一、前言

臺灣東部的臺東縱谷是歐亞板塊與菲律賓海板塊聚合的縫合帶（suture zone）。1960年代末期板塊構造學說興起，畢慶昌（Biq, 1965）首先提出臺東縱谷是一個裂谷（rift valley），由2條背向傾斜的高角度逆衝斷層所構成，西側爲向西傾斜的中央山脈斷層，而東側分隔縱谷與海岸山脈者稱爲海岸山脈斷層。徐明同（Hsu, 1971）利用1963-1969年規模大於4的地震資料，提出臺灣與鄰近地區的地體架構（圖1.1A），即臺灣南部向東隱沒至菲律賓海板塊之下，而在臺灣東部菲律賓海板塊則向北隱沒至歐亞板塊之下。畢慶昌（Biq, 1971）提出利吉層爲隱沒作用所形成的混同層（melange），之後則是島弧與大陸的聚合作用。翟懷慈（Chai, 1972）彙整有限的地質資料，推測歐亞大陸向太平洋板塊隱沒，而臺東縱谷是一構造斷裂，且呈現左移運動（圖1.1B）。此後經過許多地質學者調查研究，逐漸瞭解臺灣的地體架構。臺灣東部的活動斷層都位於這個縫合帶兩側，顯示此區域新期構造的活動特性。

臺灣島南側的海床上（巴士海峽），馬尼拉海溝（Manila Trench）是現存的隱沒帶（Ludwig *et al*., 1967; Ludwig, 1970）。畢慶昌（Biq, 1972）提出海溝向北延伸至恆春半島的西海岸。海床上內充填的沉積物向北延伸至臺灣南端的西側（Ludwig, 1979）。海溝與東側呂宋島弧（Luzon Arc）之間被認爲是一增積楔形體（accretionary prism），而許多地質學者認爲此構造可能一直延伸至屏東平原（例如 Reed *et al*., 1992）。臺灣南部的主要活動斷層，則位於此增積楔形體北側的延伸帶上。

（一）臺灣東部的活動斷層概述

臺灣東部的活動斷層，包括米崙斷層、嶺頂斷層、瑞穗斷層、玉里斷層、池上斷層、奇美斷層、鹿野斷層與利吉斷層等共8條斷層（圖1.2）。

米崙斷層，位於臺東縱谷北端，爲左移斷層兼具逆移性質，約呈南北走向，由花蓮縣七星潭海岸向南延伸至花蓮市美崙山西南方，長約8公里。本斷層是1951年地震的地震斷層，由地表破裂分布與地形分析結果，米崙斷層可能有多次活動的紀錄。由近期的地形地質與地球物理探勘結果，並無法證實斷層延伸至吉安溪以南。

