Volcanic activities in Taiwan: the past, present and future

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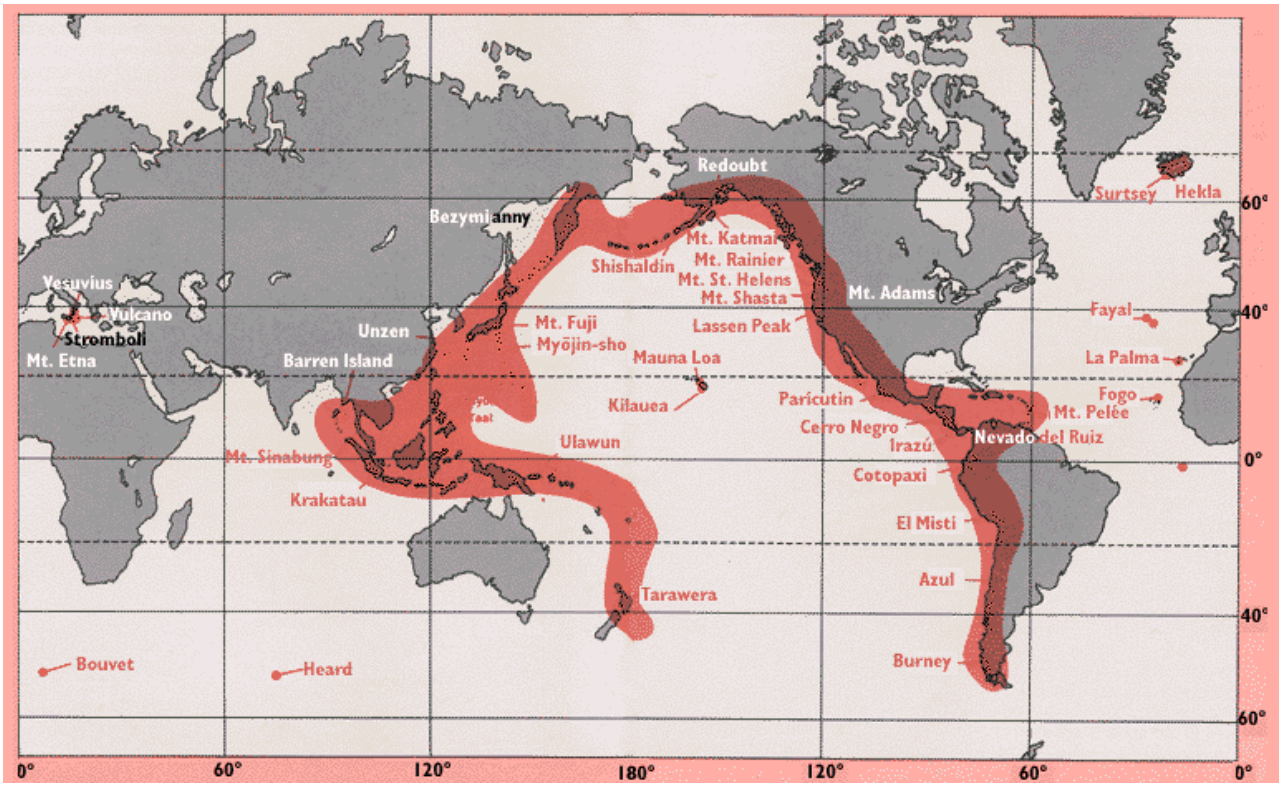
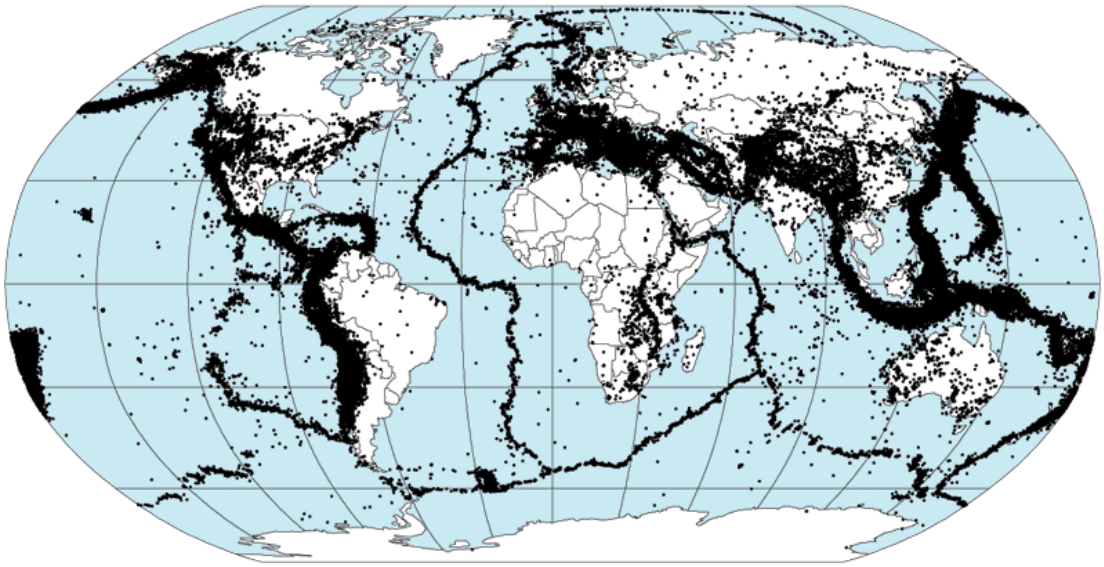
Ring of fire

