出席「2009 年美國地球物理聯盟秋季國際會議（AGU Fall Meeting）」出國差旅報告

日期：98.12.13~98.12.17

計畫編號：NSC98-2114-M-103-004

前言：

此次出席國際學術會議，適逢父親治喪事宜，僅在美停留兩天參與會議，未能全程參加學術會議，甚為可惜；但在發表論文與國際學者專家學術交流，參觀並蒐集展覽資料，仍有相當不錯的收獲。

「美國地球物理聯盟秋季大會(AGU Fall Meeting)」為國際地球科學界之年度重要學術會議之一，台灣的學者專家及博碩士研究生參加的人數亦最多（約達百人）；因函蓋的領域廣泛，規模亦日益擴大，今年預估超過 16,000 位來自全球各國的地球物理學者專家與會，為年度大規模的國際學術研討會。本年度為第 49 屆「美國地球物理聯盟秋季大會」，今年將有超過 15,000 篇論文在本次大會中發表。

由於「美國地球物理聯盟秋季大會」涵蓋領域廣泛，吸引全世界地球科學相關領域的學者專家，並可以擴大領域的交流，對地球系統進行跨領域的研究。各議題包括：

- Atmospheric Sciences
- Atmospheric and Space Electricity
- Biogeosciences
- Cryosphere
- Earth and Space Science Informatics
- Education and Human Resources
- Geodesy
- Geomagnetism and Paleomagnetism
- Global Climate Change

- Hydrology
- Mineral and Rock Physics
- Near-Surface Geophysics
- Nonlinear Geophysics
- Ocean Sciences
- Paleoceanography and Paleoclimatology
- Planetary Sciences
- Public Affairs
- Seismology
- SPA-Aeronomy
- SPA-Solar and Heliospheric Physics
- SPA-Magnetospheric Physics
- SPA-Space Physics and Aeronomy
- Study of the Earth's Deep Interior
- Tectonophysics
- Volcanology, Geochemistry, Petrology

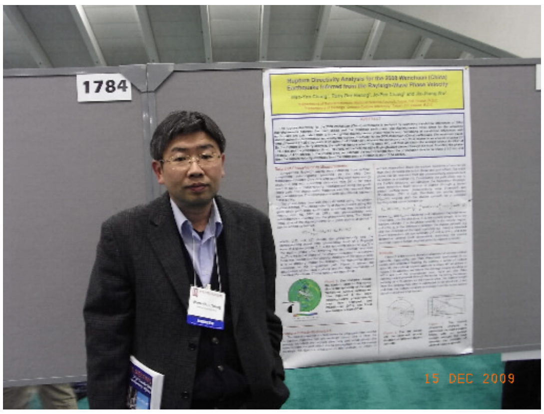
參與過程說明及感想：

個人於本次會議共發表兩篇文章，其中一篇為台灣與大陸共同召集主持的T11A議題-「2008汶川地震的地震地質和地震地體構造（Earthquake Geology AND Seismotectonics of the 2008Wenchuan Earthquake）」，第一天12月14日上午8點，題目為「從雷利波相速度進行2008年汶川地震的破裂方向分析(Rupture Directivity Analysis for the 2008 Wenchuan (China) Earthquake Inferred from the Rayleigh-Wave Phase Velocity.)」；主要說明淺源大地震發生時常伴隨明顯的地表變形，而大地震的破裂尺度(通常是長度)經常造成地震記錄觀測波形或頻譜隨測站方位的變化，這是所謂破裂方向性(rupture directivity)。由於震源的破裂方向性造成在不同方位觀測到的震源破裂歷時會有不同，在遠離破裂方向有最大的破裂歷時，地震波有較寬的波形；其朝向破裂方向則有最小的破裂歷時，地震波有較窄的波形，這相當於都普勒效應。藉由大地震的方向性分析能夠求出地震破

裂長度、破裂速度、破裂方位、震源破裂歷時等等斷層參數，基本上可用以描述大地震破裂的一些基本特性。這些斷層參數間的關係或與地震矩的關係可以規範出大地震的尺度律。有人研究指出一般地震的破裂歷時與地震矩亦有冪次律的關係，為了淺部的地震，此二者的比值介於0.25×1023 及1.0×1023 dyne cm/s2 之間，但對較深之地震，其比值稍微偏高，指出低角度逆斷層型式的地震的震源破裂歷時較正斷層型態地震為長，而雙向破裂的地震歷時似乎偏短一些。這些斷層參數和尺度律可以幫助了解大地震破裂的基本物理行為，也可提供震源破裂(source rupture)研究的參考。震源的破裂方向性除造成地震波寬的變化外，亦會造所觀測震波走時延遲和頻譜節點(node)的產生，而震波走時延遲和節點所對應的週期亦隨方位變化，因此，可用來決定斷層參數。直至今日，有幾個方法可以決定大地震的破裂方向性：(1)利用方向性函數(directivity function)分別決定1960 年智利大地震和1964 年阿拉斯加大地震的斷層長度和破裂速度；(2)利用順推模擬(forward modeling)的方式決定地震的斷層長度和破裂速度 (3)利用表面波或體波解迴旋(surface-wave or body-wave deconvolution)方法決定隨方位變化的震源時間函數，進而決定大地震的斷層長度和破裂速度；(4)利用地震頻譜的拐角頻率隨方位變化的現象，也能被利用在決定斷層參數上；(5)利用地震頻譜節點所對應的週期隨方位變化的現象決定斷層參數；(6)利用表面波相速延遲時間隨方位變化的現象，決定地震破裂長度、破裂速度、破裂方位、震源破裂歷時等等。上述的方法都能決定地震的斷層參數，但必須尋求一種有效、穩定且快速的方法做有系統的評估大地震斷層參數。近年來，表面波解迴旋法是一種經常被利用的方法，其做法是將主震與其附近一些小地震做解迴旋，找到相對震源時間函數去估算斷層參數，這有嚴格的限