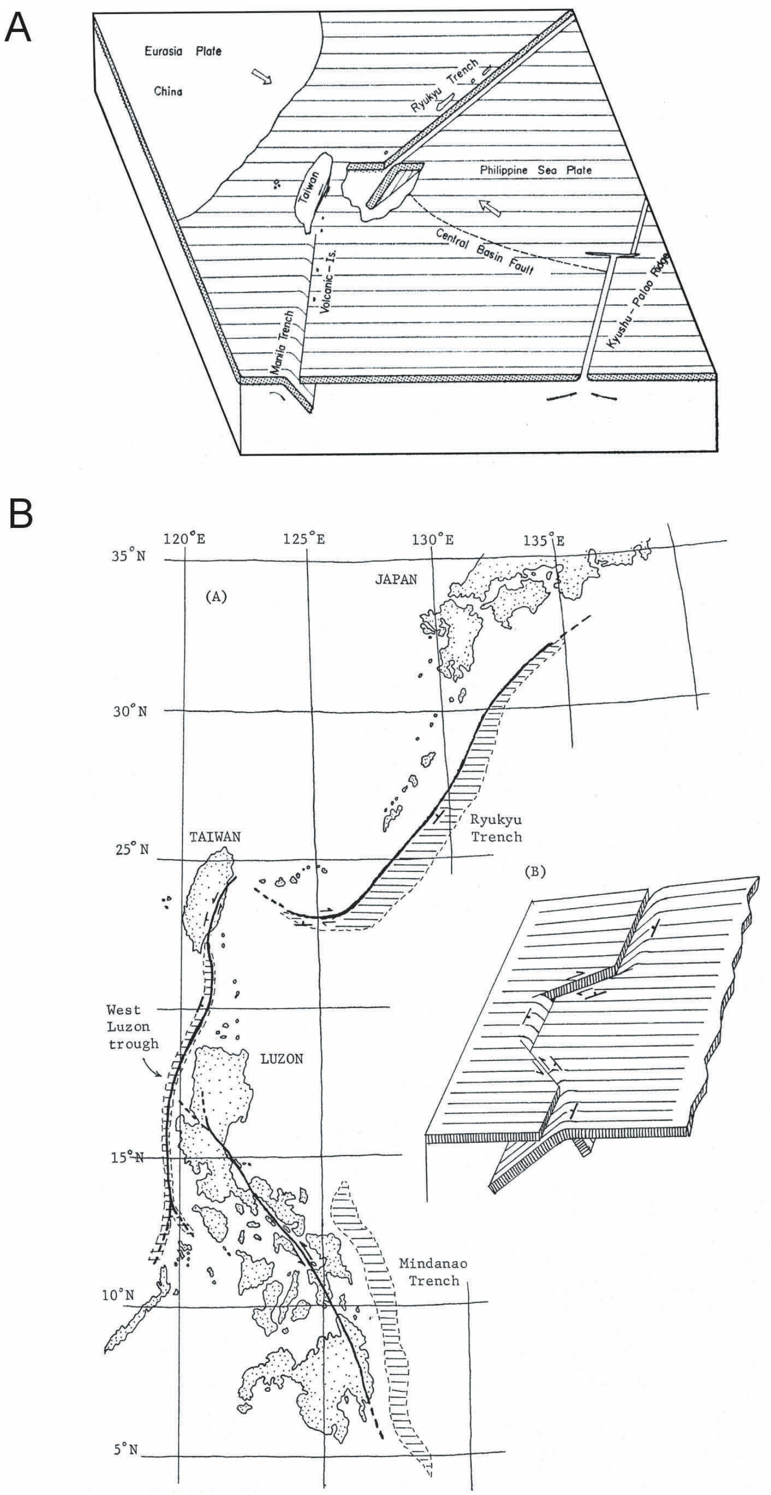

圖1.1 最早的臺灣地體構造簡圖。圖A摘自徐明同(Hsu, 1971),圖B摘自翟懷慈(Chai, 1972)。

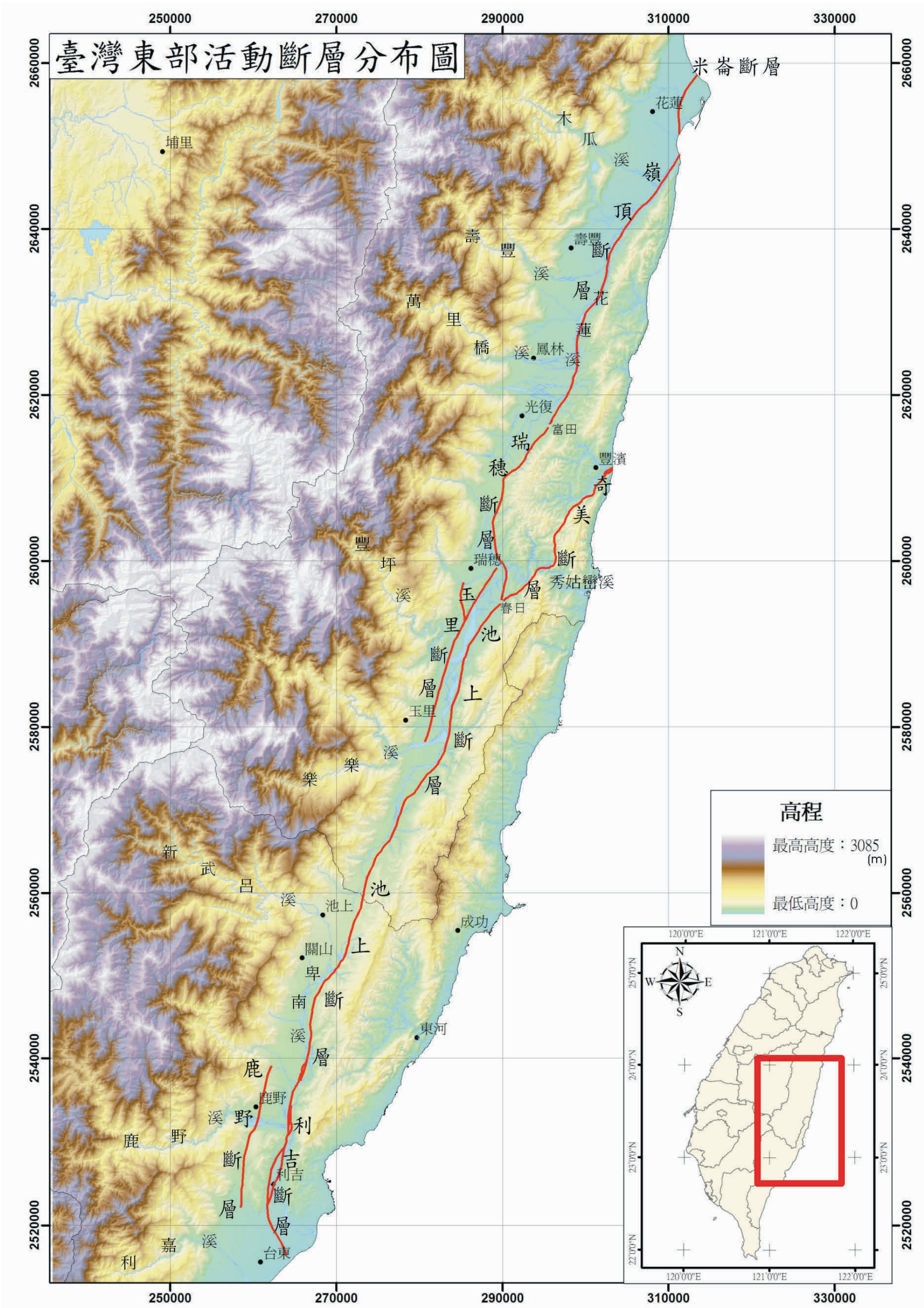

圖1.2 臺灣東部的活動斷層。（紅線部份示活動斷層；座標系統：TWD67）

嶺頂斷層，位於臺東縱谷北部與海岸山脈的交界，屬於左移兼具逆移性質的斷層，呈北北東走向，由花蓮縣嶺頂向南延伸，經月眉至光復鄉東富村（陳文山等，2008），長約30公里。在海岸山脈的西緣，地表並未發現斷層地形特徵，斷層跡位於花蓮溪河床中，被沖積物所掩覆，由 GPS 測量結果顯示斷層跡兩側在垂直與水平的速度場有明顯變化，暫列爲第二類活動斷層。以往所稱的月眉斷層，是一些斷續的地形崖與小型斷層的總稱，這些小型斷層多位於都鑾山層中，其可能在山麓沖積扇堆積前即已形成，而嶺頂斷層則是海岸山脈向西、向北擠壓的前緣斷層（板塊邊界斷層）。

瑞穗斷層，位於臺東縱谷北部與海岸山脈的交界，爲逆移斷層兼具左移性質，呈東北走向，由光復鄉東富村向南延伸至玉里鎮春日里，長約33公里（陳文山等，2006，2008）；本斷層爲1951年地震的地震斷層，一部分等同於徐鐵良（1955）所稱的玉里斷層北段，斷層的南端在春日附近與奇美斷層連接。依據槽溝開挖結果，瑞穗斷層除了1951年的地震之外，還發現3次的古地震事件，古地震的活動週期約190±20年。

玉里斷層，位於臺東縱谷中部與中央山脈的交界，爲左移斷層兼具逆移性質，呈北北東走向，由花蓮縣瑞穗鄉瑞良村向南延伸至玉里鎮客城里，長約23公里。玉里斷層是1951年地震的地表破裂，向北延伸可能連接瑞穗斷層。

