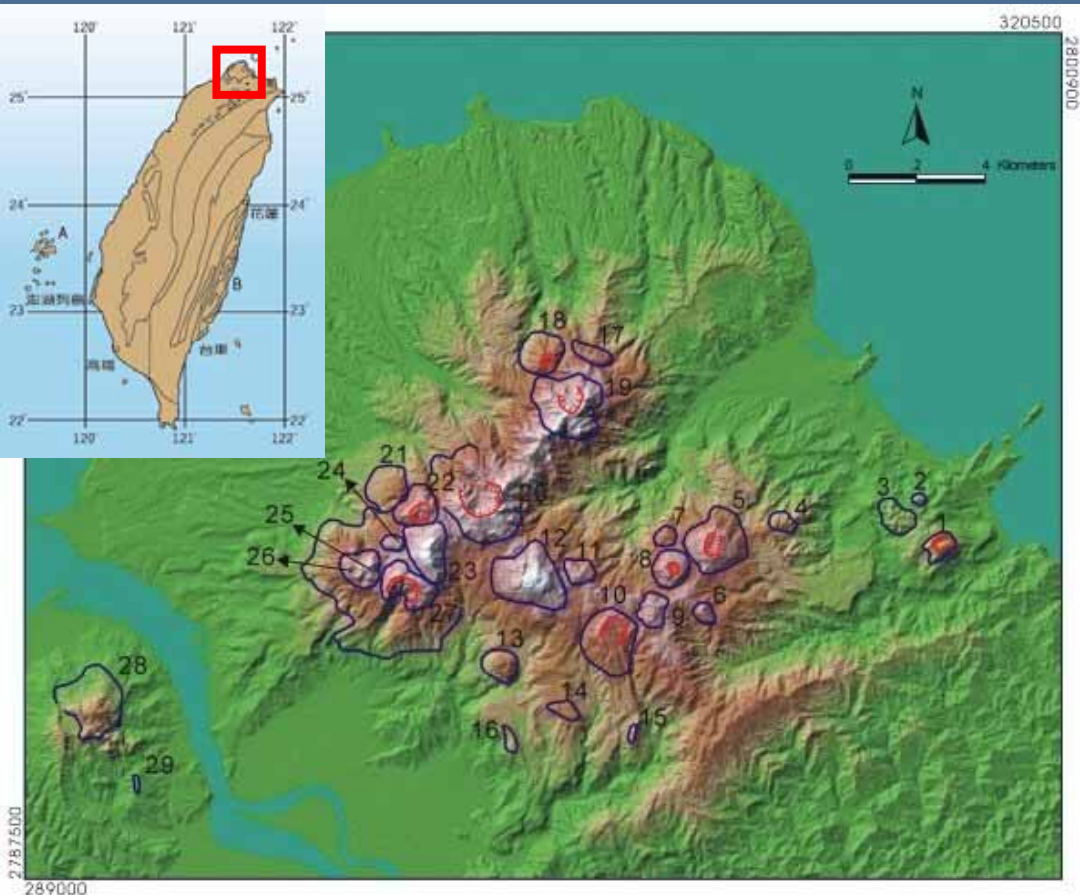
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# Tatun (大屯) volcano group



Volcanic group including more than 20 volcanoes

No record of volcano eruption in history

It was considered extinct volcano based on the previous geological dating results until recently.

Recently, some evidences of active volcano were found.

圖5 大屯火山群共有二十九個火山：1.丁火朽山、2.八斗山1、3.八斗山2、4.桮寮湖山、5.磺嘴山、6.大尖山、7.八煙山、8.冬瓜山、9.鹿寮坪莊山、10.內寮山、11.七股山、12.七星山、13.紗帽山、14.小草山、15.鵝米山、16.白雲山、17.嵩山1、18.嵩山2、19.竹子山、20.小觀音山、21.烘爐山、22.菜公坑山、23.大屯山、24.二子山、25.面天山、26.向天山、27.南大屯山、28.觀音山、29.萬年塔。藍線表示火山錐體外緣，紅線表示火山口。



# Volcanic Ashes in Holocene (Chen et al., 2000)

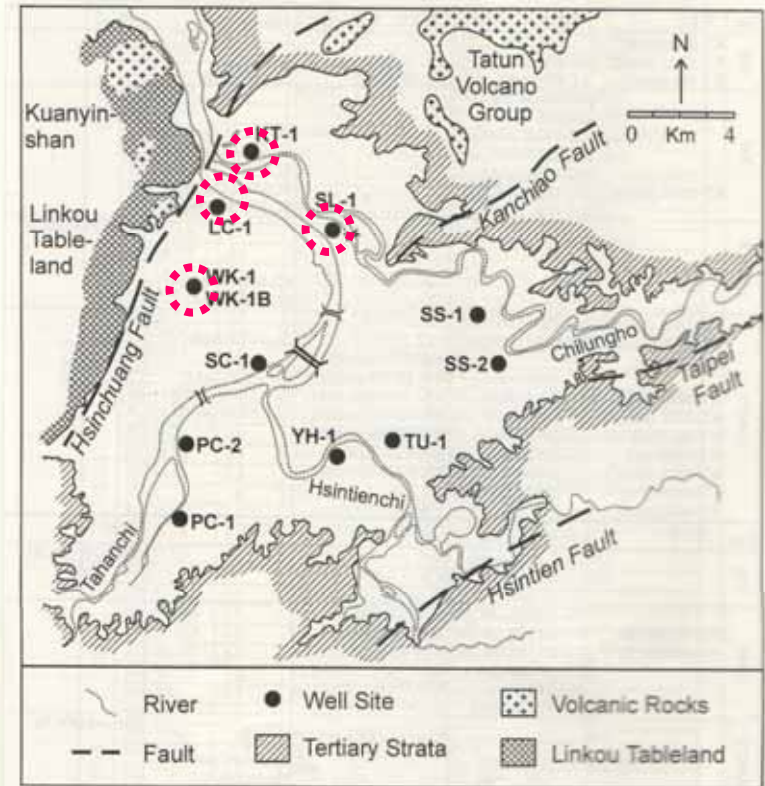
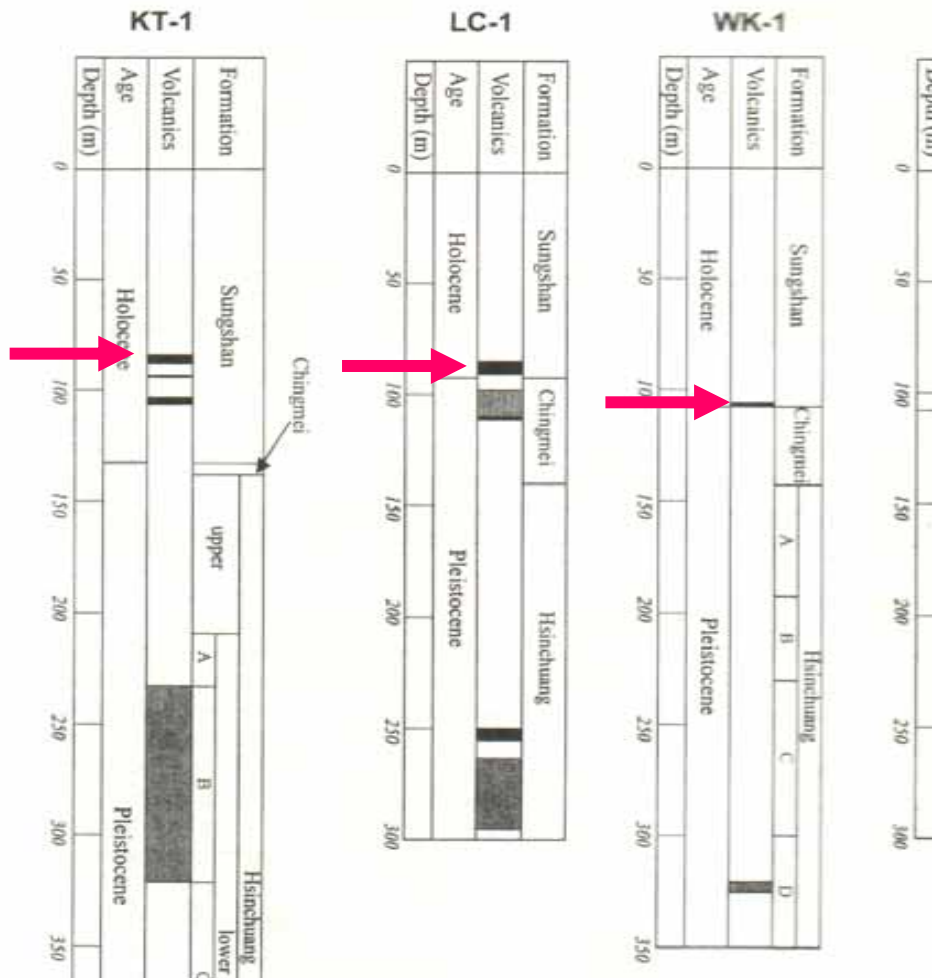
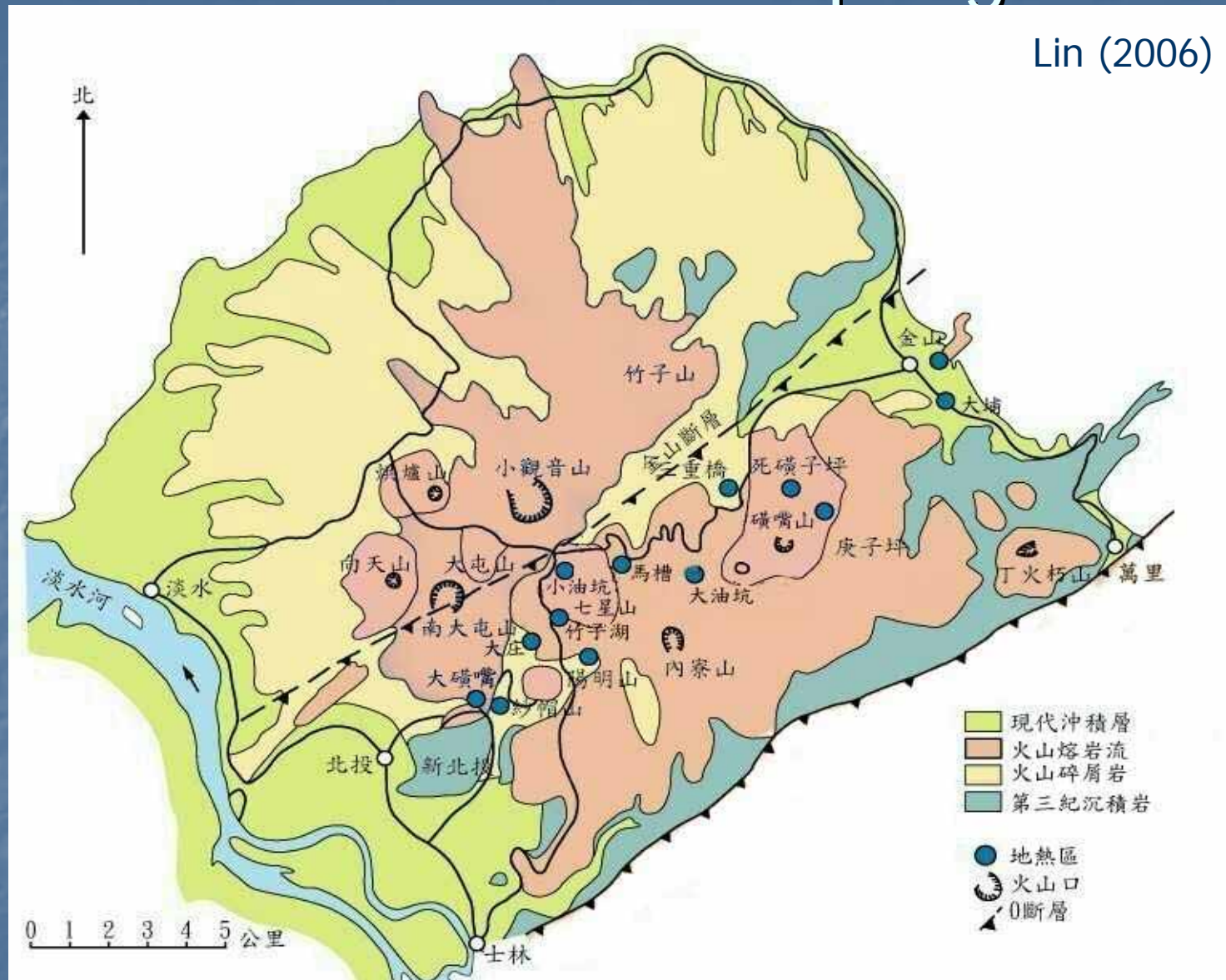


Figure 1. Sample location map of studied well sites in the Taipei Basin. Abbreviations of well names are those described in the preface map of the Special Issue for the "Subsurface Geology and Engineering Environment of Taipei Basin" published by the Central Geological Survey, ROC in 1999.