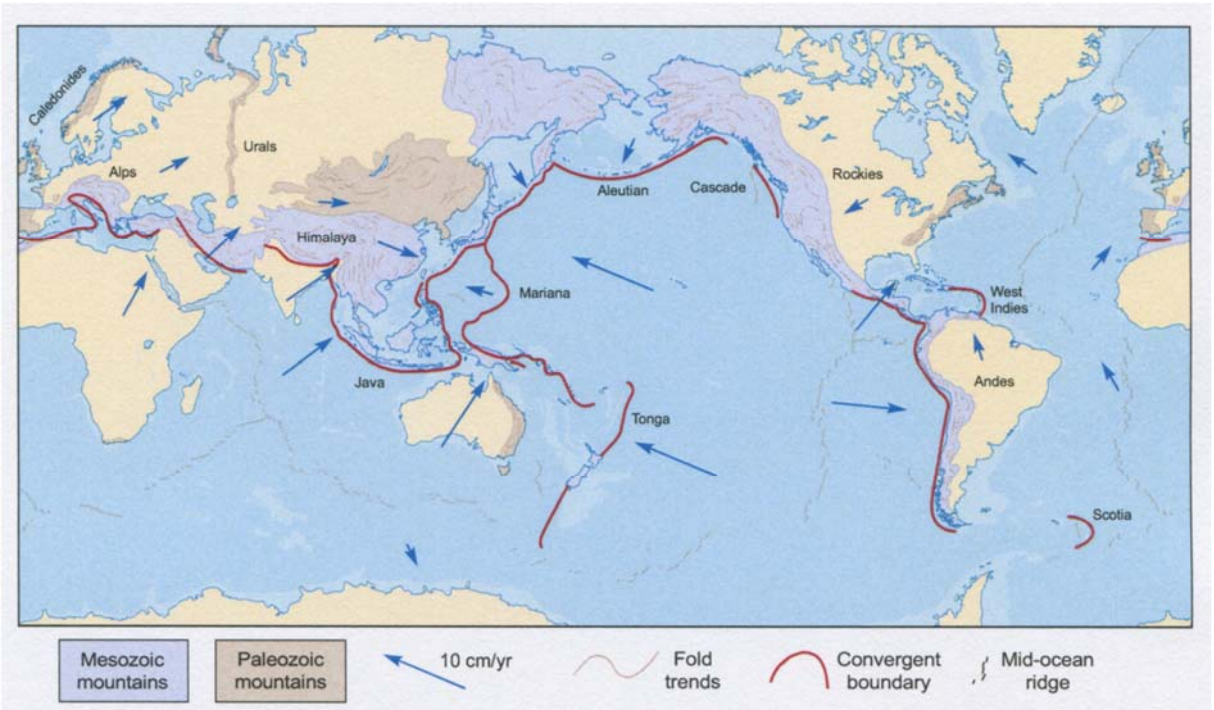


Preliminary Determination of Epicenters
358,214 Events, 1963 - 1998

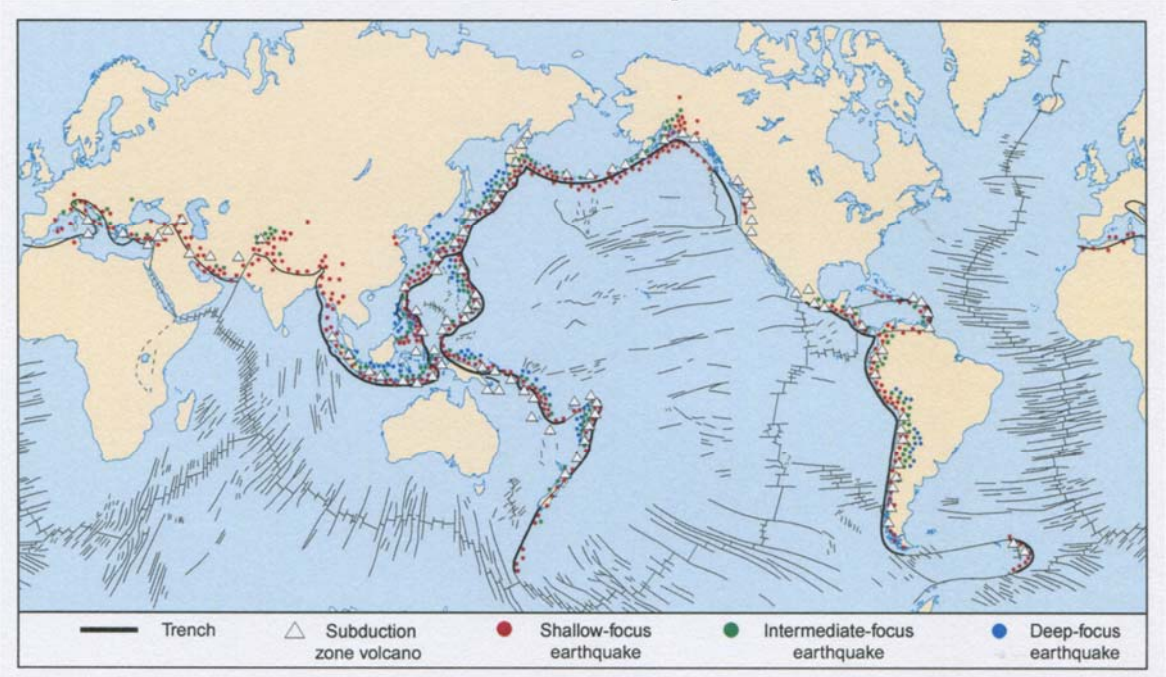


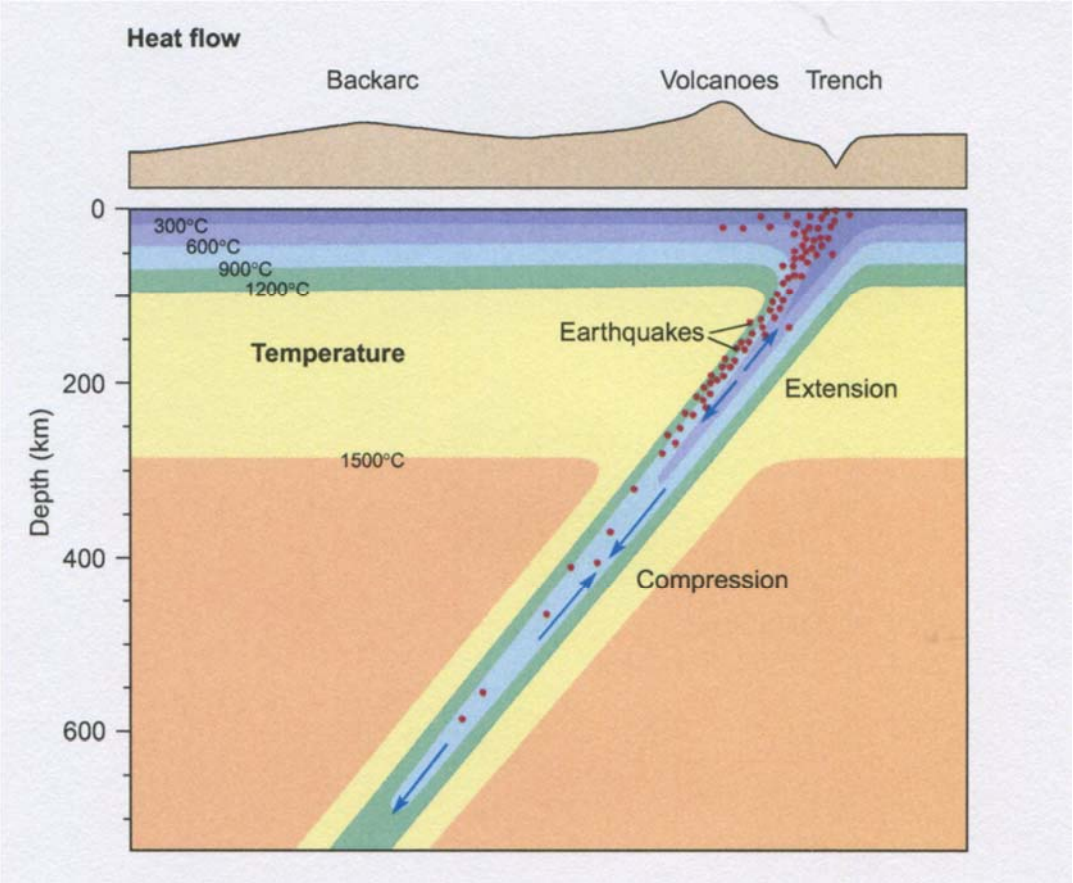
Basically they correspond to the plate boundaries

Relationship between ring of fire and plate motion

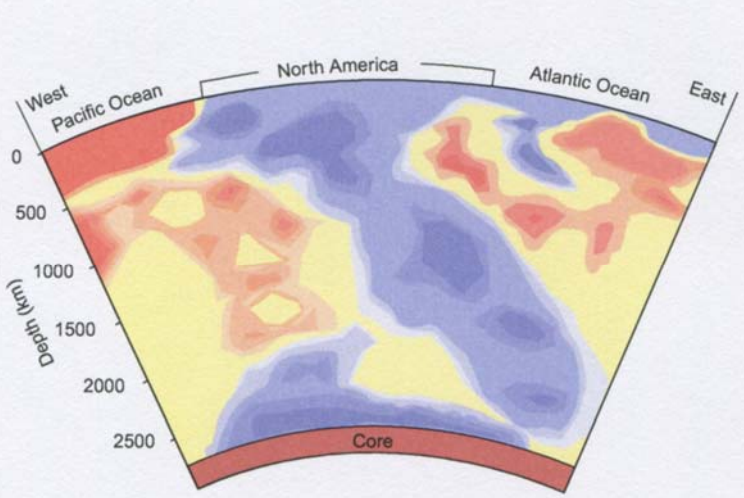


Volcano and earthquake are twins





Tomography of North America



Faster than average (cold)
Average
Slower than average (hot)

FIGURE 21.7 The trace of a cold subducted slab appears to extend from the continental margin all the way to the core-mantle boundary in this seismic tomograph of Earth's interior beneath North America. Blue represents the cold parts of the mantle, which have high seismic wave velocities; red represents the warmest parts of the mantle, which have lower seismic velocities. *(Modified from S. P. Grand and R. D. van der Hilst)*

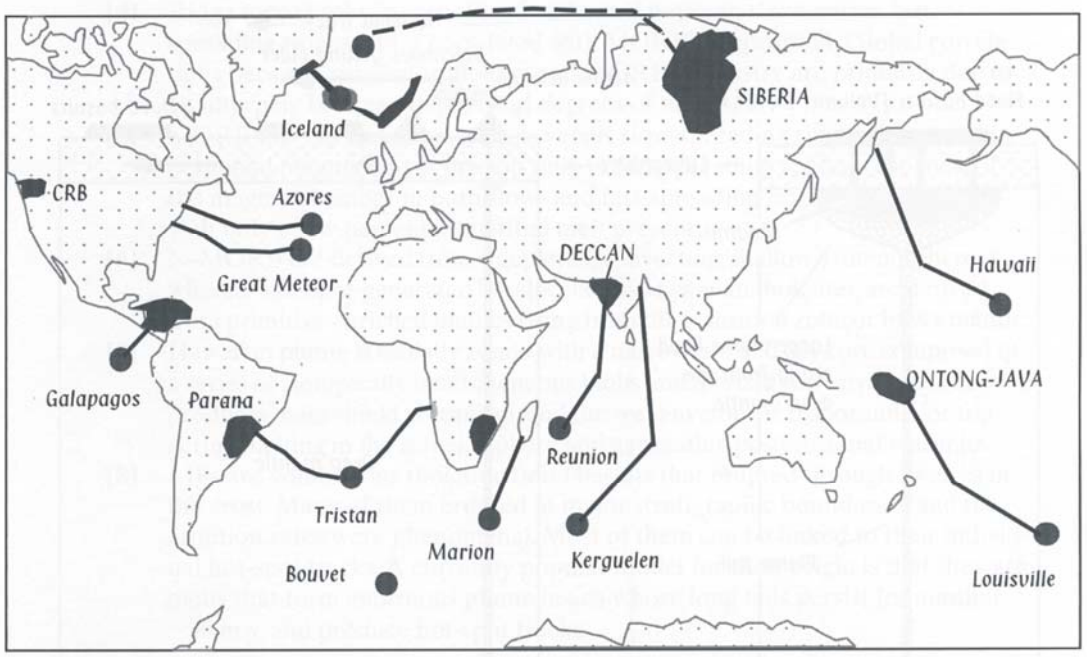


FIGURE 11.15 *LIPs and their corresponding (alleged) hot-spot tracks.* Currently active hot spots are shown as filled circles and the LIPs are shown as shaded irregular areas. (Redrawn after Duncan and Richards, 1989)