奇美斷層，位於海岸山脈的中部，爲逆移斷層，呈東北走向，由玉里鎮春日里向東北延伸經德武、奇美村至花蓮縣豐濱，長約30公里。斷層南端在春日鄉附近連接瑞穗斷層與池上斷層。斷層截切更新世晚期的階地礫石層，尙未有全新世活動的證據。

池上斷層，位於臺東縱谷南部，爲逆移斷層兼具左移性質，約呈北北東走向；由花蓮縣玉里鎮春日里向南延伸經臺東縣池上鄉萬安村，再延伸至鹿野鄉瑞隆村，長約67公里。1951年地震（規模6.8）與2003年地震（規模6.8），池上斷層均產生地表破裂。依據槽溝開挖結果，池上斷層在過去800年間有5-10次的古地震事件，活動週期爲50-160年。

鹿野斷層，位於臺東縱谷南部與中央山脈的交界，爲逆移斷層，約呈南北走向，由臺東縣鹿野鄉鹿寮向南延伸至卑南鄉檳榔附近，長約17公里。槽溝開挖結果顯示全新世沉積層受到褶皺與斷層作用，鹿野斷層改列第一類活動斷層。

利吉斷層，位於臺東縱谷南端，爲逆移斷層，東北走向轉南南東走向，由臺東縣延平鄉鸞山向南延伸至岩灣，再轉向東南延伸至臺東市，長約20公里。斷層截切更新世地層，GPS 觀測資料結果，目前主要地殼變形可能集中於利吉斷層西側的分支斷層（卑南山斷層）。

依據本所2004-2008年在臺灣東部地區的 GPS 觀測結果（饒瑞鈞等，2008），臺東縱谷北段向西北西方向位移，位移速率約10-50公厘/年（相對澎湖島白沙站S01R），而縱谷南段向西北方向位移，位移速率50-80公厘/年（相對澎湖島白沙站S01R），東西向的速度場有由東向西逐漸變小趨勢（圖1.3），顯現臺東縱谷南北段不同的地殼變形型態。在垂直速度場的變化方面，海岸山脈東岸抬升速率爲50-80公厘/年，向西降低至30-40公厘/年，至縱谷以西則爲-10-0公厘/年（負値爲下降）。