Generically, Active volcano is defined as a volcano that erupted within 10,000 years.

# Fumaroles & hot springs

Lin (2006)

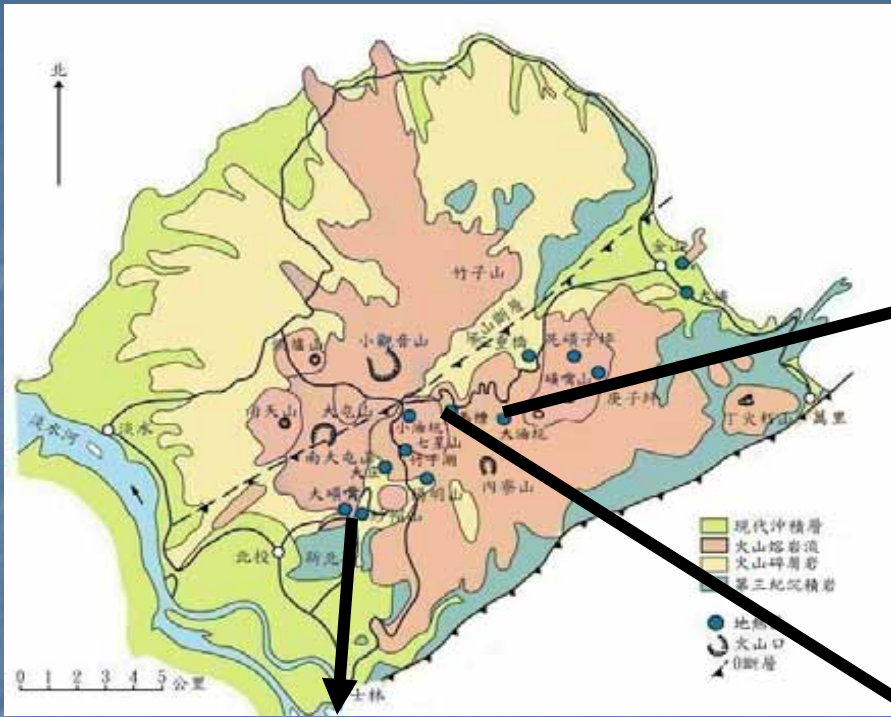


There are still more than 10 geothermal and fumarolic activities.



# Fumaroles & hot springs

Tayoukeng(大油坑)



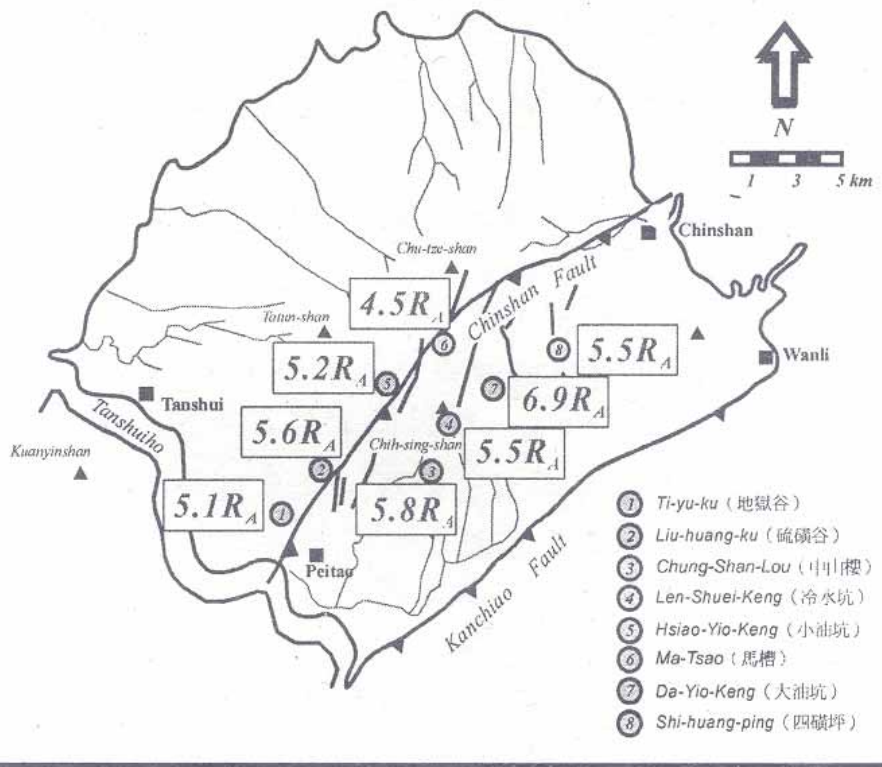
Syaoyoukeng(小油坑)



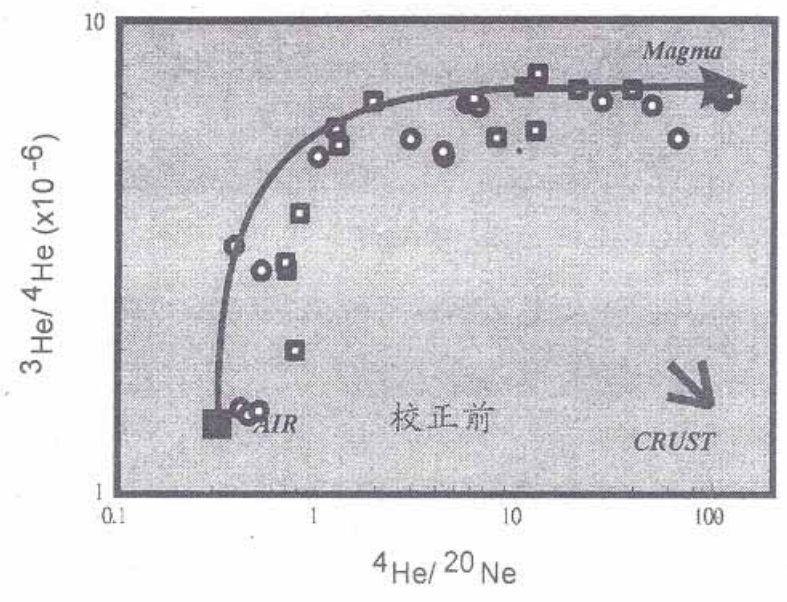
BeitouCyuan(北投泉源)



# Helium isotope ratios (Yan, 1999)



圖二十：大屯火山群各地噴氣之平均氦同位素比值

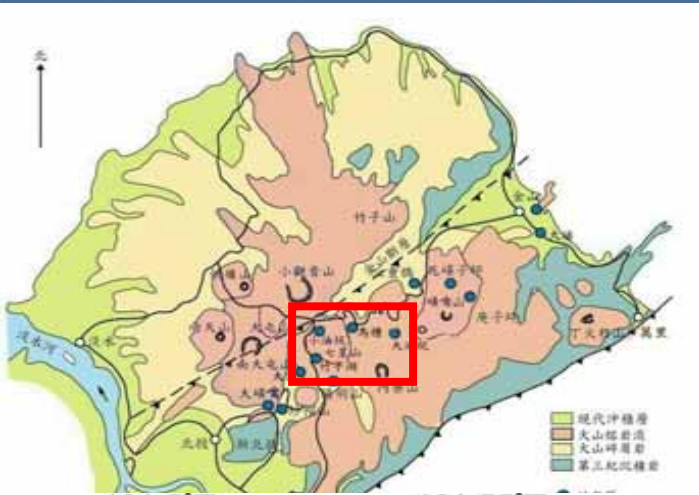


圖十七： $^3\text{He}/^4\text{He}$  對  $^4\text{He}/^{20}\text{Ne}$  作圖

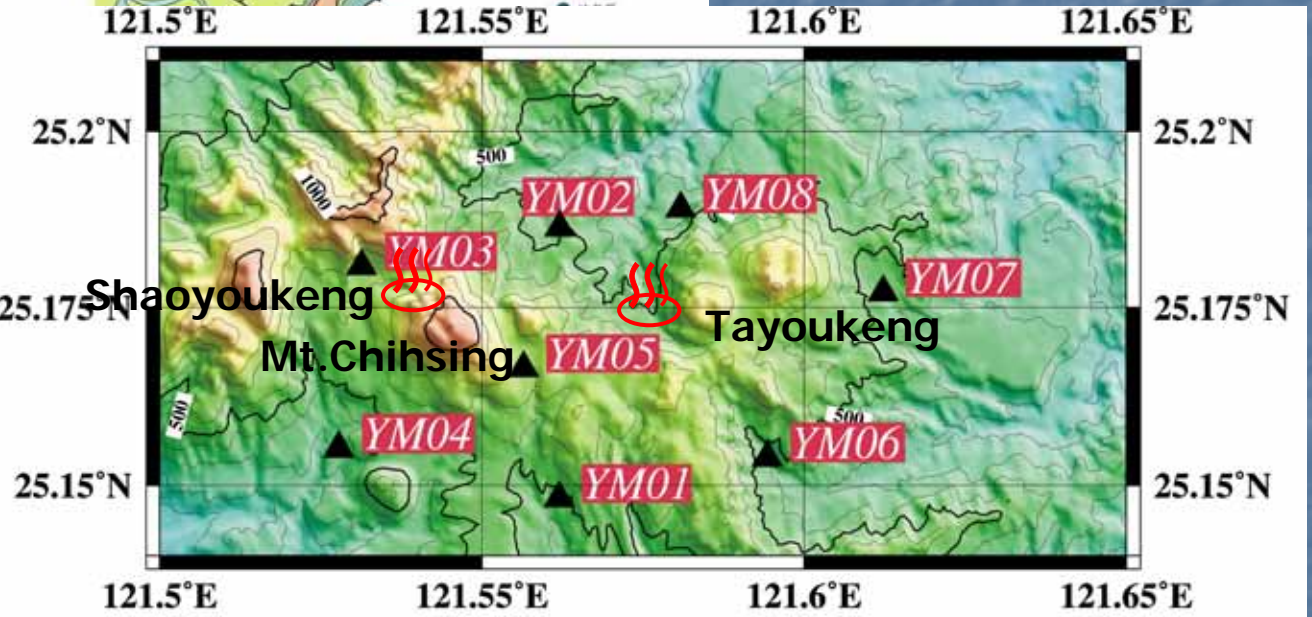
Yan (1999) suggests some magma chambers might be still existing beneath the Tatun volcanoes based on the results of Helium isotope ratios.



