

行政院國家科學委員會專題研究計畫 成果報告

台灣西南海域活斷層的調查與孕震構造研究(II)

計畫類別：整合型計畫

計畫編號：NSC91-2119-M-002-018-

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執行單位：國立臺灣大學海洋研究所

計畫主持人：劉家瑄

計畫參與人員：Benoit Deffontaines, 陳之馨

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行政院國家科學委員會補助專題研究計畫成果報告

地震及活斷層研究(孕震帶構造) - 台灣西南海域活斷層調查與孕震構造研究(II)

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地震及活斷層研究(孕震帶構造) - 台灣西南海域活斷層調查與孕震構造研究(II)

Investigation of the active faults offshore southwestern Taiwan and
their seismogenic properties

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一、中文摘要

本研究以兩年的時間分析探討了台灣西南海域的地形與反射逆斷層資料，以調查測繪台灣西南海域斷層分布與活動型態。由於台灣造山帶由北向南發育，從台灣西南海域向北到陸上造山帶，在空間上提供了一個觀察從無震的斷層構造演化為孕震帶斷層構造 (seismogenic fault structure)。本研究的一個重點即在於探討分析在台灣南部海域中的一條主要脫序逆斷層從南往北的構造變化。本計畫執行的兩年中，收集整理了通過此主要逆斷層的多條逆斷層剖面進行分析，發現從南到北其斷層幾何形態有相當的變化。

在西南海域活斷層的分布與活動型態方面，本研究分析了高解析度的水深資料及反射震測資料，觀察到大陸地殼開始進入隱沒帶時在增積岩體上所形成的特殊構造型態。台灣西南海域增積岩體靠近南海大陸坡的一側發育出許多線性構造，這些線性構造主要受到弧陸碰撞擠壓作用造成的台灣西南地塊向西南方向逃脫(tectonic escape)作用影響，另加上原大陸邊緣基盤形貌的控制。本年度完成一篇探討這個地區特殊構造的論文，正送國際期刊審查

中。此篇論文報導了在台灣西南海域增積岩體前緣的活動斷層研究，發現變形前緣的構造在大陸斜坡上改為雁行狀排列而非一個單一構造。同時研究發現的一系列線形斷裂構造也證實研究地區正向西南方向移動。

關鍵詞：台灣西南海域、反射震測、脫序逆斷層、變形前緣。

Abstract

This 2-year research project intends to investigate the active fault systems and their seismogenic properties in the area offshore southwestern Taiwan. This report presents the two-year study results.

In the active fault investigation, high-resolution bathymetry map of the study area has been compiled which reveal distribution of complicated fault systems. Unique structural pattern has been observed that shows the effect of the continental margin crust to the development of the accretionary wedge near Taiwan. Many topographic lineaments have been developed

on the frontal portion of the accretionary wedge off southwestern Taiwan. These lineaments could be developed due to the tectonic escape of the southwestern Taiwan block during the arc-continent collision processes. The different nature of the continental margin crust (from oceanic crust in the south to continental crust in the north) also contributes to the unique structural pattern observed. A manuscript describing this study result has been submitted to Marine Geophysical Research and is under review.

Original idea of extract fluids from fault scarps to study the fault properties of a major out-of-sequence thrust in the first year of this project did not provide useful information, thus the focus was shifted to seismic study during the second year. Several seismic reflection profiles running across this major out-of-sequence thrust have been analyzed, and it appears that from south to north the fault plan geometry has changed following the transition from subduction to collision.

Keywords: Offshore Southwestern Taiwan,
Seismic reflection, Active faults,
Deformation front.

二、緣由與目的

Distinctive morphotectonic features in the area offshore southern Taiwan reflect the transition from subduction to collision (Liu et al., 1998). The presence of the Chinese continental margin has a major effect on the deformation pattern of the subduction-

collision system. A basement high (the Peikang High) in the Chinese continental margin acts as an indenter to the Taiwan mountain belt and causes tectonic escape of Southwest Taiwan toward southwest (Lu and Malavieille, 1994; Lu et al., 1998).

This paper presents detailed analyses of high-resolution swath bathymetry data collected during the ACT survey in 1996 (Lallemant et al., 1997) and seismic reflection profile data collected during the TAICRUST and ACT surveys in the area offshore southwestern Taiwan. Distinctive deformation patterns and morphotectonic characteristics of the accretionary wedge provide clues to the geodynamic processes in this transitional deformation zone where passive continental margin first enters the subduction system. The location and structural characteristics of the deformation front are presented, several morphologic lineaments are described and their significance and implication to the escape tectonics of southwest Taiwan are discussed. Finally we present a geodynamic model to explain the observed deformation patterns in the study area.