MORB case

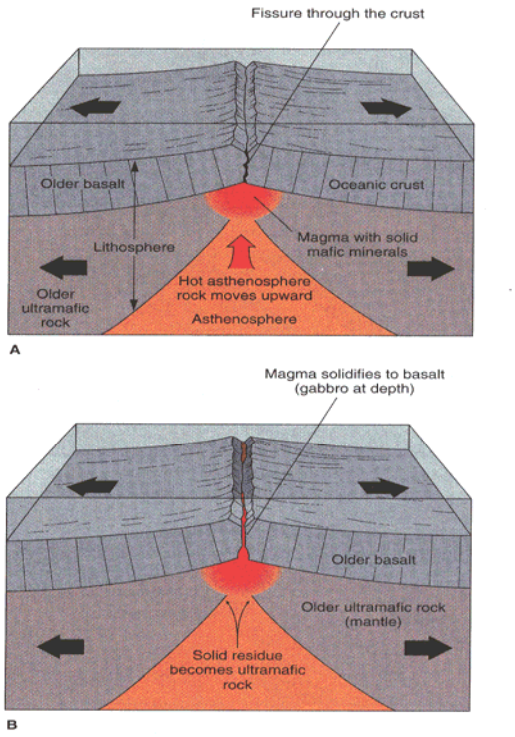


Figure 3.20

Schematic representation of how basaltic oceanic crust and the underlying ultramafic mantle rock form at a diverging boundary. The process is more continuous than the two-step diagram implies. (*A*) Partial melting of asthenosphere takes place beneath a mid-oceanic ridge. (*B*) The magma squeezes into the fissure system. Solid mafic minerals are left behind as ultramafic rock.

Hawaii case

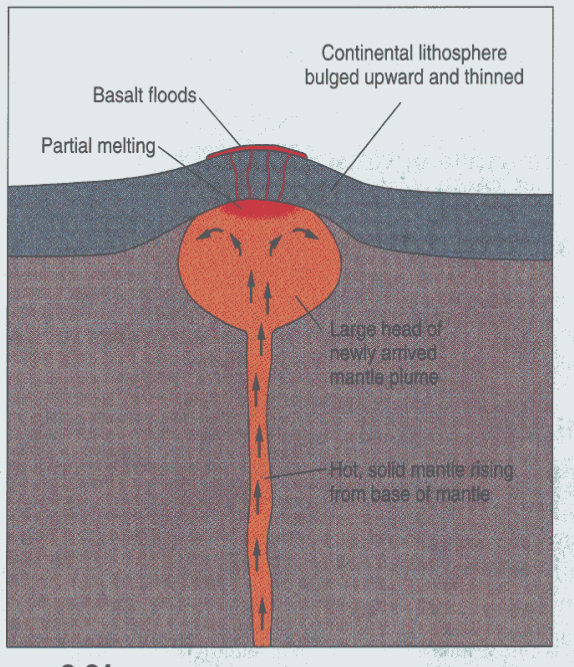
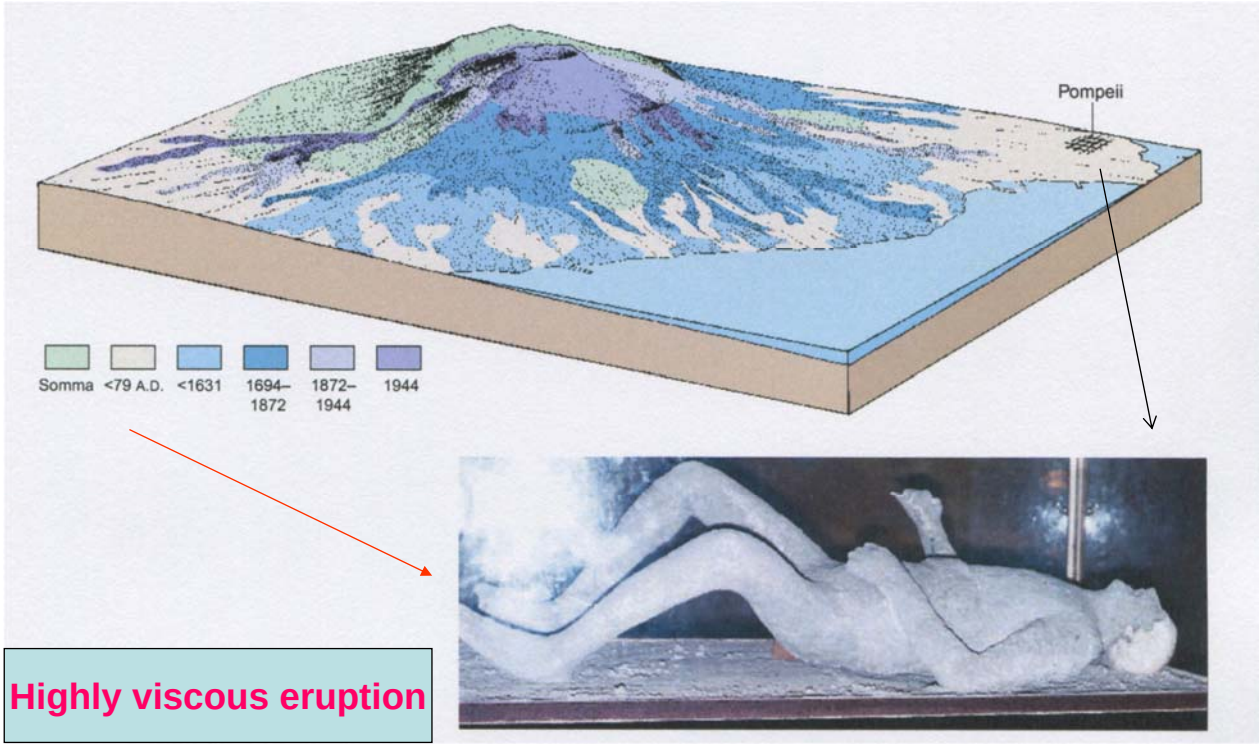


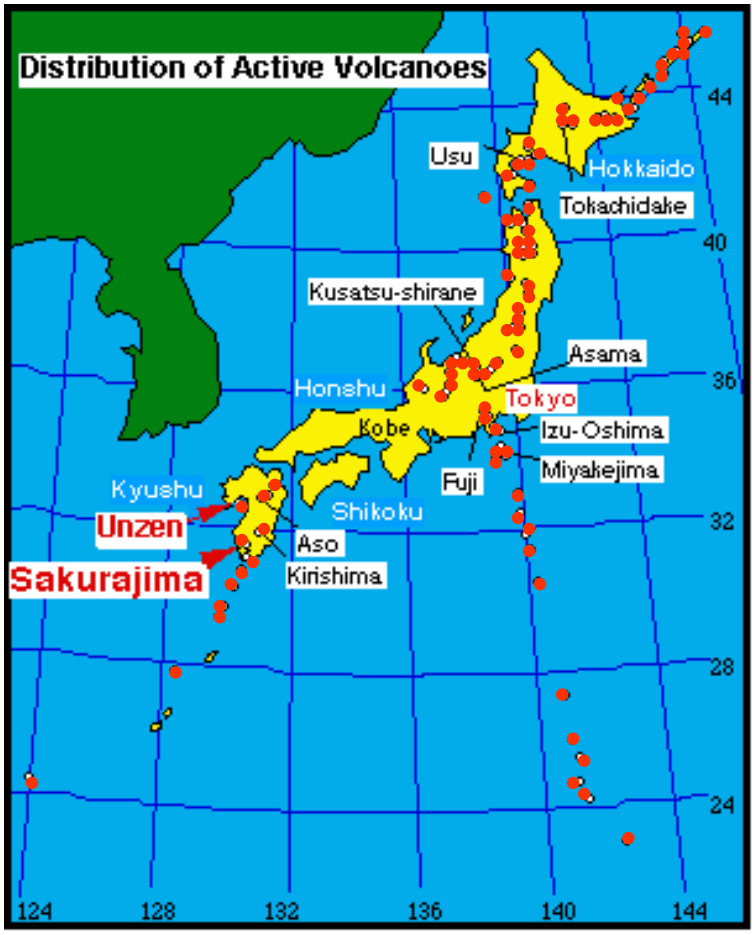
Figure 3.21

A hot mantle plume with a large head rises from the lower mantle. When it reaches the base of the lithosphere it uplifts and stretches the overlying lithosphere. The reduced pressure results in partial melting, producing basaltic magma. Large volumes of magma travel through fissures and flood the earth's surface.