# Seismic observation in Chihshingshan(七星山)

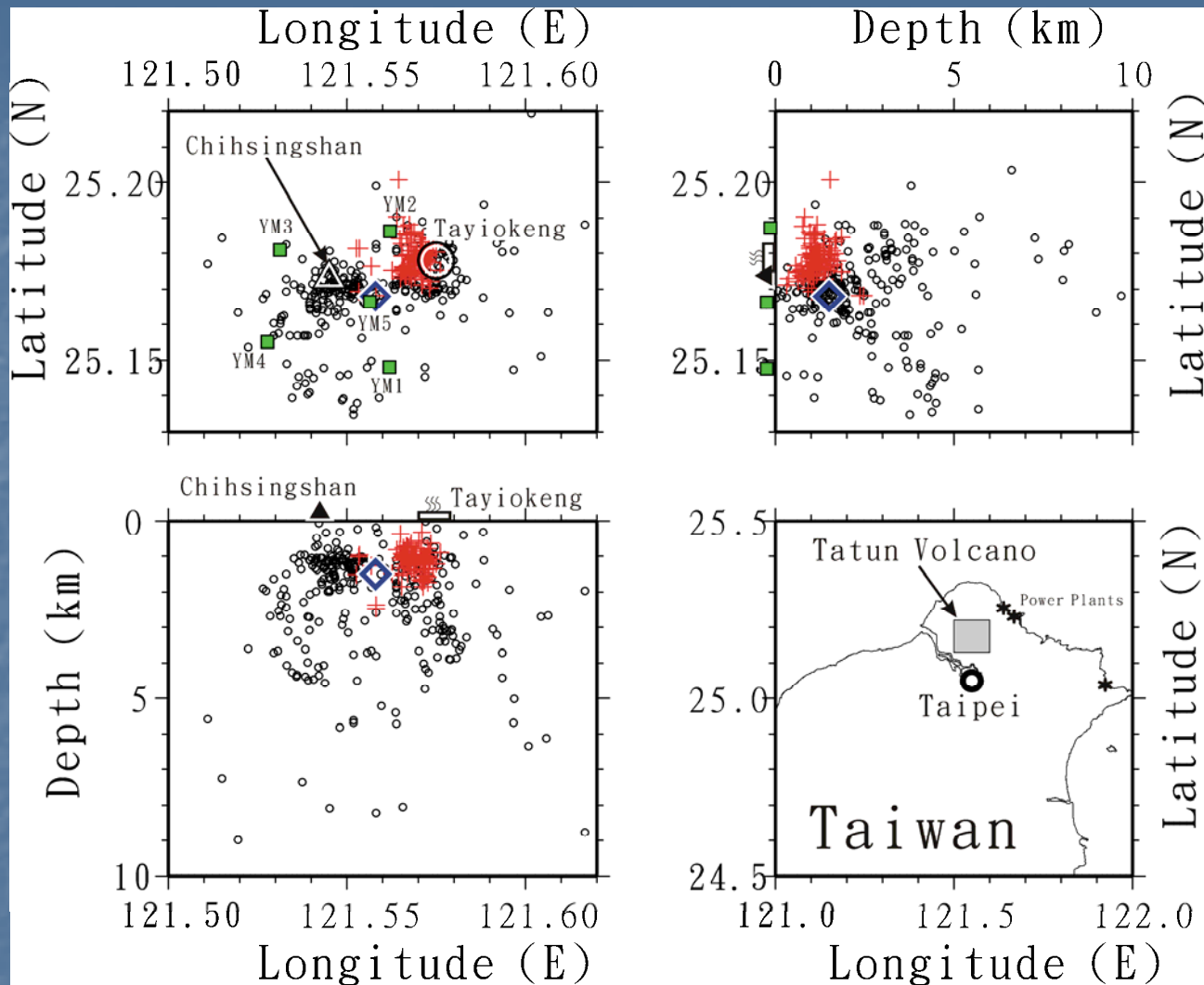


Seismic network composed of eight seismic stations were deployed at 2003 by Lin et al.(2005).



Topography

# Micro-seismic activities



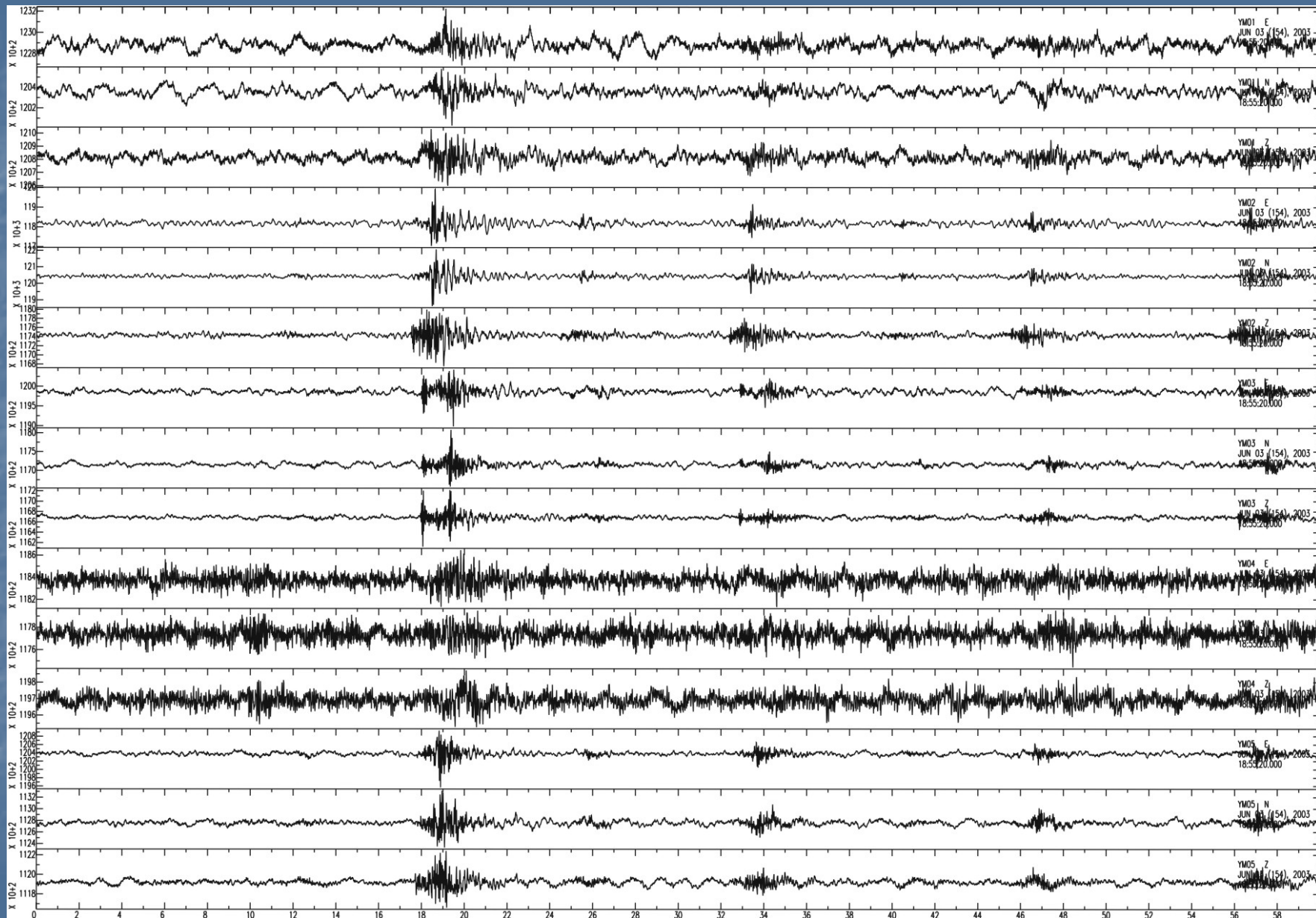
- VT earthquake
- ◇ Tornillos
- + Spasmodic Bursts

Lin et al.(2005)

Micro-seismic activities such as the volcano-tectonic earthquakes, tremors, monochromatic events and Tornillos were detected in and around Chihsing-shan.