有關臺灣東部活動斷層的主要特性，如表1.1。

(二)臺灣南部的活動斷層概述

臺灣南部的活動斷層，包括小崗山斷層、旗山斷層、潮州斷層與恆春斷層等，共4條斷層（圖1.4）。

小崗山斷層，可能爲逆移斷層，呈北北東走向，由高雄縣阿蓮鄉南蓮村向南延伸至燕巢鄉瓊林村，長約8公里。斷層並未截穿至地表，但造成上覆全新世地層的撓曲，顯示這些滑動面在全新世也有可能活動，並具有相當的活動潛勢，暫列第二類活動斷層。

旗山斷層，位於麓山帶的西南部，爲逆移斷層，呈東北走向，由高雄縣旗山鎭向南延伸至高雄縣仁武鄉，長約30公里。斷層由主斷層與多個分支斷層構成變形帶，寬度約40-400公尺之間，主斷層寬度爲9-30公尺。斷層截切全新世的砂礫石層，暫列第一類活動斷層。以往認爲斷層向北連接內英斷層，最近的調查結果顯示兩斷層的特性不同，也未發現內英斷層在更新世晚期活動的證據，因此建議內英斷層的部分自活動斷層目錄中移除。

潮州斷層，位於屏東平原與中央山脈的交界，爲逆移斷層兼具左移性質，呈南北走向。斷層北段，又稱爲土壟灣斷層，由高雄縣六龜鄉寶來村向南延伸至大津村，長約28公里；南段由大津村向南延伸至枋寮鄉加祿村，長約61公里，合計長度約89公里。斷層的北段爲階地礫岩層或沖積扇礫石層所掩覆，可能爲盲斷層的形式，斷層的南段在新埤附近發現板岩逆衝於階地礫石層之上，研判潮州斷層在更新世晚期可能有活動現象，暫列第二類活動斷層。