Eruptions of the Vesuvius volcano, Italy



Highly viscous eruption


Distribution of Active Volcanoes
Usu
Hokkaido
Tokachidake
Kusatsu-shirane
Asama
Honshu
Tokyo
Kobe
Izu-Oshima
Miyakejima
Fuji
Kyushu
Unzen
Shikoku
Aso
Sakurajima
Kirishima
44
40
36
32
28
24
124
128
132
136
140
144

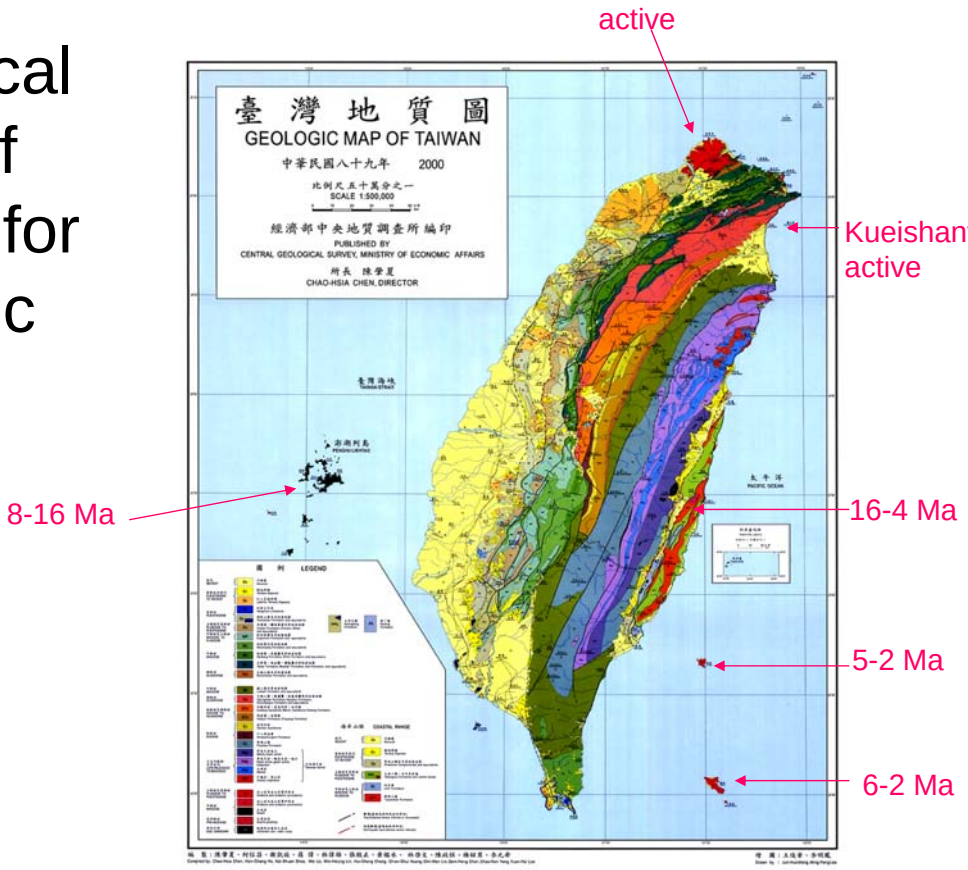

Major Volcanoes of the Philippines
Luzon Strait
0 100 200 kilometers
0 100 200 miles
PHILIPPINES
South China Sea
Luzon
Philippine Sea
Pinatubo
MANILA
Taal
Mayon
Mindoro
Samar
Panay
Leyte
Palawan
Guimaras Island
Canlaon
Negros
Sulu Sea
Mindanao
Ragang
Celebes Sea
USGS
Topinka, USGS/CVO, 1999, From CIA Basemap, 1997


Mayon Volcano


Ash explosion at dawn on 12-18-2009

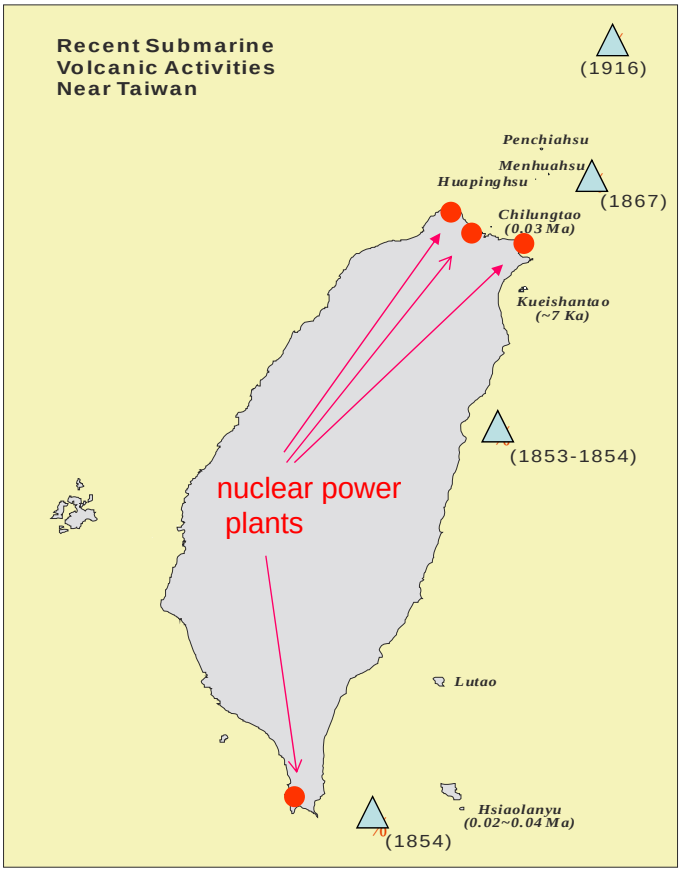

(c) 2009 Tryfon Topalidis
Eruption on 12-29-2009

Geological map of Taiwan: for volcanic rocks



- **Why volcanic activities are important in Taiwan?**

- Active volcanoes are close to the capital city—megacity disaster
- They are close to the nuclear power plants as well—nuclear radiation disaster



Submarine eruptions: Basically the records of sailing diary of captains

Data sources

Kuno, H. (1973) *Data Sheets of the Post-Miocene Volcanoes of the World with Index Maps, Sheet XIII (39 & 40). Working Group on the World Volcanological Map,* IAVCEI Publication Office, Rome, Italy.

Hedervari, P. (1984) *Catalog of submarine volcanoes and hydrological phenomena associated with volcanic events, **1500 B.C. to December 31, 1899***: World Data Center A for Solid Earth Geophysics, U.S. Department of Commerce, NOAA, Boulder, Colorado.

Kueishantao

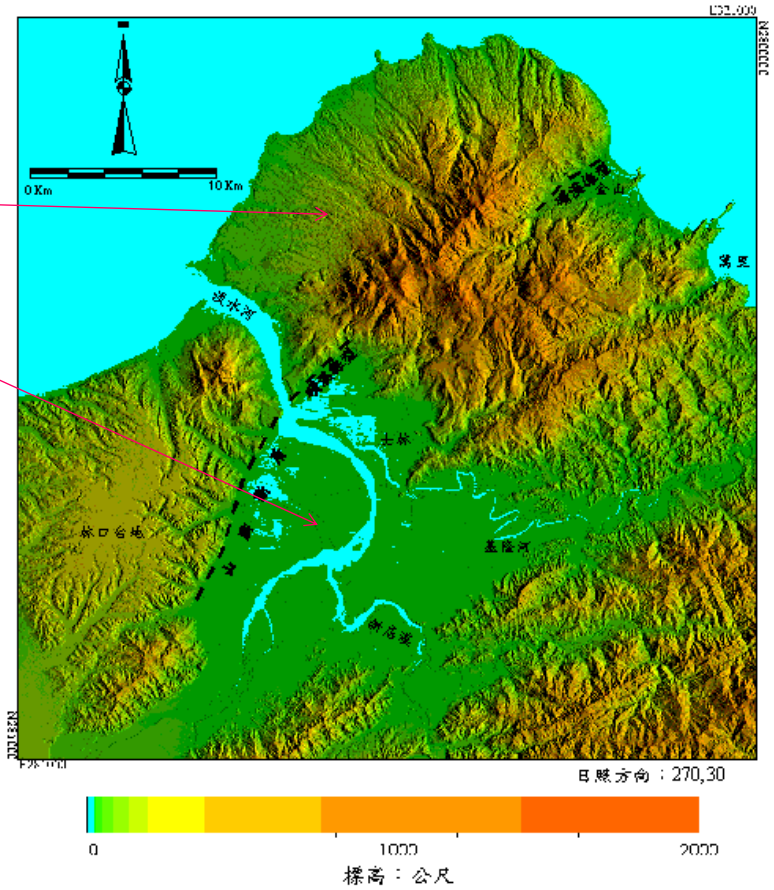
Smithsonian's National Museum of Natural History
Global Volcanism Program