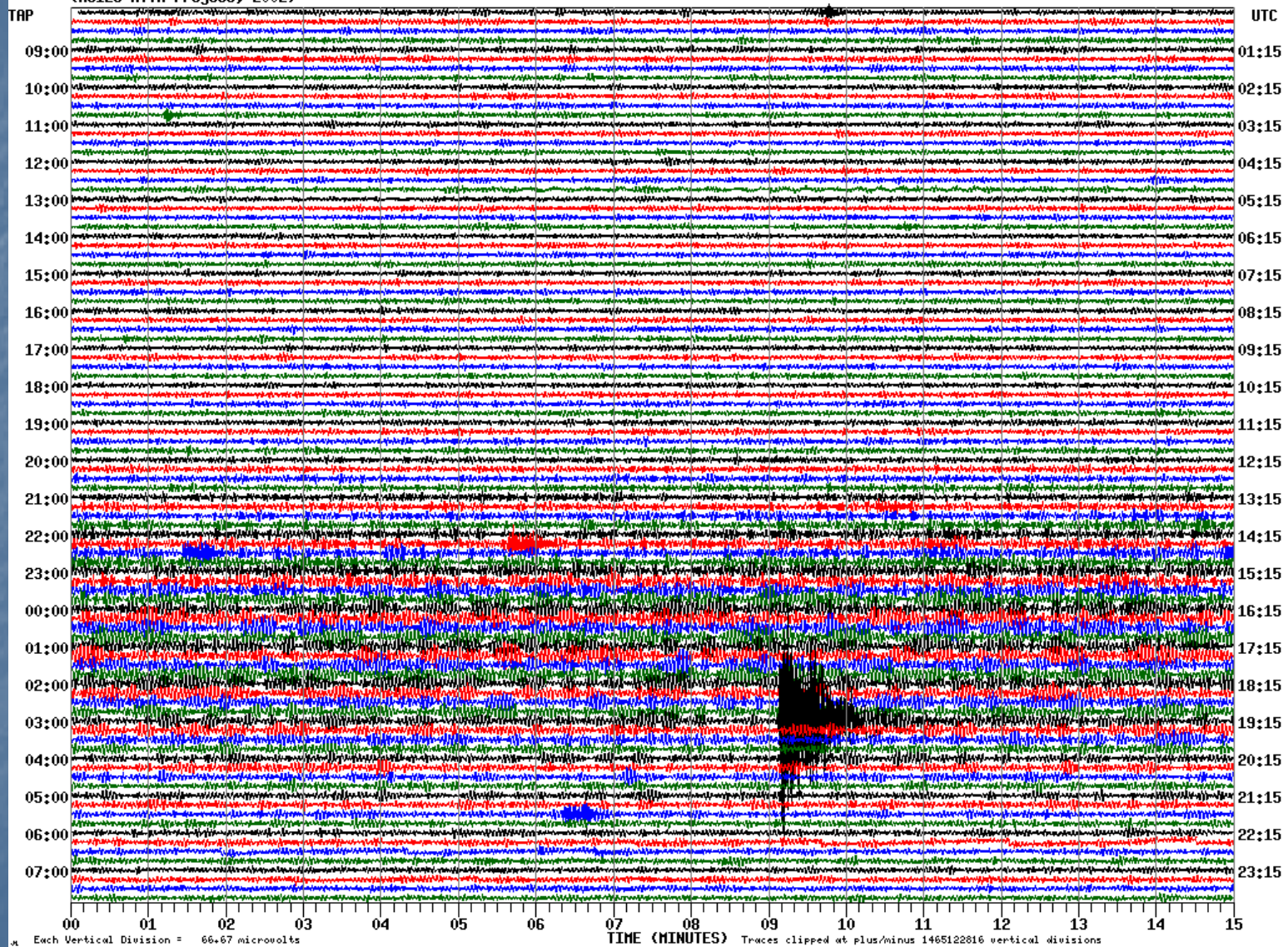


# Swarms



# Tremors

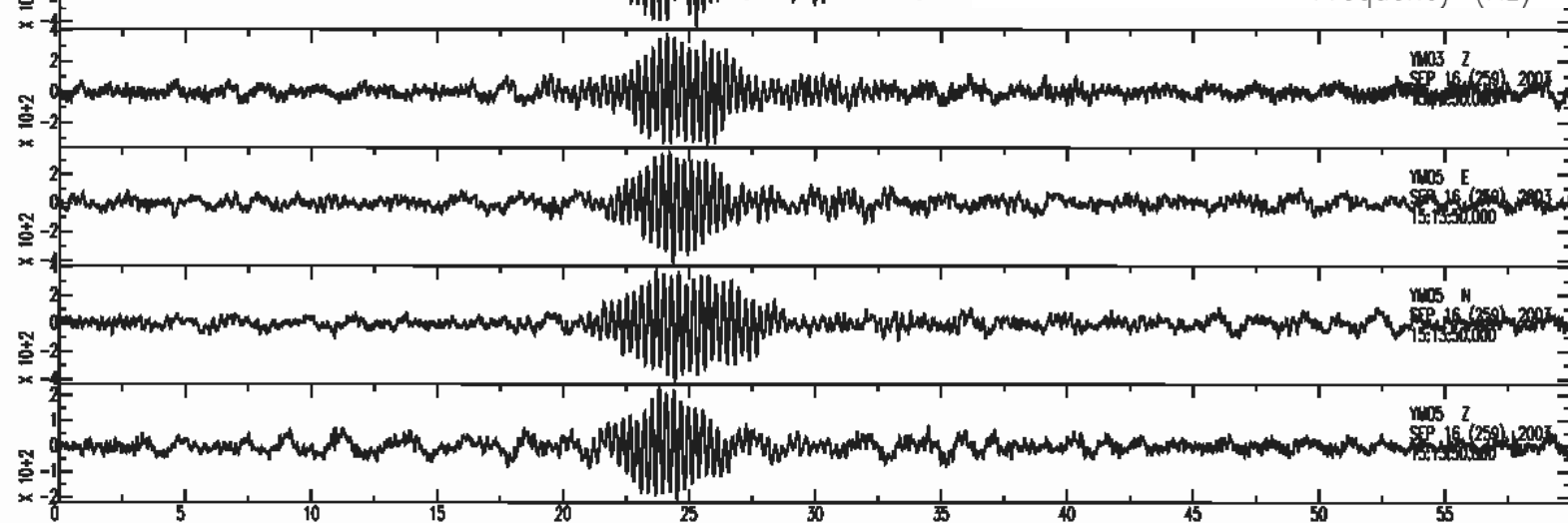
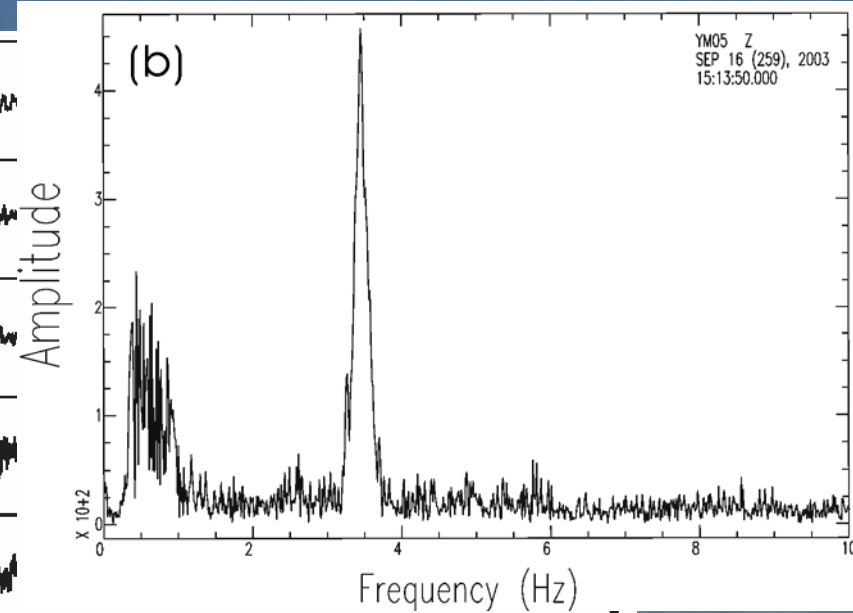
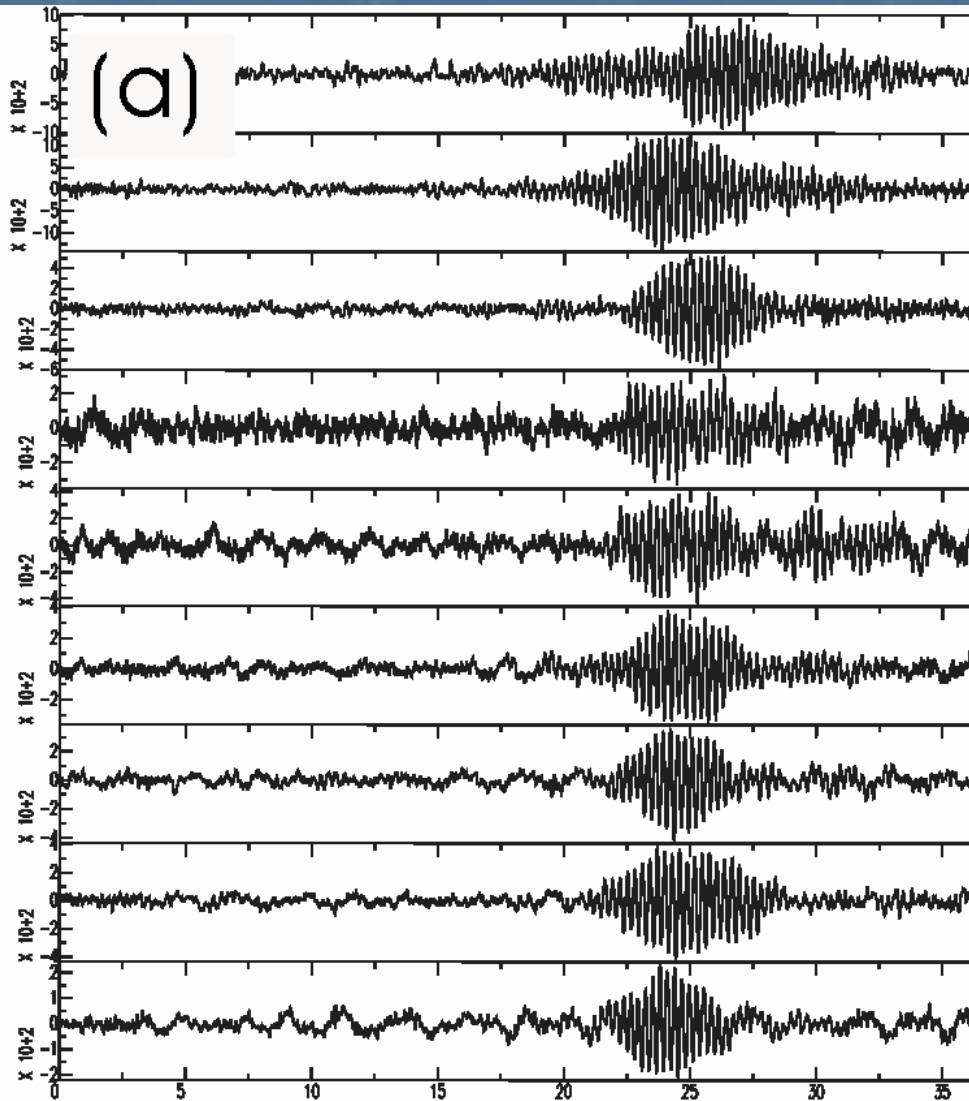
Apr 2, 2003  
YMO1 Z TH  
(ASIES NTA Project, 2002)



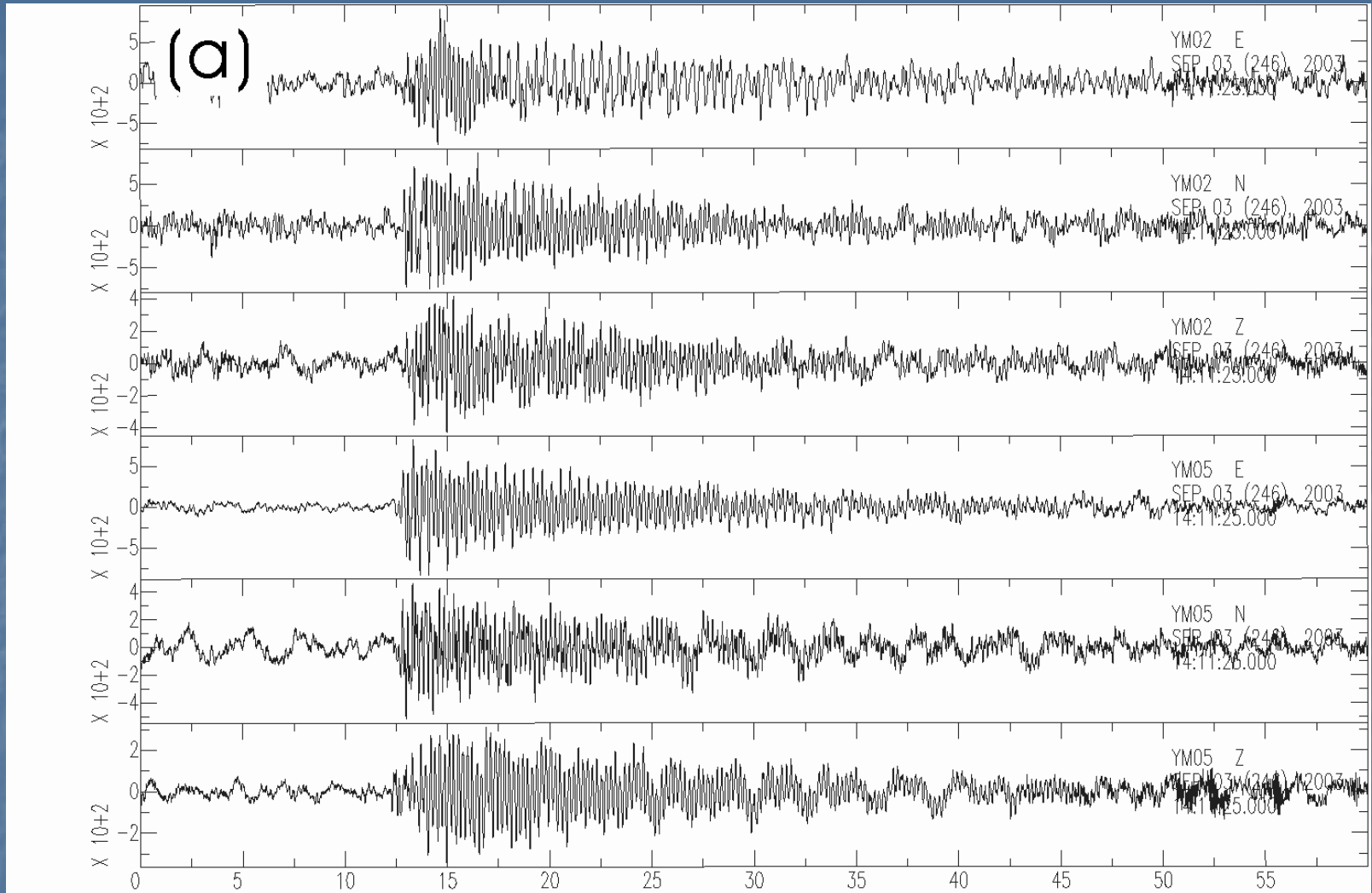
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48



# Monochromatic signals



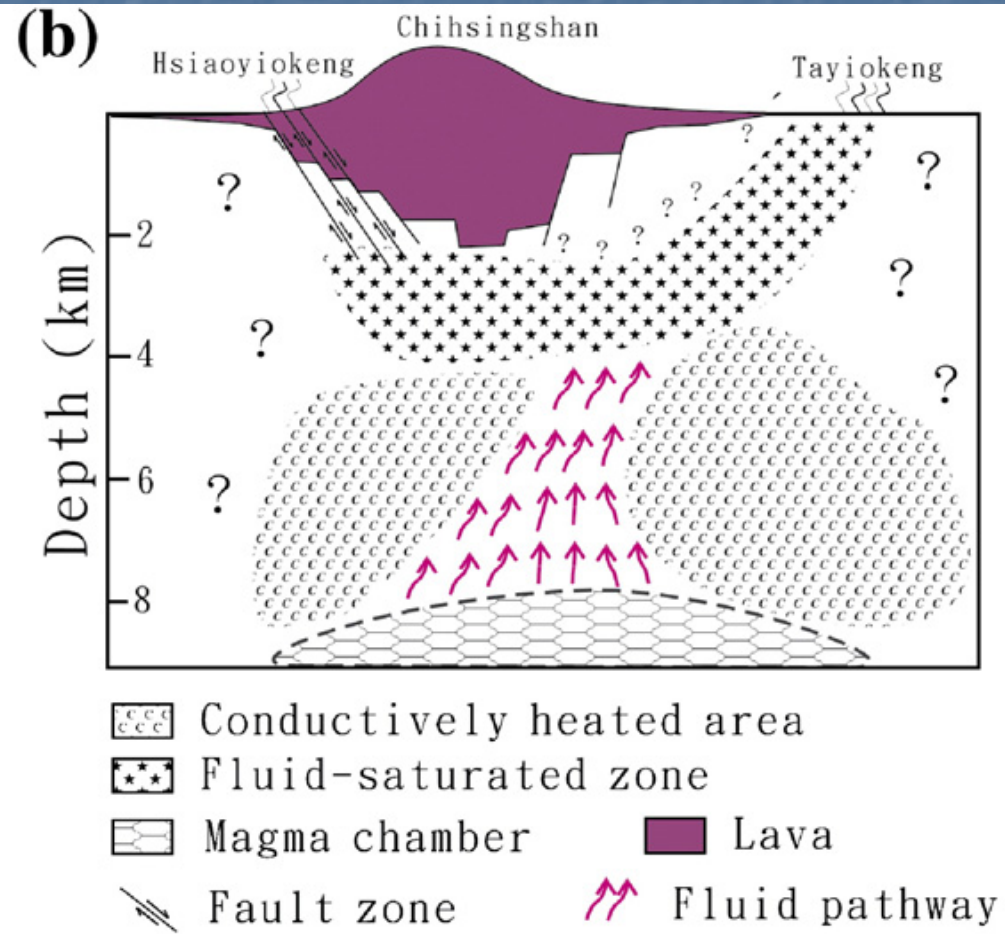
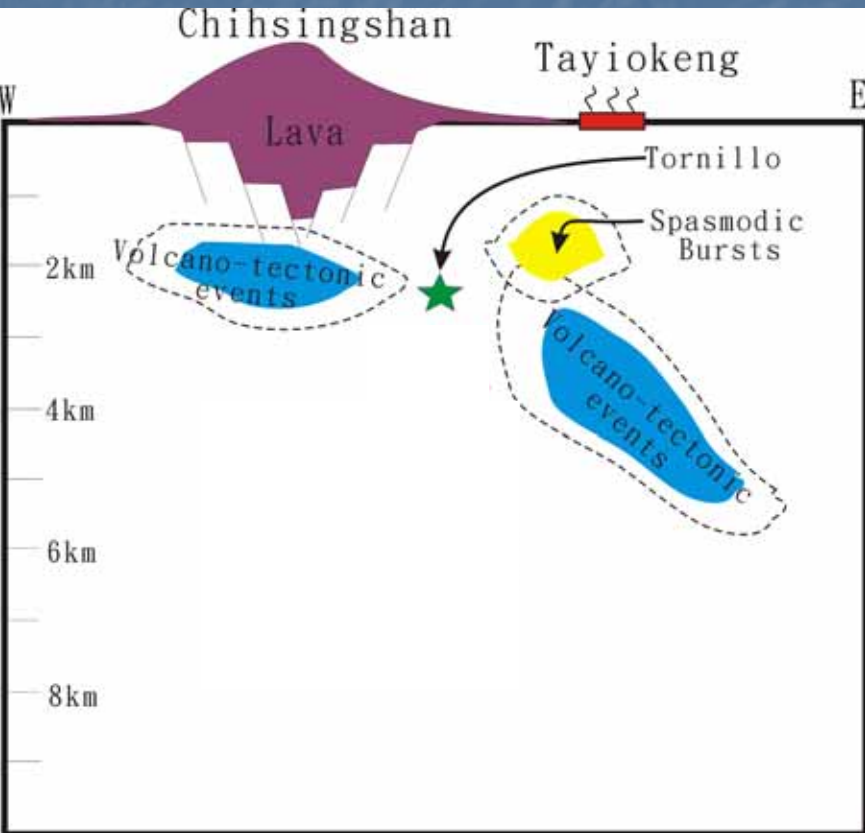
# Tornillos