恆春斷層，位於恆春半島，爲逆移斷層，呈北北西走向，由屏東縣車城鄉海口向南延伸至恆春鎭南灣，長約16公里。斷層截切更新世晚期的石灰岩層，暫列第二類活動斷層。

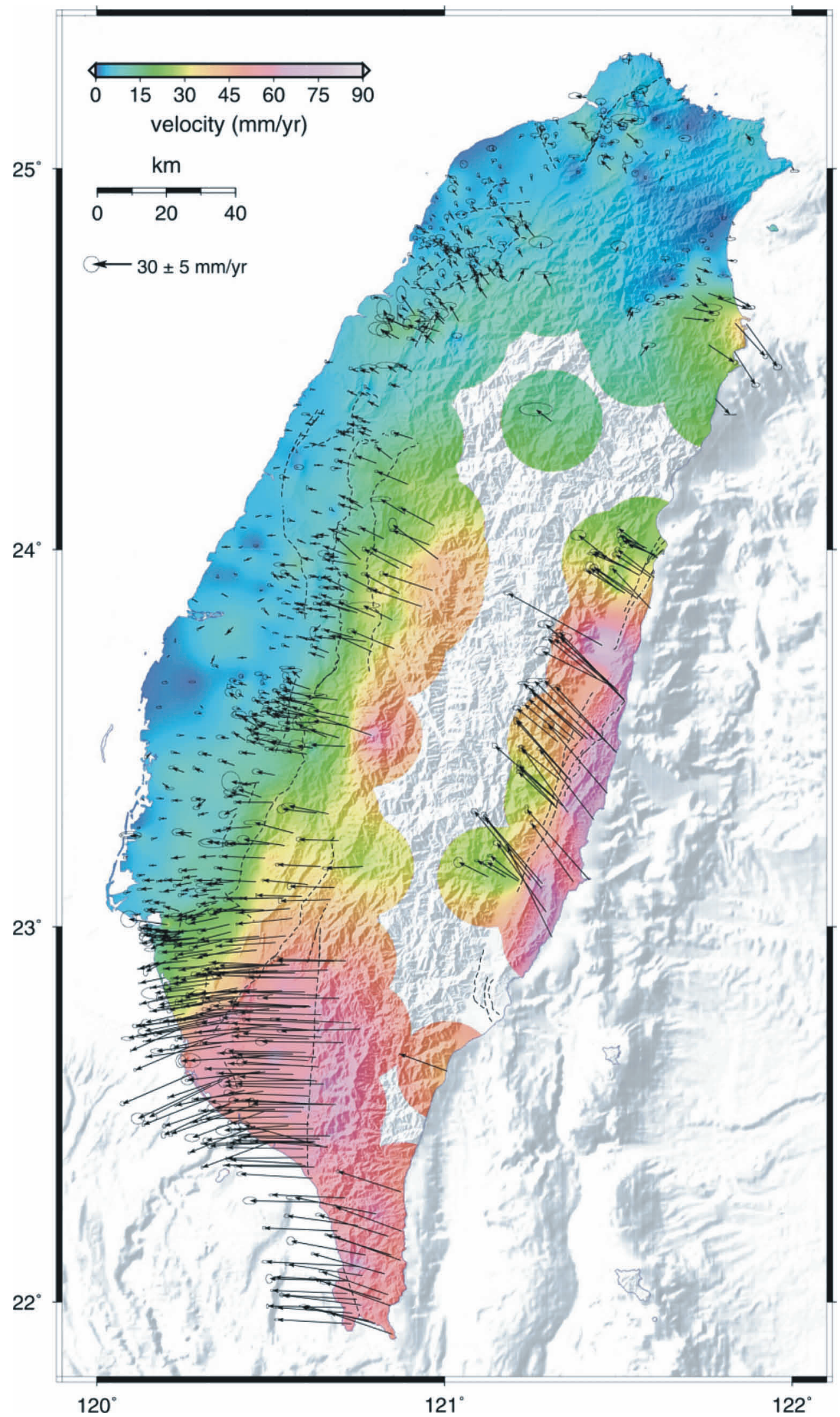

圖1.3 臺灣地區相對於澎湖白沙站（S01R）2002-2008年GPS水平方向速度場（饒瑞鈞等，2008）。

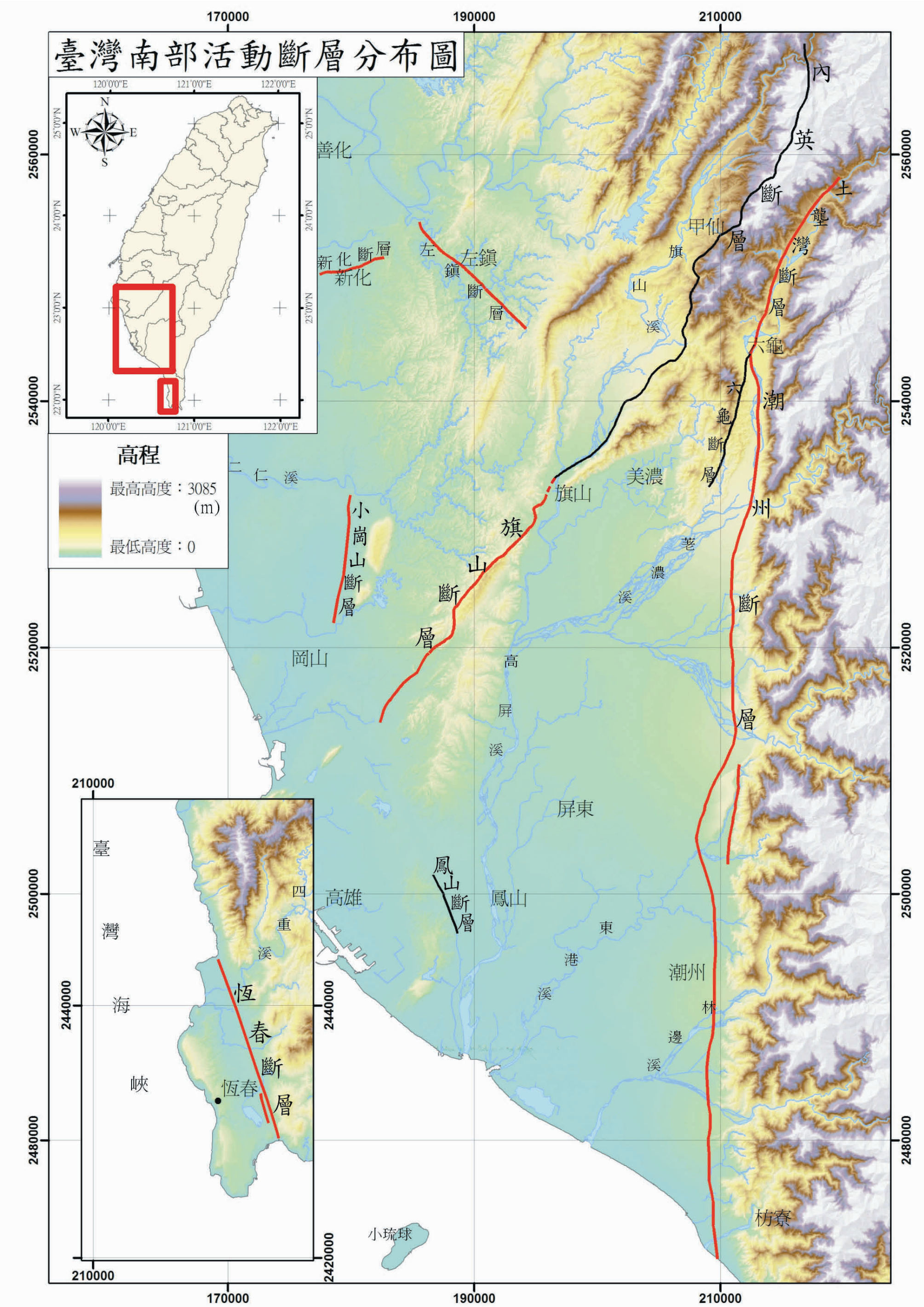

圖1.4 臺灣南部的活動斷層。（紅線部份示活動斷層；座標系統：TWD67）

此外，六龜斷層，位於南部麓山帶（圖1.4），爲北北東走向的左移斷層，由高雄縣六龜鄉新發村向南延伸至美濃鎮新寮村（林啓文等，2000），近期調查結果該區主要地殼變形集中於潮州斷層，建議由活動斷層目錄中移除。鳳山線形（鳳山斷層），位於與鳳山丘陵東側（圖1.4），原本被列爲存疑性活動斷層（林啓文等，2000），雖然有線狀崖特徵，經由野外地質調查、地質鑽探以及地球物理探勘結果，均未發現斷層存在的地質證據，建議由活動斷層目錄中移除。

饒瑞鈞等（2006）由 GPS 資料分析臺灣南部的地殼變形結果（高屏地區的觀測資料爲1995-2006年，恆春地區的觀測資料爲2003-2006年），跨越旗山斷層的水平方向位移速度，由61公厘/年，方向263°，降至50公厘/年，方向264°，顯示旗山斷層吸收約10公厘/年的縮短量。橫跨潮州斷層與恆春斷層的東西向的壓縮量很小，水平位移速度由東側的58.2公厘/年，方向273°，至西側的58.6公厘/年，方向273°，由2002-2008年速度場分析，臺灣南部相對於澎湖白沙站 S01R 於旗山斷層及中央山脈南段西翼地區的速度場近乎一致，爲51.9 ± 6.6公厘/年，方位角由東向西逐漸由277°轉至247°（圖1.3），經修正2006年12月26日屏東外海地震的同震資料後，恆春地區的速度場約爲39.6-91.2公厘/年。

有關臺灣南部活動斷層的主要特性，如表1.1。

表1.1 臺灣東部與南部活動斷層特性一覽表

斷層名稱	分類[*1]	長度(公里)	滑移特性[*2]	跨斷層水平速度變化(公厘/年)[*3]		跨斷層垂直速度變化(公厘/年)[*4]		最近一次活動時間[*5]
				平行斷層走向	垂直斷層走向	精密水準	GPS	