Country:	Taiwan	
Subregion Name:	East of Taiwan	
Volcano Number:	0801-031	
Volcano Type:	Stratovolcano	
Volcano Status:	Historical	
Last Known Eruption:	1785 ± 10 years	
Summit Elevation:	401 m	1,316 feet
Latitude:	24.85°N	24°51'0"N
Longitude:	121.92°E	121°55'0"E

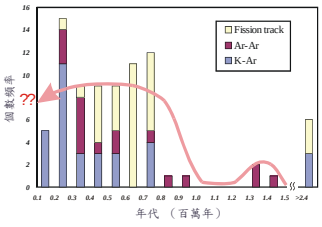
Historical accounts during the time of King Qianlong of the Qing Dynasty (1775-1795 AD)

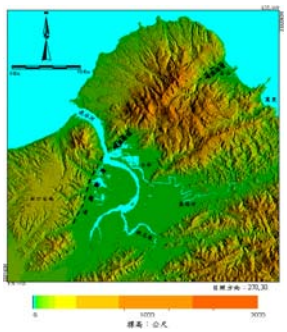
TL age determination of siltstone xenolith found at Kueishantao shows a result of 7± 0.7 ka for the lower part of the volcanic sequence. (Chen et al., 2001: *Quat. Sci. Reviews*)

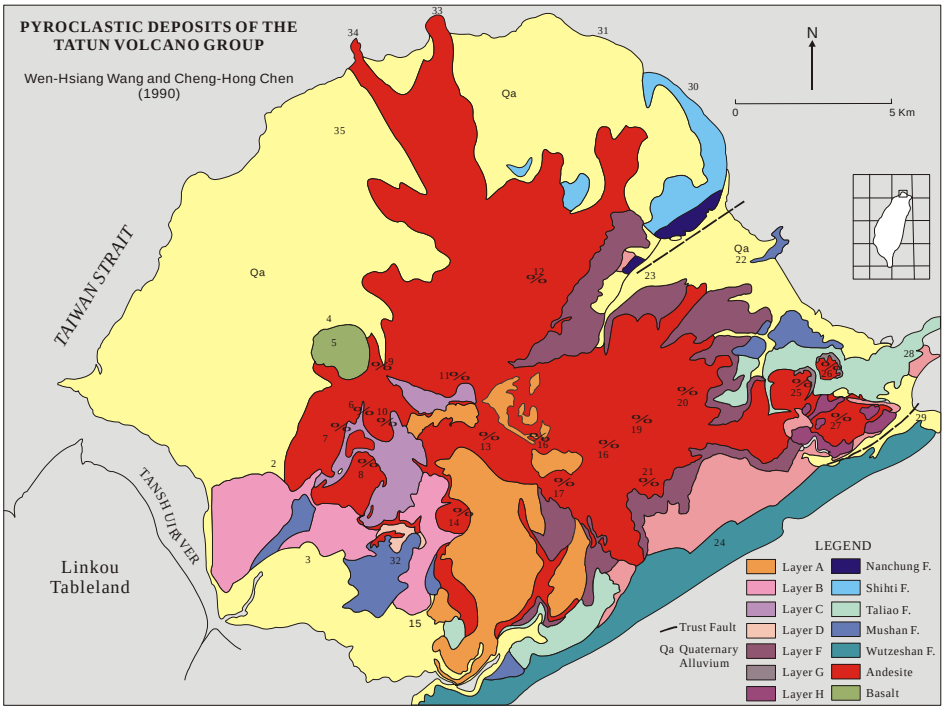
Tatun Vocanic Group
north to
the Taipei Basin



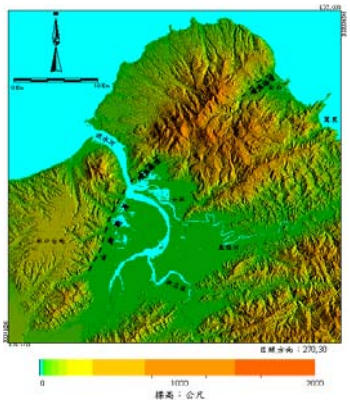
Age dating of the volcanic rocks

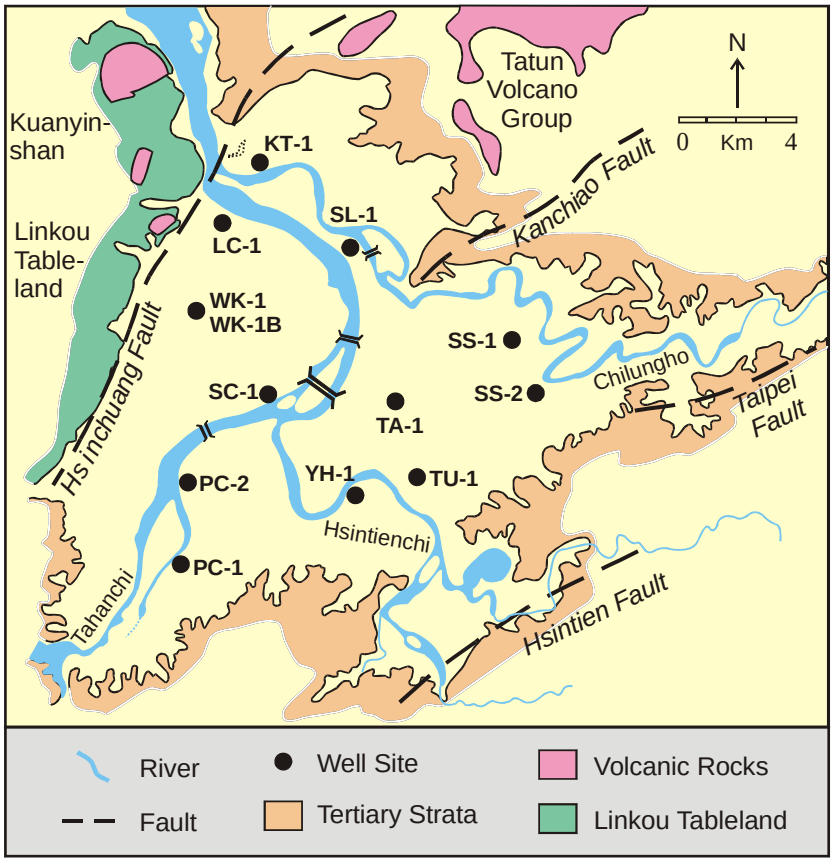




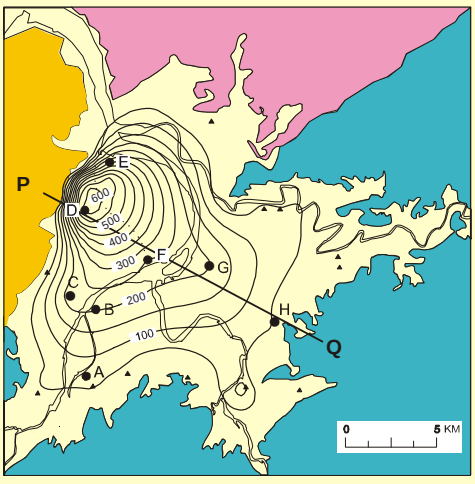


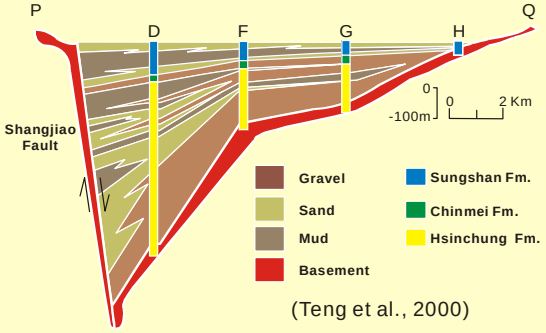
Well location



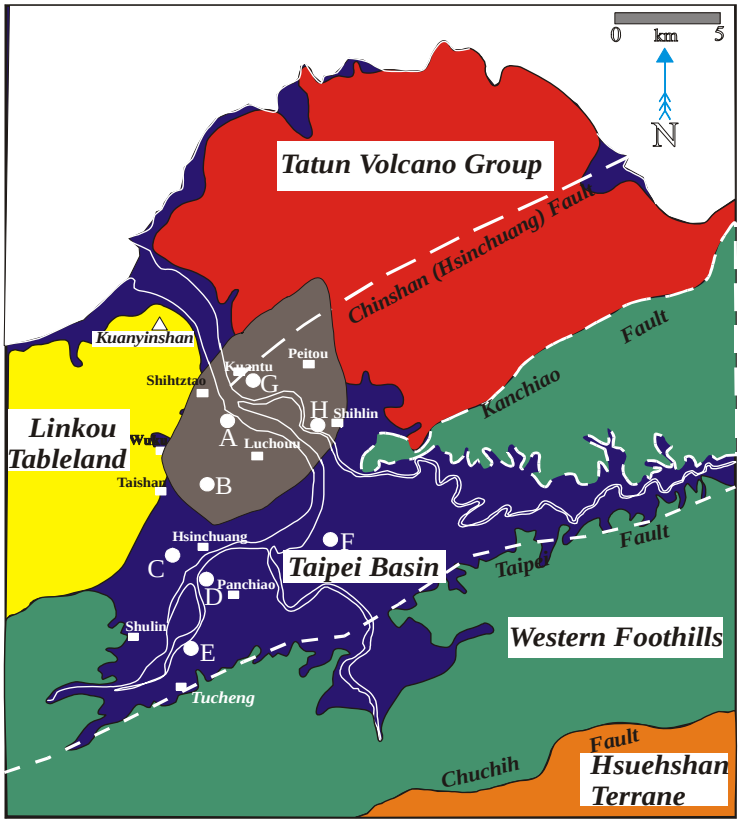


Basement Contours of Taipei Basin





(Teng et al., 2000)