Seismic activity in Tatun volcano is similar to that of active volcanoes in the world and indicates Tatun volcano is still active.



# Interpretation by Konstantios et al. (2006)



Konstantios et al. (2006) constructed a possible configuration of the volcano-hydrothermal system based on the knowledge of local geology and the result of seismic observation.

# Precise Leveling survey in Chihsing-shan

If a zone of highly fractured and fluid-saturated rock fed with exsolved magmatic fluids lies beneath Chihsin-shan, it is more likely to cause a deformation.

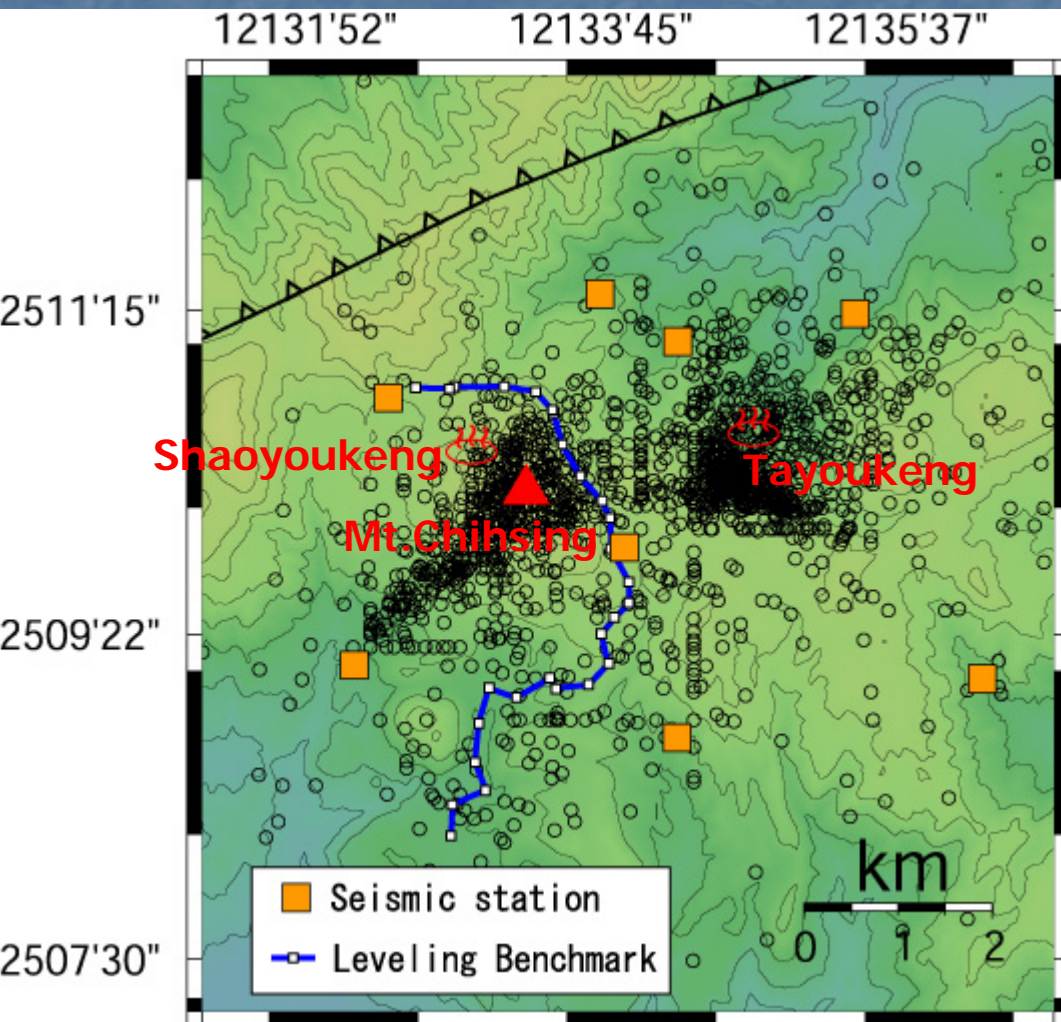
Since volcanic deformation is limited in narrow area but is complex in general, we should make dense and accurate observation network in narrow area. Precise leveling is a method suited to our request.

Leveling data will provide useful information with regard to the understanding of the volcano-hydrothermal system in Tatun volcano.





# Leveling route



Leveling route composed of 22 benchmarks were deployed at 2006.

The leveling survey was conducted in June 2006, March 2007 and August 2007.

# Installed benchmark



A round head nail was installed as benchmark on the existing concrete block.  
Distance between two benchmarks are about 400m.



# Correction for thermal expansion of rod



Leveling rod is made by an invar that have a very small effect of temperature change.

Leica provide thermal expansion coefficient of rod of  $< 1$ ppm as technical data.

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Maximum height difference of the leveling route	: 434mm
mean temperature difference in the levelings in between March 2007 and August 2007	: 11
Thermal expansion coefficient of rod	: 1ppm

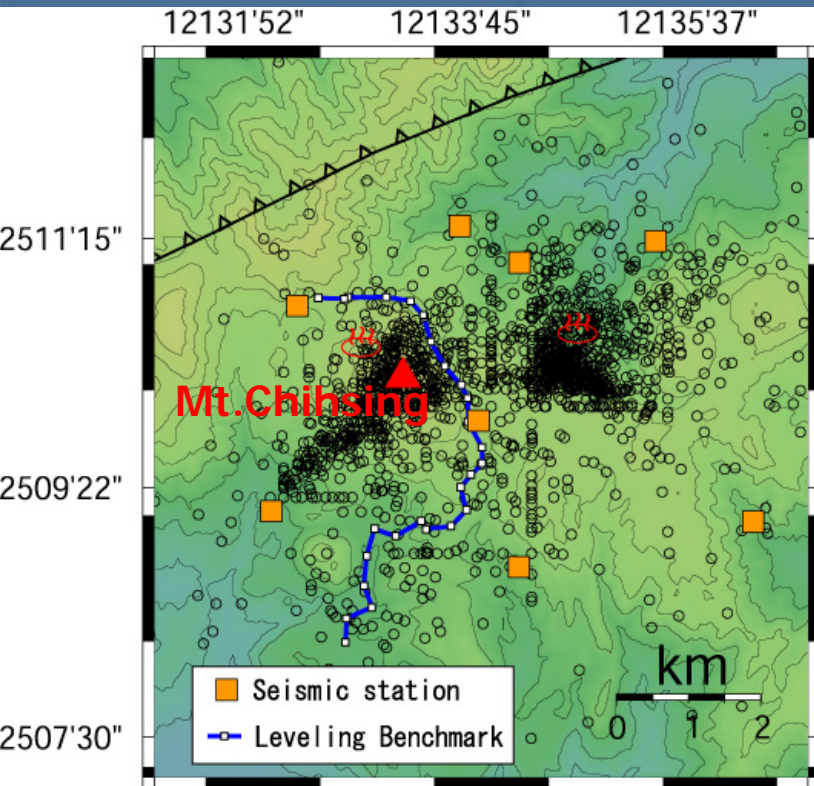
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Maximum expected error of thermal expansion of rod : **4.8mm**

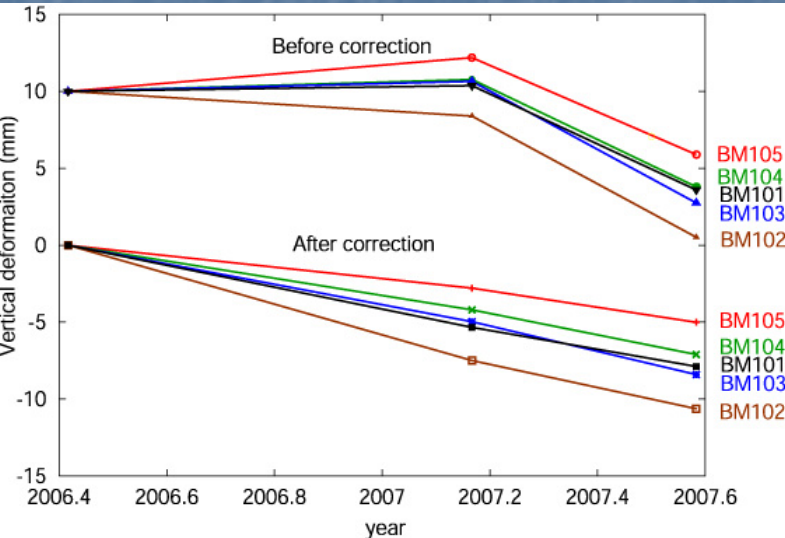
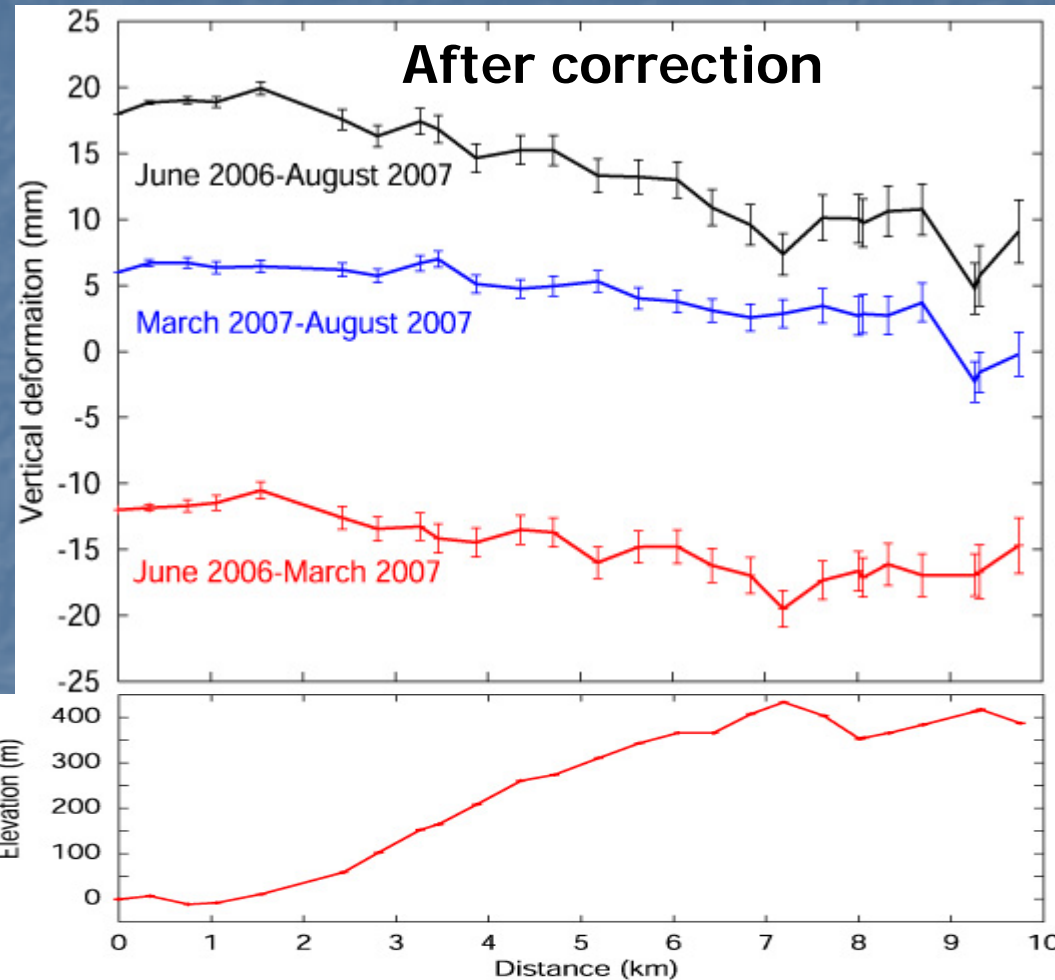
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We should consider the effect, if we compare results measured in different seasons.