三、研究步驟

A high-resolution digital terrain model has been created using the full resolution of the ACT swath bathymetric data. Hill-shading images of the study area generated from this high resolution DTM and illuminated from various directions are used for morphological analyses in this study. The different resulting images are

then photo-interpreted for morphostructural features, such as local alignments of the submarine drainage, asymmetric shape of the ridges, etc.

Seismic reflection profiles collected in the studied area reveal that underneath the complicated Penghu submarine channel system, extensional structures are observed in the Chinese continental shelf and slope region, whereas imbricated fold and thrust sheets characterize the Luzon accretionary wedge. By carefully analyzing detailed submarine morphology that revealed by the ACT swath bathymetry survey and the closely spaced seismic reflection profile data, we are able to establish the structural pattern of the deformation front here and the distribution and characters of many morphological lineaments.

四、研究結果

The Luzon accretionary wedge that extends from north of the Luzon island to the Taiwan mountain belt presents a case example of the subduction-collision tectonics. The area offshore and onland southwest Taiwan is the place where the passive Chinese continental margin first encroaches on the Taiwan mountain belt. Seismic reflection profile data and high-resolution swath bathymetry data, together with the recent onland geological investigation, provide new constraints on the variation of structural styles along the frontal portion of the accretionary wedge and the location of the deformation front of the Luzon subduction-Taiwan collision

system offshore southwestern Taiwan.

The Luzon accretionary wedge consists of a lower slope domain characterized by mostly W-vergent ramp anticlines and thrusts, and an intensely deformed upper slope domain in the area south of Taiwan. Due to the outgrowth of the accretionary wedge as the influx of orogenic sediments increases toward Taiwan, the trend of the frontal folds and thrusts in the lower slope domain changes from a NE-SW direction north of Luzon island to a NW-SE direction north of 20°N. In the area offshore SW Taiwan, the NE-SW trending Chinese continental margin prevents the westward advance of the outward growing accretionary wedge. NW-SE trending ramp anticlines turn into a N-S trending direction and the frontal anticlines of the accretionary wedge are buried and terminated underneath the Chinese continental slope. Detailed swath bathymetry data reveals different morphological characters of the anticlines and the slope gullies formed by erosional cutting of the Penghu channel system. Seismic profiles across the foot of the continental slope also confirm the different structural nature between the anticlines and slope gullies. The location and geometry of the deformation front, defined as the most frontal contractional structure along a convergent plate boundary, thus can be better constrained based on the sea floor morphology.

This study suggests that north of 22°N, the deformation front can no longer be delineated along a single frontal contractional structure. It follows a series of

termination points of the frontal anticlines along the NE-SW trending Chinese continental slope, and extends northeastward to Tainan onshore Taiwan. Results from recent on land geological investigations are highly coherent that the Tainan anticline corresponds to the location of the deformation front.

Various topographic lineaments have been observed on the frontal portion of the accretionary wedge in the studied area from high-resolution swath bathymetry data. One of the most prominent one, the NE-SW trending Yung-An lineament, forms the southwestern boundary of the upper Penghu Submarine Canyon system. These lineaments, together with the changing orientation of the anticlinal ridges and faults in the frontal accretionary wedge, are strongly controlled by the presence of NE-SW trending Chinese continental slope and the southwestward expulsion of SW Taiwan.

tectonics in the Taiwan Mountain belt: insights from experimental modelling. *Earth Plan. Sci. Lett.*, 121, 477- 494.

Lu, C.Y., Jeng, F.S., Chang, K.J., and Jian, W.T. (1998) Impact of basement High on the Structure and Kinematics of the Western Taiwan Thrust Wedge: Insights From Sandbox Models: *Terre. Atmos. Oceanic Sci.*, 9(3), 533-550.

五、參考文獻

Lallemand S.E., Liu C.-S. and the ACT scientific crew - Swath Bathymetry Mapping Reveals Details of the Active Arc-Continent Collision Offshore Taiwan; *EOS*, Transactions, AGU, 78, 17, 173-175, 1997.

Liu, C.S., Liu S.Y., Lallemand, S.E., Lundberg, N. and Reed, D. (1998) Digital Elevation Model Offshore Taiwan and Its Tectonic Implications. *TAO*, 9(4), 705-738.

Lu, C.Y., Malavieille, J. (1994) Oblique convergence, indentation and rotation