米崙斷層	一	8	左移兼逆移	8.4±5.7	6.8±6.3	-17.9	8.7±16.9	西元 1951 年
嶺頂斷層	二	30	左移兼逆移	8.4±5.7	6.8±6.3	-19.6	8.7±16.9	更新世晚期
瑞穗斷層	一	33	逆移兼左移	-	-	-	-	西元 1951 年
玉里斷層	一	23	左移兼逆移	14.5±3.6	5.6±4.9	-0.8	13.2±17.6	西元 1951 年
奇美斷層	二	30	逆移	6.5±2.3	4.1±8.7	3.9	7.9±10.1	更新世晚期
池上斷層	一	67	逆移兼左移	-	-	-		西元 2003 年
鹿野斷層	一	17	逆移	-	-	-		更新世晚期
利吉斷層	二	20	逆移	-	-	-		更新世晚期
小崗山斷層	二	8	逆移	-3.6±2.8	8.6±3.1	-	9.7±8.9	更新世晚期
旗山斷層	一	30	逆移	-4.2±5.7	5.4±7.2	-3.6	-1.2±13.4	距今 7,189 年前
潮州斷層	二	89	逆移兼左移	1.1±3.4	0.3±1.8	-3.6	6.9±8.4	更新世晚期
恆春斷層	二	16	逆移	3.9±3.9	5.4±4.4	1.0	-0.7±6.2	更新世晚期

註：

＊1：第一類活動斷層，爲過去10,000年內曾經活動過的斷層；第二類活動斷層，爲過去100,000年內曾經活動過的斷層；存疑性活動斷層，爲過去500,000年內活動過，但尚無法確定過去100,000年內是否活動過的斷層。

＊2：爲斷層兩側岩層的長期相對運動形式。

＊3：平行斷層走向的速度分量，正值代表左移形式，負值代表右移形式。採用饒瑞鈞等（2006，2008）的分析結果。

＊4：正值代表抬升，負值代表下降。採用饒瑞鈞等（2006，2008）的分析結果。

＊5：除了歷史地震紀錄之外，本項資料爲被斷層截切的岩層的時代。

誌謝

本報告爲中央地質調查所執行「地震地質調查與活動斷層資料庫建置計畫（91-95年）」與「地震地質與地變動潛勢分析計畫（96-99年）」的部分成果。感謝國立臺灣大學地質科學系陳于高教授、中央研究院地球科學所李建成博士與國立成功大學地球科學系饒瑞鈞教授審稿，並提供許多寶貴的建議。在調查與撰寫過程中，承蒙下列學者與專家提供資料與協助，作者敬致謝忱。