# Correction for thermal expansion of rod



Thermal expansion coefficient of rod : 1ppm



Corrected result shows steady change through time and is plausible estimation.

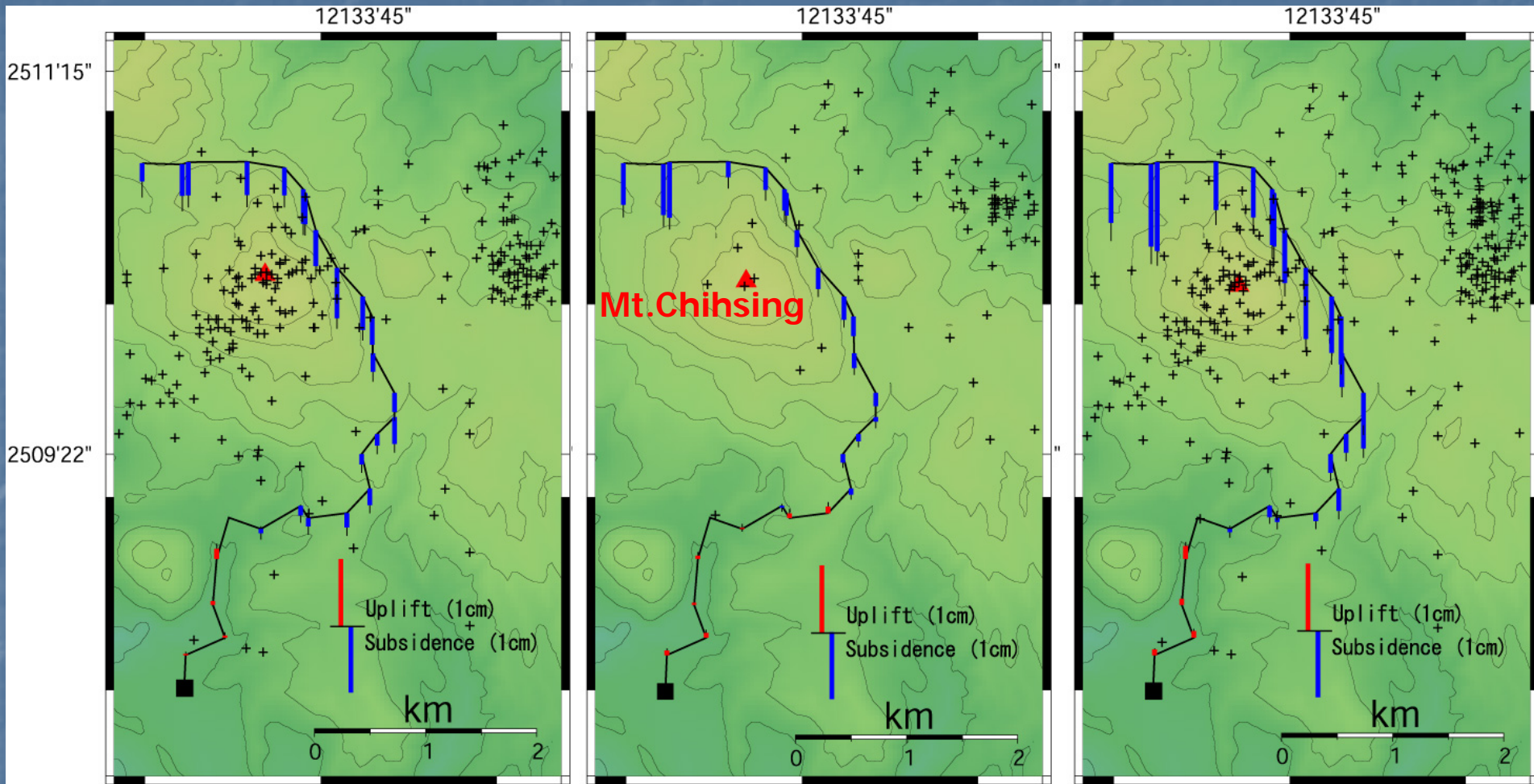


# Vertical deformation

June 2006-March 2007

March 2007-August 2007

June 2006-August 2007

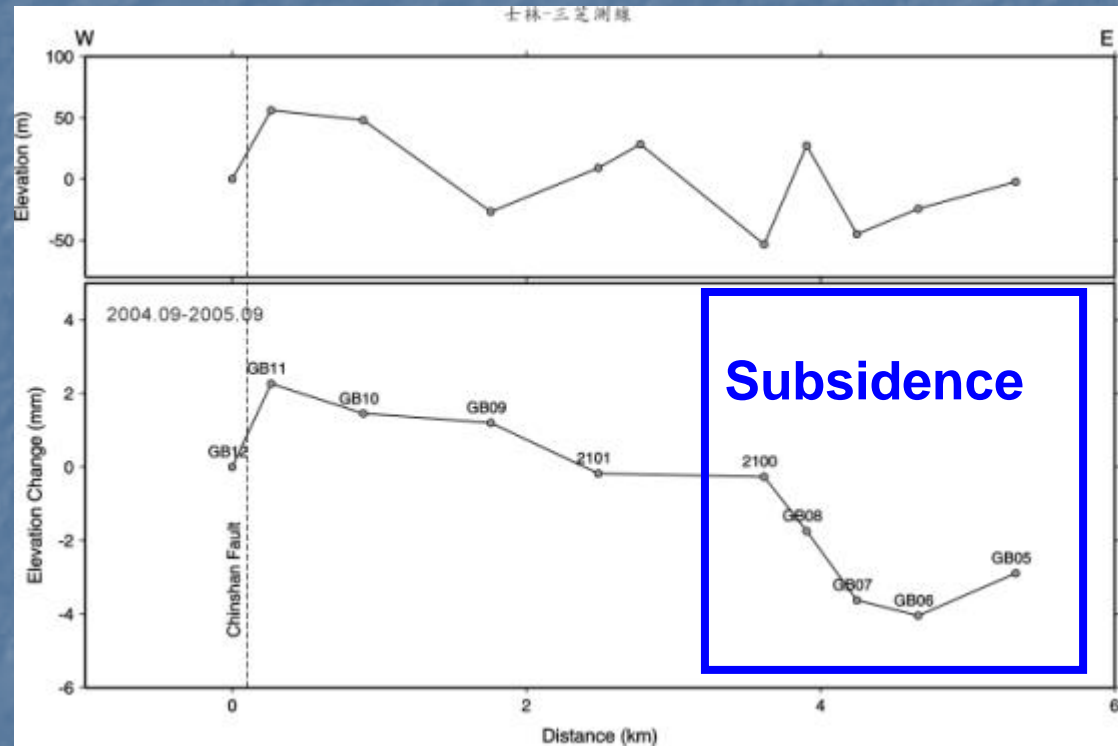
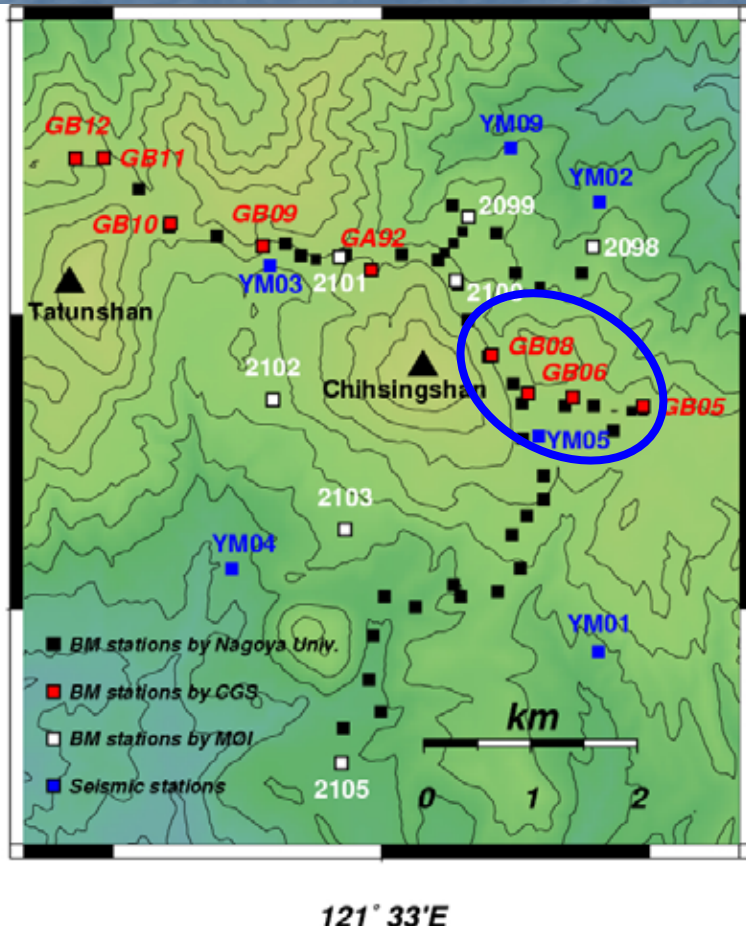


Subsidence of 1cm/year in the northeast part of volcano.

# Leveling result by Central Geological Survey (CGS)

CGS conducted precise leveling for a research of Jinshan (金山) fault at the period from 2004 to 2005.