A: Well of Luchou
B: No. 5 Well of Wuku
C: No. 1 Well of Hsinchuang
D: No. 1 Well of Hsinhaichiao
E: No. 2 Well of Shihkungchu
F: No. 2 Well of Hsinkungyuan
G: Well of Kuantu
H: Well of Shihlin

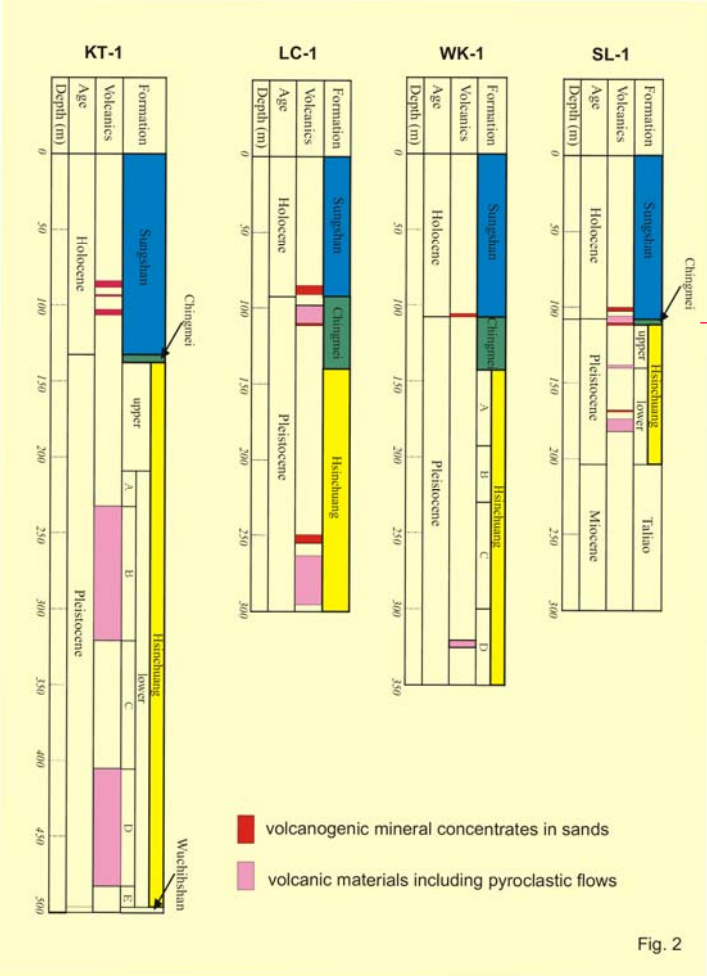
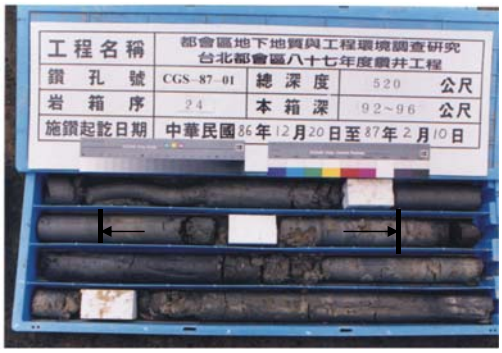