地形地質調查：鍾令和先生、石同生先生、林偉雄先生、盧詩丁先生、林燕慧小姐、劉桓吉博士、陳致言先生、衣德成先生、郭育安先生、張雲翔先生。

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Active Faults of Eastern and Southern Taiwan

Explanatory Text for the Strip Maps of Active Faults

SCALE 1:25,000

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ABSTRACT

The East Taiwan Longitudinal Valley is a suture zone of plate convergence of the Eurasian and the Philippine Sea Plates that are evident by frequent seismic activity as well as rapid vertical uplift of the Coastal Range. Most of the active faults in eastern Taiwan are located in this valley. Moreover, the offshore of southern Taiwan is considered to be an accretionary prism bounded by the Manila Trench to the west and the Luzon Arc to the east. The Dec. 26, 2006 earthquake (Mw 7.0) that occurred with an epicenter located offshore in southwestern Taiwan and shook southernmost Taiwan might be closely related to present-day tectonic configuration, i.e. some researchers proposed that active faults in southern Taiwan are structural characteristics of the northern extension of the accretionary wedge. The Central Geological Survey has deployed detailed investigation including geological mapping, boring, trenching, geophysical investigations and geodetic measurements since 2002 in order to evaluate the reactivity of active faults for the purpose of hazard mitigation. This report presents the recent achievement of investigation of active faults and that are briefly described as follows.

There are 8 active faults located in eastern Taiwan. The Milun Fault is a sinistral-slip fault with reverse-slip component, strikes north, and is located in the northernmost part of East Taiwan Longitudinal Valley extending for 8 km long. It formed surface ruptures in the 1951 Hualien

Earthquake and might reactivate several times in late Pleistocene. The Lingding Fault is located on the border between the northernmost part of the Longitudinal Valley and the Coastal Range, strikes NNE and extends for 30 km long. This fault is suggested to be a sinistral-slip fault with reverse-slip component, although it was covered by alluvial deposits. In addition, the so-called Yuehmei Fault noted in some previous reports is composed of several intermittent, small faults that are located within the volcanic rock of the Tuluanshan Formation, i.e. the hanging wall of the Lingding Fault, and all the small faults do not cut late Pleistocene strata so it was temporarily removed from the active fault list. The Rueyshui Fault is an earthquake fault that reactivated in 1951 Earthquake and exhibits reverse-slip movement. This fault strikes NE and is located in the middle part of the Longitudinal Valley extending for 33 km long, and is estimated to have recurrence interval about 190 ± 20 years. The Yuli Fault is a reverse-slip fault with a sinistral-slip component, strikes NNE, and is located at the border between the Central Range and the Longitudinal Valley extending for 23 km long. This fault also was reactivated in the 1951 Hualien Earthquake and caused several surface ruptures. The Chimei Fault is a reverse-slip fault, strikes NE, and transverses across the Coastal Range extending for 30 km long. It was proposed that this fault to be reactivated in late Pleistocene according to it caused terrace deposits to tilt. The Chihshang Fault is a reverse-slip fault with a sinistral slip component, strikes NNE, and is located in the southern part of the Longitudinal Valley extending for 67 km long. This fault reactivated and formed surface ruptures in the 1951 Taitung Earthquake and the 2003 Chihshang Earthquake. Based on the trenching study, there are at least 5 paleoseismic events in the last 800 years with a recurrence interval of about 50-170 years. The Luyeh Fault is a reverse-slip fault, strikes north, and is located at the border between the Central Range and the Longitudinal Valley extending for 17 km long. This fault caused the flexure of terrace deposits; however, it is not exposed to the surface. The Lichi Fault is a reverse-slip fault, strikes NE and turns SSE, and is located in the southern part of the Longitudinal Valley extending for 20 km long. This fault has reactivated during late Pleistocene but not Holocene.