September 2004- September 2005

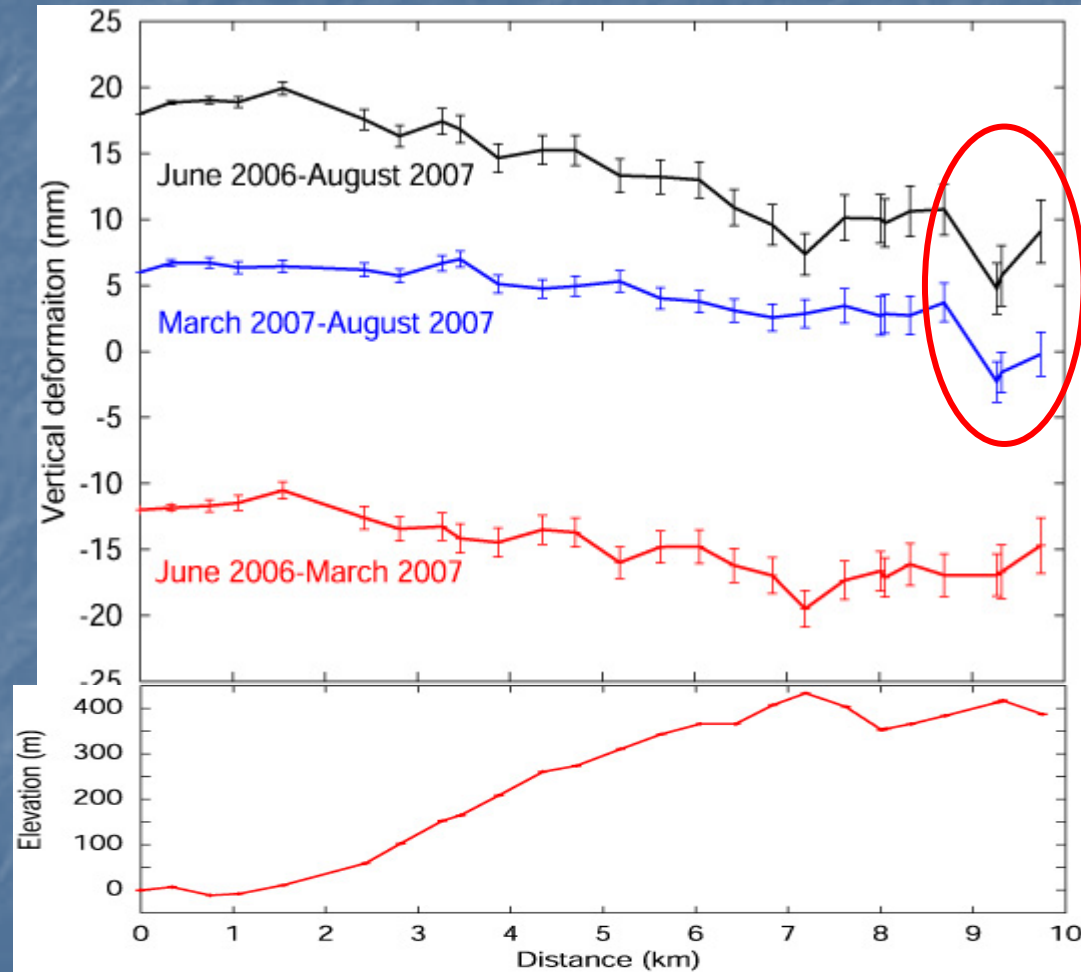
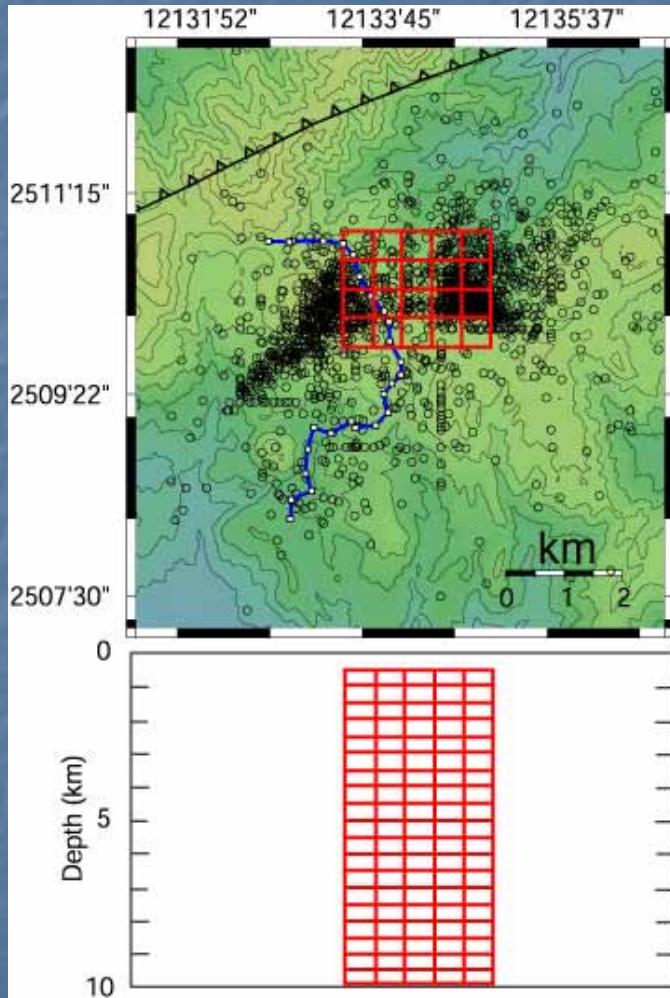


Their result indicates the subsidence around Len-Shuei-Keng (冷水坑), and is consistent with our result.



# Searching area

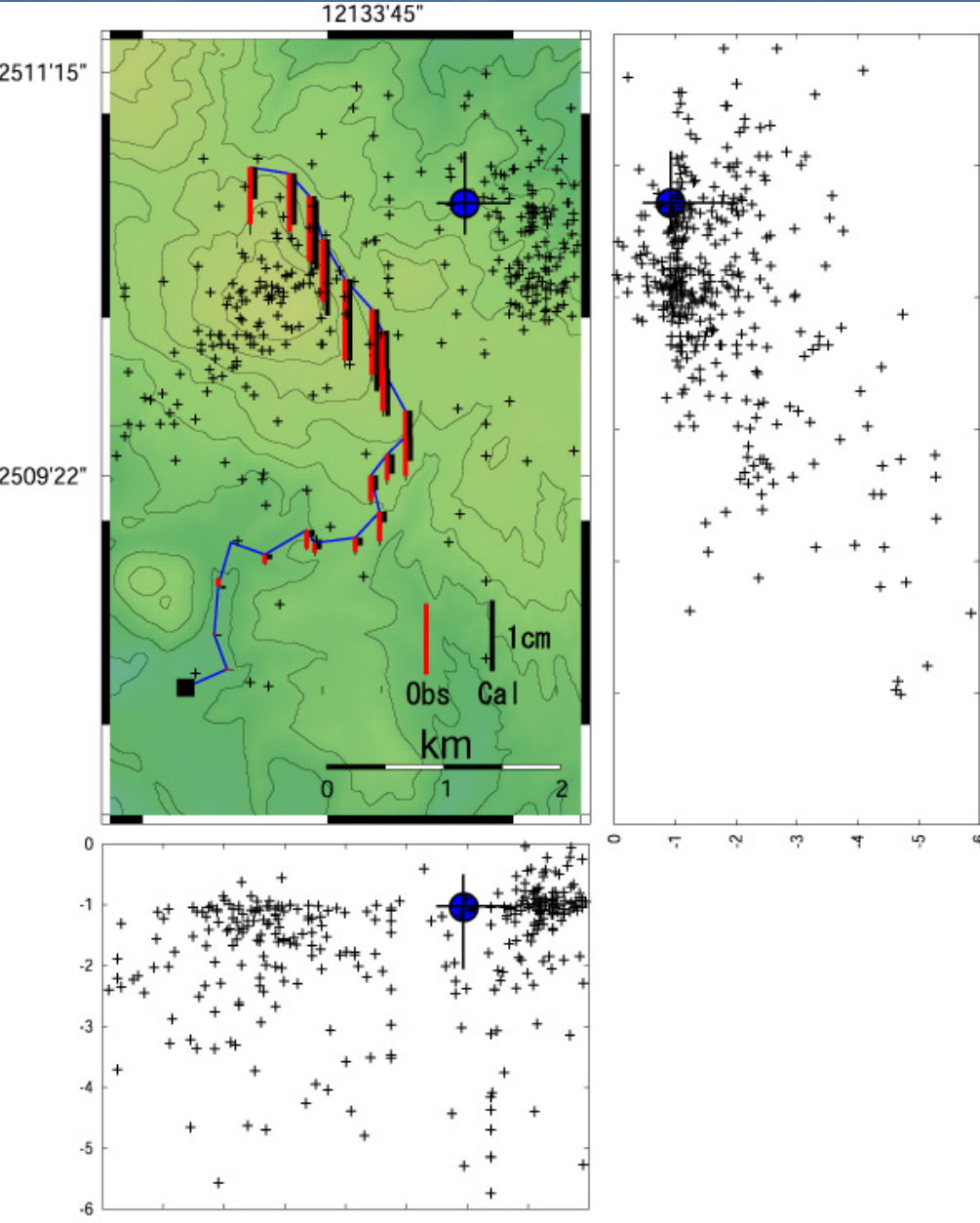
Optimal parameters of a spherical source is estimated from the vertical deformation between June 2006-August 2007 by genetic algorithm.



Search area was selected based on CGS result.

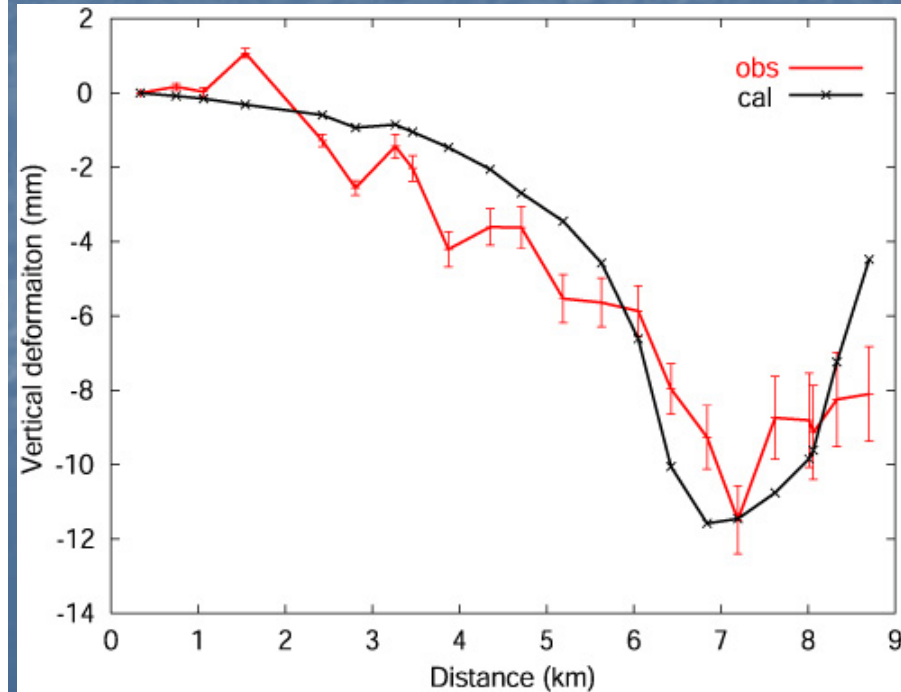
Data differing from volcano-wide trend were removed.

# Estimated spherical source



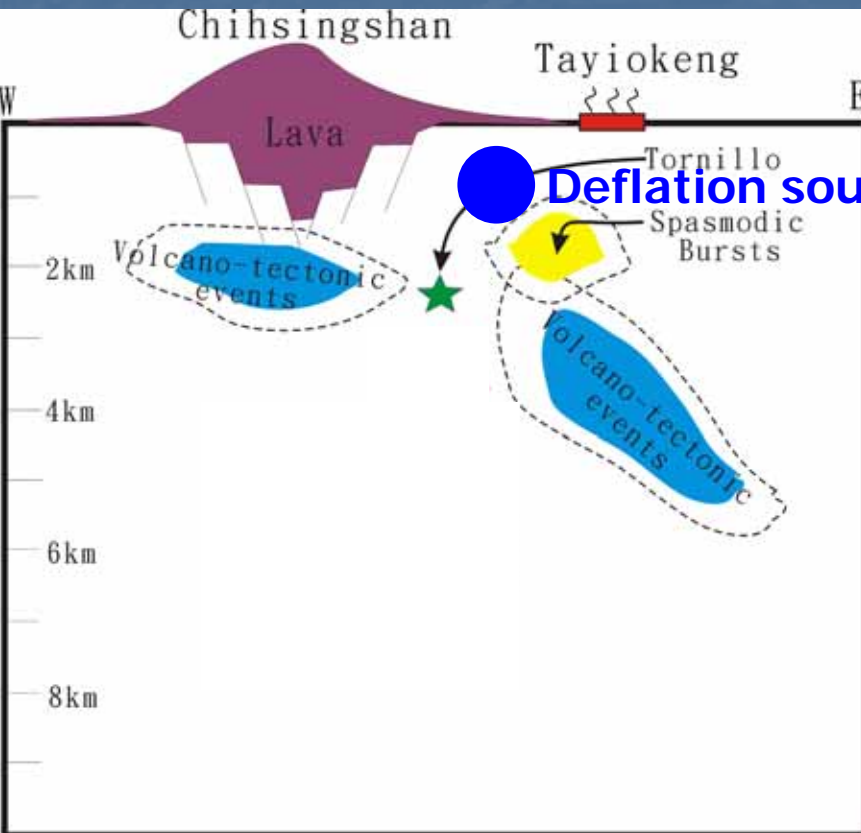
Volume change :  $-1.9 \times 10^5 \text{m}^3$

The spherical source was estimated around swarm area beneath Tayoukeng.