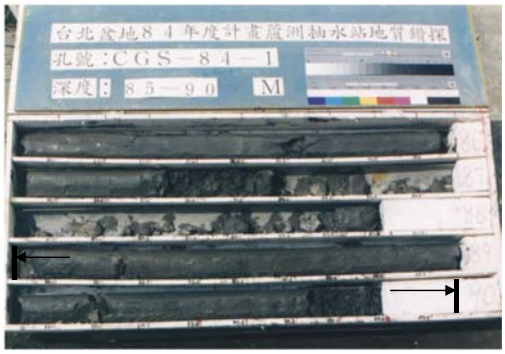
Fig. 2

→ see cores

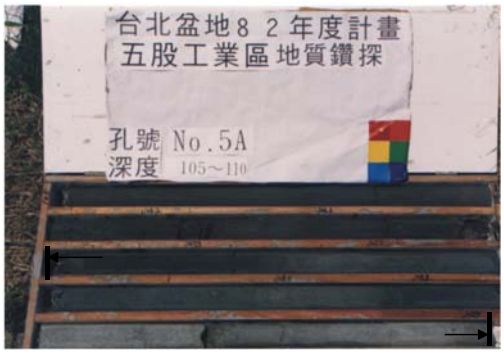
士林井106至110.4公尺（松山層底部）



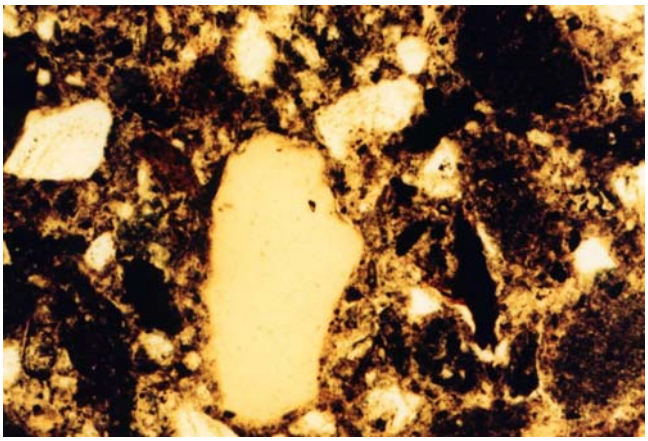
關渡井93.15至93.8公尺（松山層底部）



蘆洲井88至90公尺（松山層底部）

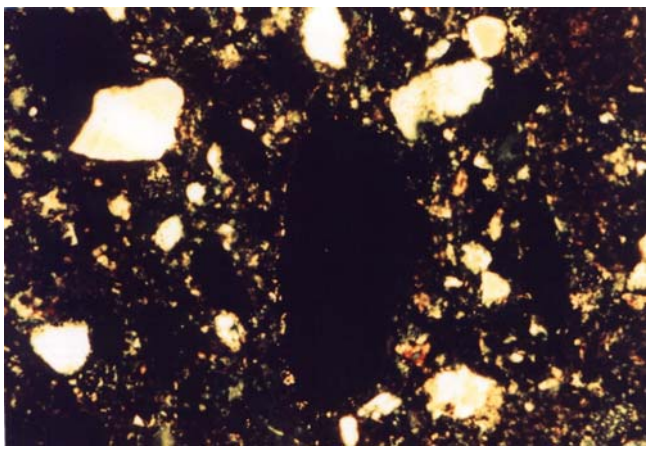


五股井107至110.8公尺（松山層底部）



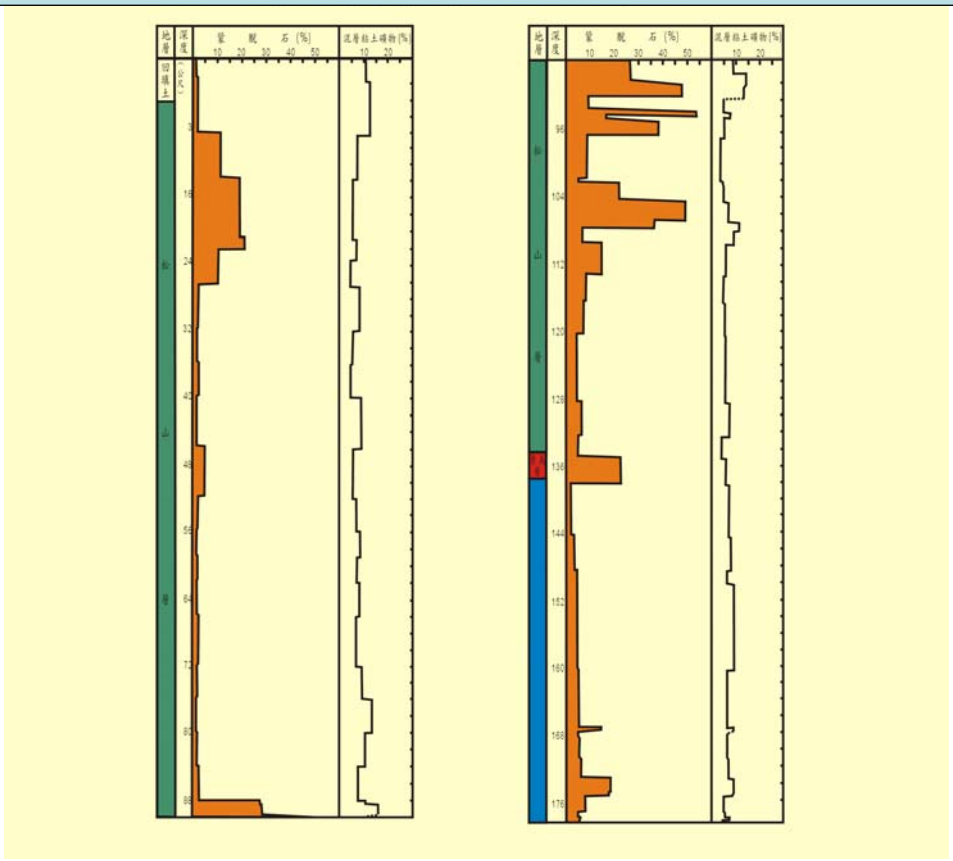
Volcanic glasses under microscope

Open nicol



Close nicol

Montmorillonite fraction in the clay portion along the core of Well KT-1



Representatives of debris of Forest fire

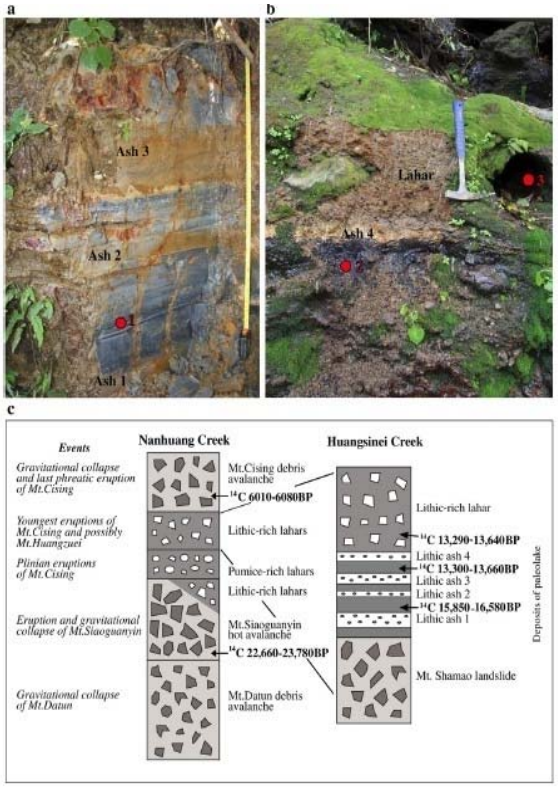
Microcharcoal preserved in the Well KT-1 at depth 88.4 m:
C-14 dating (AMS) = 16,950±150 yrBP (Chen et al., 2010; TAOS)

Volcano geology (^{14}Cage dating)

1. Volcanic ashes in Taipei Basin **~17,000 yrBP** (Chen et al., 2002)

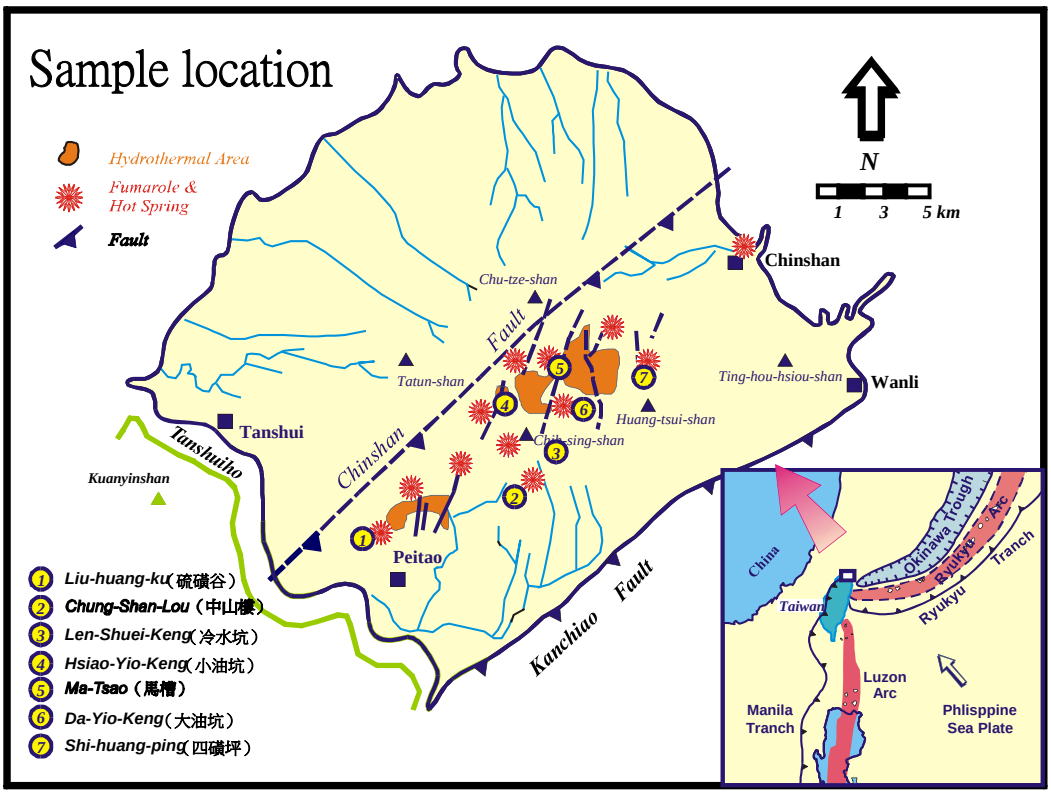
2. Chesingshan volcanic ashes **~6,000 yrBP** (Chen and Lee, 2010; WPGM)

3. Chesingshan gravitational collapse **~6,000 yrBP**
   (Belousov et al., 2010)



(Belousov et al., 2010)

Hot springs and volcanic gases in Tatun Volcanic Group

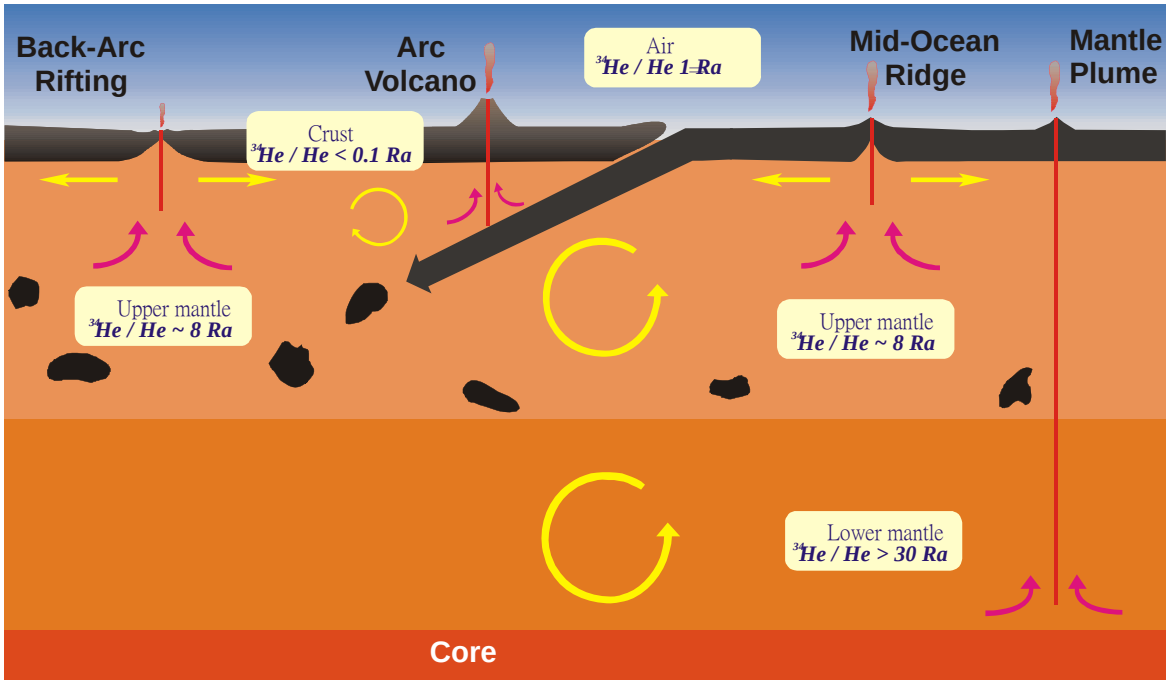


Major gas constituents of the fumaroles

採樣地點	CH_4	N_2	O_2	H_2S	Ar	CO_2	SO_2
大油坑噴氣（DYK）	0.27%	16.48%	2.04%	0.82%	0.11%	80.25%	0.03%
四磺坪溫泉氣泡（SHP）	0.99%	11.18%	0.96%	6.33%	0.05%	80.41%	0.07%
中山樓溫泉氣泡（CSL）	0.52%	13.22%	1.17%	10.58%	0.11%	74.29%	0.10%
硫磺谷溫泉氣泡（LHK-2）	0.93%	11.80%	1.08%	5.67%	0.07%	80.37%	0.08%
硫磺谷噴氣（LHK-1）	0.70%	12.99%	1.28%	12.21%	0.08%	72.61%	0.12%
冷水坑噴氣（LSK）	0.50%	13.21%	1.22%	16.94%	0.09%	67.81%	0.23%
小油坑噴氣（SYK）	2.13%	13.05%	1.39%	5.18%	0.08%	78.10%	0.06%
馬槽溫泉氣泡（MS）	2.69%	11.09%	0.94%	1.89%	0.06%	83.29%	0.04%
地熱谷溫泉氣泡（TYK）	0.59%	10.97%	1.07%	7.47%	0.13%	79.66%	0.12%