There are 4 active faults located in southern Taiwan. The Chishan Fault is a reverse-slip fault, strikes NE, and is located in the southern Foothills extending for 30 km. The deformation zone of this fault consists of a main gouge zone and several branch faults that sum up to 400 m wide. According to the findings of cutting the Holocene terrace deposits, the Chishan Fault is reclassified as an active fault of the first category. Moreover, a fault named Ne-In Fault, previously connected in the northern extension of the Chishan Fault, has no evidence of reactivating in late Pleistocene and therefore it is proper to remove from the active fault list. The Hsiaokangshan fault is probably a reverse-slip fault, strikes NNE, and is located between the Foothills and the western Plain that extends for 8 km. Based on the boring data in the subsurface of Hsiaokangshan area, it may have a broad fault zone that is composed of many small-scale blind faults. Although it is difficult to locate the macroscopic fault line of the Hsiaokangshan lineament, it has high potential to deform and translate along certain fault planes resulting on the folding of strata and high uplift rate. The Chaochou Fault is a reverse-slip fault with a sinistral component, strikes north and is located at the border between the Pingtung Plain and southern Central Range extending for 89 km. Northern segment of the Chaochou Fault is covered by terrace and alluvial deposits, and proposed to be a blind fault, while the southern segment displaces the lateritic conglomerate beds indicating that it reactivated in late Pleistocene. The Hengchun Fault is a reverse-slip fault, strikes NNW, and is located at the Hengchun Peninsula extending for 16 km. Based on the findings of cutting the late Pleistocene bioclastic strata it is reclassified as an active fault of the second category. In addition, the Liukuei Fault is a left-lateral slip fault, strikes NNE, and is located at the border between the southern Foothills and southern Central Range and was previously classified as a secondary category active fault. Because the latest crustal movement in this area mainly concentrates around the Chaochou Fault that located at the eastern side of the Liukuei Fault, it is proposed to eliminate the latter from the active fault list. The Fongshan Fault was categorized as suspect active faults exhibiting linear scarps in satellite images; however there is no geologic evidence to prove the faults exists. So it is proposed to eliminate from the active fault list.

Based on the geodetic measurements from 2004-2008, the northern part of the Longitudinal Valley (north of the Chimei Fault) moved toward WNW with a displacement rate of 10-50 mm/yr, while the southern part moved toward NW with a displacement rate of 50-80 mm/yr and decreased from east toward west. It indicates that the present crustal deformation is concentrated on the southern part of the valley. In addition, the vertical uplift rate is about 50-80 mm/yr in the eastern part of the Coastal Range, 30-40 mm/yr in the western part, and -10 to 0 mm/yr west of the Longitudinal Valley. In southern Taiwan, results of GPS measurements show that the horizontal displacement around the Chishan Fault moves toward SW with a displacement rate of about 50-60 mm/yr, and the fault absorbed 10 mm/yr of shortening. While the displacement rates around the Chaochou Fault are about 58 mm/yr toward west that indicates no significant difference around this fault. The displacement patterns in both sides of the

Hengchun Fault show similar results, i.e. move westward with a rate about 40-50 mm/yr. However, southern Taiwan might need continually updated geodetic measurements for analyzing activity of active faults.

Summarized table of characteristics of active faults of eastern and southern Taiwan.

Fault Name	category of fault*I	fault length (km)	sense of movement*II	horizontal slip rate (mm/yr)*III		vertical slip rate (mm/yr)*IV		time of latest reactivation*V
				Parallel to fault strike	Normal to fault strike	Precise Leveling	GPS	
Milun Fault	I	8	sinistral w. reverse	8.4±5.7	6.8±6.3	-17.9	8.7±16.9	1951AD
Lingding Fault	II	30	sinistral w. reverse	8.4±5.7	6.8±6.3	-19.6	8.7±16.9	late Pleistocene
Rueyshui Fault	I	33	reverse w. sinistral	-	-	-		1951 AD
Yuli Fault	I	23	sinistral w. reverse	14.5±3.6	5.6±4.9	-0.8	13.2±17.6	1951 AD
Chimei Fault	II	30	reverse	6.5±2.3	4.1±8.7	3.9	7.9±10.1	late Pleistocene
Chihshang Fault	I	67	reverse w. sinistral	-	-	-		2003AD
Luyeh Fault	I	17	reverse	-	-	-		late Pleistocene
Lichi Fault	II	20	reverse	-	-	-		late Pleistocene
Hsiaokangshan	II	8	reverse	-3.6±2.8	8.6±3.1	-	9.7±8.9	late Pleistocene
Chishan Fault	I	30	reverse	-4.2±5.7	5.4±7.2	-3.6	-1.2±13.4	＜7,189BP
Chaochou Fault	II	89	reverse w. sinistral	1.1±3.4	0.3±1.8	-3.6	6.9±8.4	late Pleistocene
Hengchun Fault	II	16	reverse	3.9±3.9	5.4±4.4	1.0	-0.7±6.2	late Pleistocene

Notes:

I. Active fault of the first category- fault reactivated during the last 10,000 years; active fault of the second category- fault reactivated during the last 100,000 years; suspect active fault- reactivated during the last 500,000 years but could not be ascertained as to whether it had been reactivated during the last 100,000 years.

II. The long-term relative movement of a fault, evident by fault separation.

III. The velocity component parallel to the strike of fault. Positive value represents sinistral-slip, negative value dextral-slip. Short-term data based on the measurements from 1999 to 2008 (after Rau et al., 2006, 2008).

IV. Positive value stands for uplifting, negative value for depression. Short-term data based on the measurements from 2002 to 2008 (after Rau et al., 2006, 2008).

V. The age of youngest stratum cut by active fault, and the latest historical event for an earthquake fault.