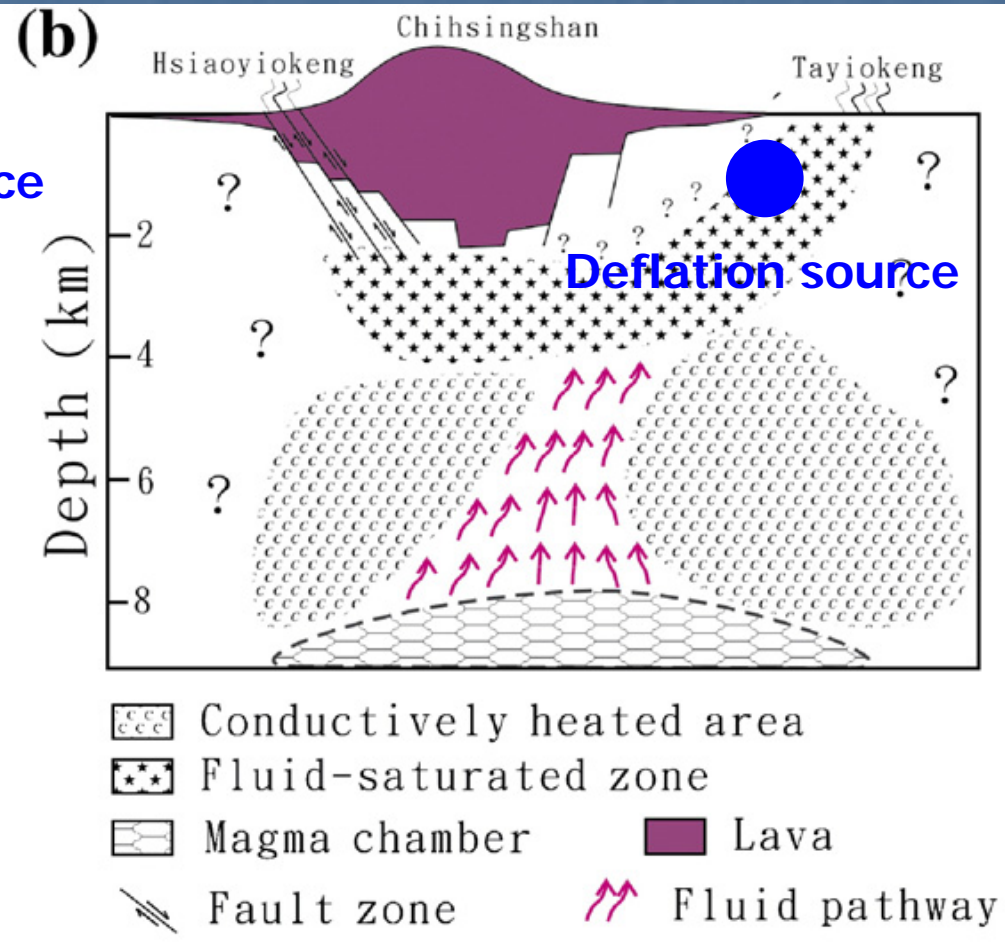




# Location of spherical source

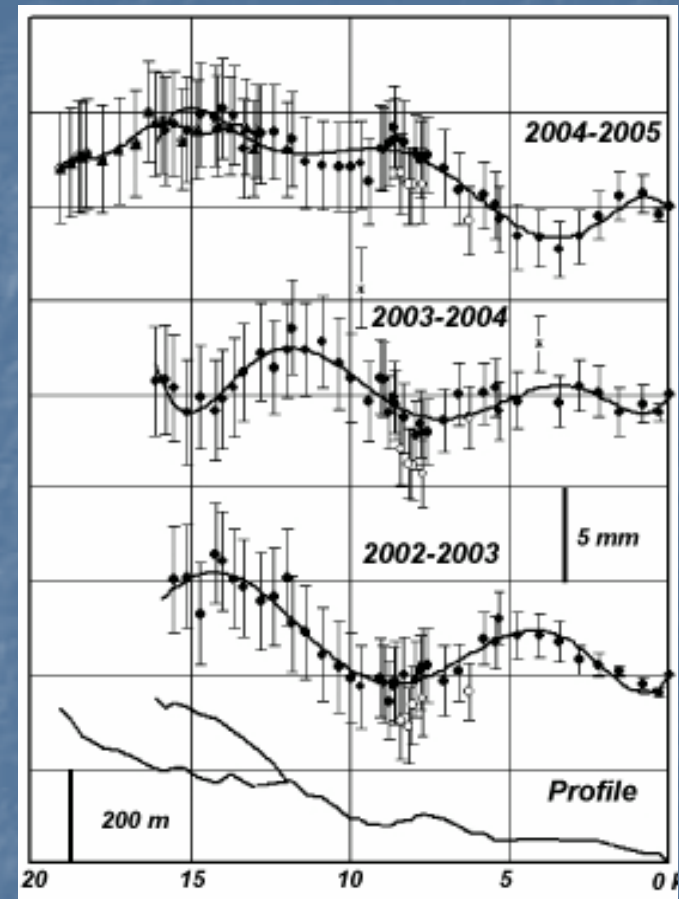
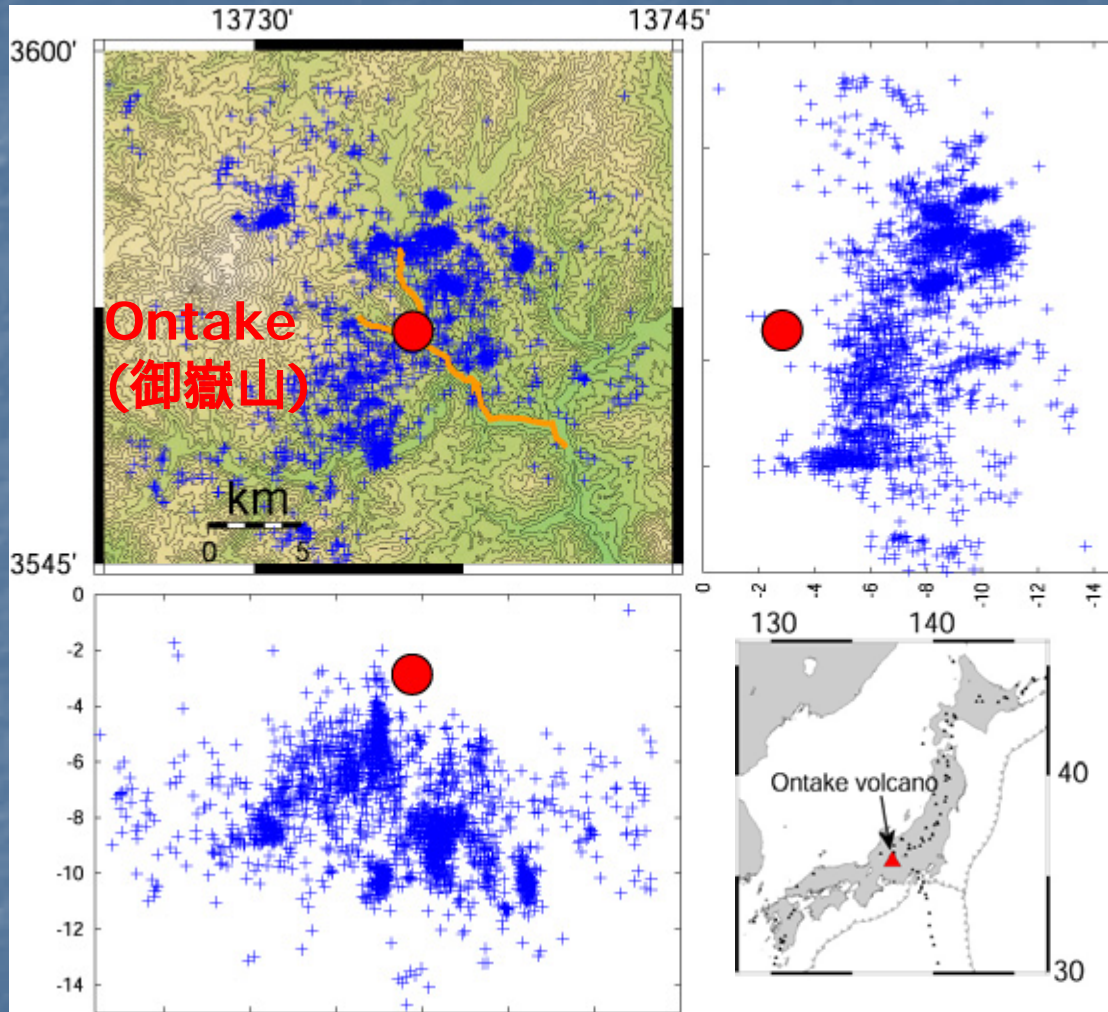


Konstantios et al.(2006)



The spherical source is located around spasmodic burst area and also in the fluid-saturated zone supposed by Konstantinou et al.(2006).

# Comparison with other volcano



Kimata et al. (2005)

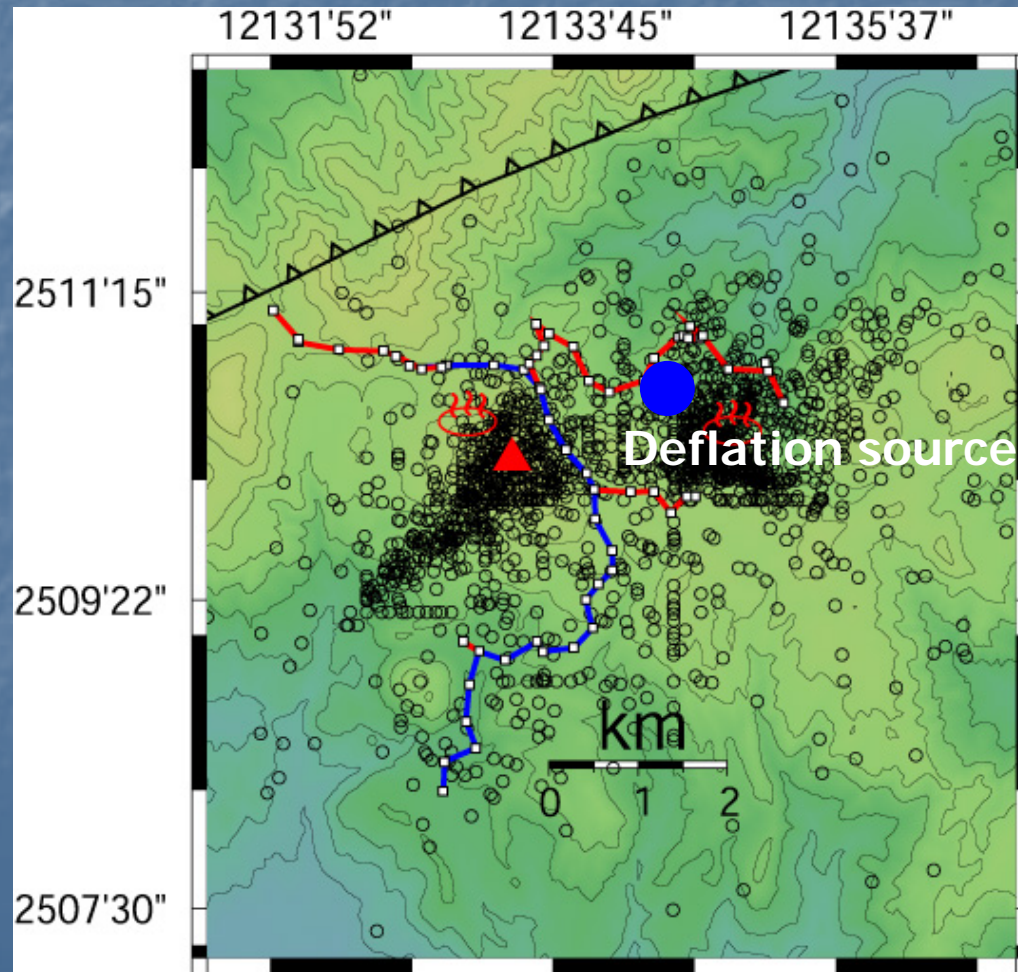
Volume change :  $2 \sim 4 \times 10^5 \text{m}^3$



# New leveling routes

The distribution of the leveling route deployed at 2006 is not good enough to estimate the exact location of pressure source and its shape.

We made a new leveling route over a distance of 10 km on August 2007 (red lines). We will be able to discuss the detail relationship between earthquake swarm and deformation in the near future.



# Summary

- Precise leveling route from south part to north part of the Chihsing-shan volcano was established
- The leveling surveys were conducted in June 2006, March 2007 and August 2007.
- Subsidence of 1cm/year was detected in the northeast part of volcano.
- The spherical source was estimated around swarm area beneath Tayoukeng.
- New leveling route was deployed on August 2007 to discuss the deformation source in detail



Thank you for your kind attention.