Conclusions: **CO_2**(68～84%), **H_2S & SO_2** (0.9～17.2%) and **N_2** (11～16%) are the major components

The use of helium isotope on volcanic gases: $^3He/^4He$

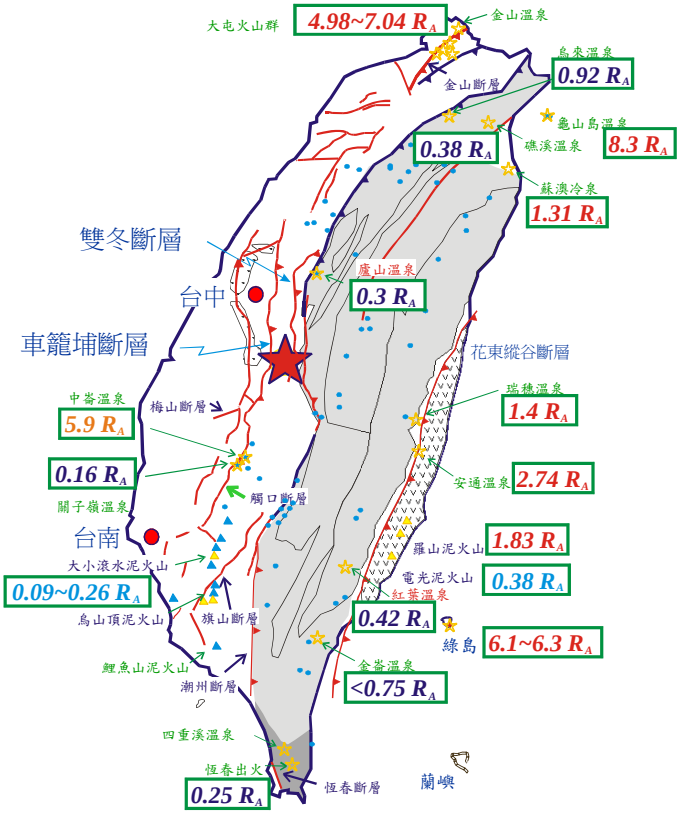


He isotope ratios of the gases in the Tatun Volcanic Group

Location	*Sample type*	$(^3He/^4He)_{raw}$	*Rc/Ra*	±	$^4He/^{20}Ne$	$[^4He]ppm$
大油坑（DYK）	F	8.9E-06	6.8	0.3	7.5	11.9
四磺坪（SHP）	B	8.4E-06	6.2	0.3	19.0	11.8
中山樓（CSL）	B	8.2E-06	6.1	0.3	11.4	10.9
硫磺谷（LHK-2）	B	8.0E-06	5.9	0.3	12.1	9.3
硫磺谷（LHK-1）	F	7.8E-06	5.9	0.4	12.6	6.8
冷水坑（LSK）	F	7.7E-06	5.5	0.3	5.3	7.1
小油坑（SYK）	F	7.0E-06	5.3	0.3	9.9	8.1
馬槽（MS）	B	6.6E-06	4.9	0.3	15.5	12.8
地熱谷（TYK）	B	5.2E-06	4.7	0.3	1.9	2.6
註：B - 溫泉氣泡						
F - 火山噴氣						

Conclusions: $^3He/^4He$ ratios range from $6.8R_A$ to $4.7R_A$, a sign of active volcano

台灣火山噴氣、溫泉、泥火山氦同位素分析結果



Potential hazards in the Taipei Basin

- It is a subsiding half-graben, the deepest Quaternary deposits is down to 680 m in the northwest corner.
- In 1694, the Taipei earthquake caused a depression of 3 m in the basin, making the so-called Kanhsi Taipei Lake in the western part of the basin.

ICSU: Natural Disaster Mitigation and Megacities

Tatun Volcano Observatory (TVO)

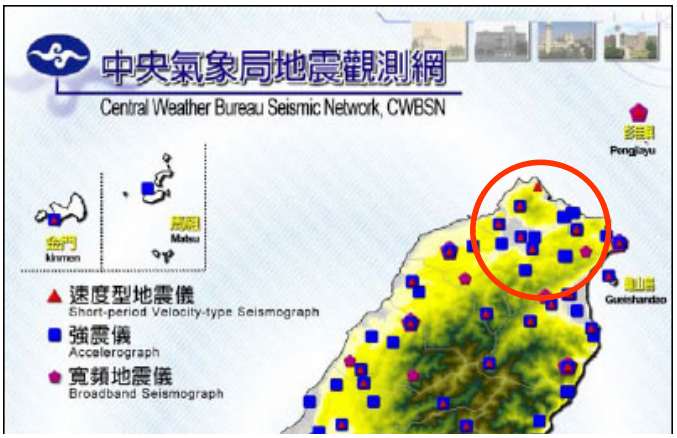
Installed at 2011

National Science Council, Ministry of Interior, Academia Sinica, Central Weather Bureau, Central Geological Survey

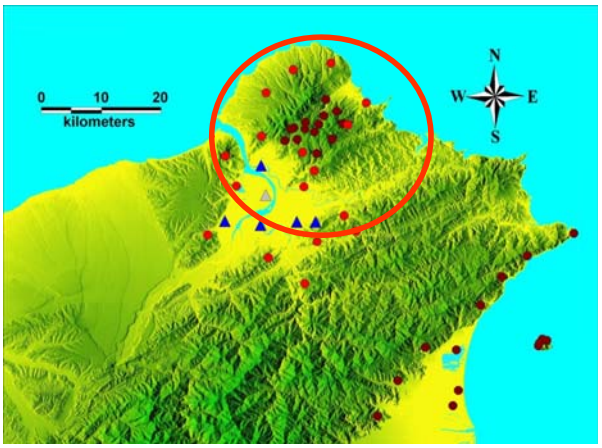
Monitoring setups in TVO

- Earthquake monitoring: 18 seismic stations (9 real-time)
- Crust deformation monitoring: 5 GPS stations (3 real-time)
- CO_2 variation in volcanic gas and hot spring: 1 real-time geochemical station
- Temperature changes of hot spring: 1 real-time station
- On-site viewing of fumaroles: 1 real-time station

Networking with other seismic and GPS stations

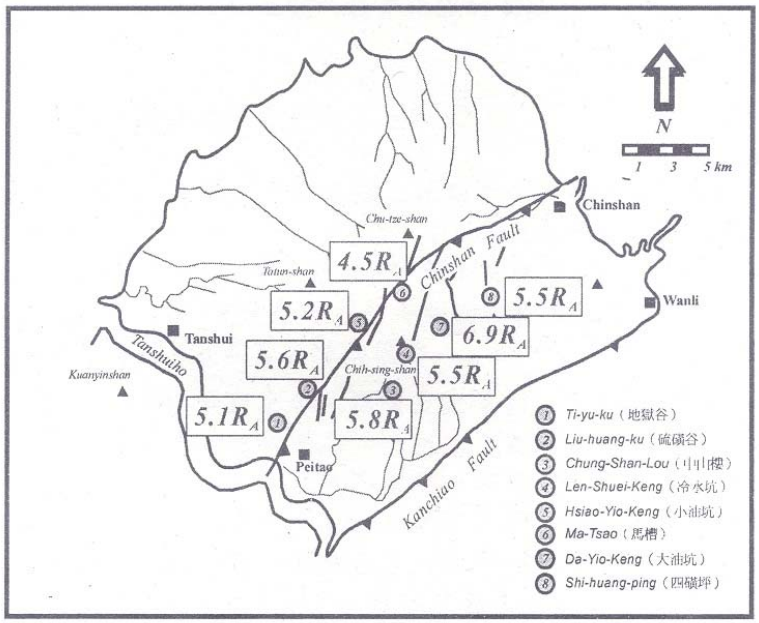


Central Weather Bureau's stations



Central Geological Survey and Academia Sinica's stations

He isotope analysis on regular time-interval basis



National Taiwan University

Targets

Taiwan Volcano Observatory - Tatun

T V O

1. **Establish the warning system**
2. **Scientific researches and education**
3. **Energy exploration**

Framework of Current Disaster Management Organizations in Taiwan

According “Disaster Prevention and Response Act”, enforced in 2000