制，就是小地震的深度、位置、震源型態須與主震一致，這時常是困難的。我們提出利用主震與其附近小地震的相速延遲時間的差異評估地震斷層參數，此法的精神在於大地震破裂方向性造成大的相速延遲時間，而小地震相較於大地震可視為無破裂方向性的影響，故二者的相速延遲的差異即可代表震源破裂歷時，不同方位的破裂歷時不同，可藉此評估地震斷層參數，由於此法分別計算主震與其附近小地震的相速，因此主震與小地震的深度、位置、震源型態不需要一致，但小地震位置儘量與主震一致可避免誤差的產生，然而此法的缺點在於若缺乏小地震時，則無法估算主震與小地震的相速延遲時間的差異。因此，尋求另一種快速、有效且穩定地評估大地震破裂方向性的方法是需要的。

另一篇第三天下午 1:40：分配於 S33B 議題，題目為「從震波層析探討台灣觸口斷層地區的 3 維速度構造(3-D Velocity Structure of Chukou Fault Area, Taiwan from Seismic Tomography)」，因 12 月 16 日凌晨已提前返台，由溫士忠博士發表（如附錄）。會上可與相同議題的其他文章共同討論交流，對國際地震研究趨勢有更進一步的了解，收穫豐富。



圖一、發表論文照片

第二天議程開始有各項展覽，會議之餘，參觀會場中各種展示，

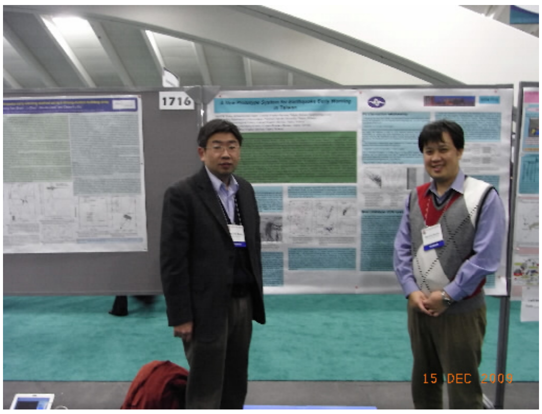
包括書籍、化石、儀器公司、美國相關研究單位；如美國地質調查所(USGS)、美國航空及太空總署(NASA)等單位，有關全球的各項觀測資料探討全球環境變化等資料圖表，均甚有價值，我也攜回一些海報資料，主要為 NASA 全球觀測（土地、大氣、水文、極地冰原等）研究圖表可作為相關研究之參考。

值得一提的是本次美國地球物理聯盟秋季大會，由台灣學者與大陸共同規劃的議題「「2008 汶川地震的地震地質和地震地體構造」中，即有 31 篇文章發表，其中不乏兩岸學者共同的合作成果，汶川大地震已發生超過一年半，各國科學家早已躍躍欲試，投入震後研究調查工作，各個專業期刊也已開始準備發表空間，來容納未來增加的這些科學成果，可見這個大地震的科學價值已為注目，台灣在地震科學的研究上不輸美日，而大陸自然科學基金委與台灣國科會推動的「兩岸汶川地震合作研究」已執行一年，許多不錯的研究成果可以在國際科學界發表，不但可以再一次檢驗我們的實力，也可以再一次提昇我們的能見度的機會。

台灣的地震科學在九二一地震後有了長足的進步，使得台灣的地震相關研究已有良好的基礎，然而受限於有限的大地震研究實例，我們又不能坐等下一個九二一來時再一次提昇，因此利用世界各地所發生的大地震，才能快速且多元了解地震的成因，這些知識的累積一定可以有效減少台灣地震災害，因此積極的參加其他地方的大地震研究工作，尤其是汶川大地震與台灣的集集大地震有多方面的共通性，深入研究與調查四川地震，可以直接促進了解台灣的地震行為，並對本土防震減災提供具體貢獻。

地震是地球內部應力調整與能量轉移時的物理現象，這一個自

然現象伴隨地球數十億年的發展不曾中斷，隨著地球冷卻地表有了生物的孕育，晚近又有了人類快速的繁衍，因此地震所帶來的震動與伴隨而來的斷層行為，才造成嚴重的災害。如何能藉由對大地震的震級調查與地質、地震資料分析積累，對大地震成因及災害防範的經驗，以減少未來大地震時的生命財產損失，並企圖深入了解地震的成因與危害，有朝一日能夠達成快速預警與地震預測，才是地震科學研究的終極目標。大地震的危害是不分國家與地區的，需全體人類共同的面對與防範。大地震歸屬罕見自然災害，且每一個大地震皆有其獨特性，其發生的周期與存在的歷史，遠遠長於人類的生命，所以現今的科學雖然先進，但對地震觀察仍限於資料不足的窘境，因此全世界的地質、地震及地震工程科學家，皆珍惜於研究任何一個新發生的大地震。1999 年發生於台灣中部的九二一地震，雖然對台灣造成嚴重的損失，然而台灣完備的地震觀測網所獲得的資料，經過數年的分析研究對提昇世界的地震科學研究與工程設計層級有很大的貢獻。發生於四川汶川縣境的大地震，人類嚴重生命與財產損失的悲劇再一次發生。一個規模 8.0 的大地震，又再一次的提供了豐富的研究素材，當然也是我們深入研討地震科學的契機，台灣是一個多震災的國家，無論是從科學提昇的角度，或是防災的角度來看汶川大地震，應有不錯的研究成果在國際上發表。



圖二、參觀中央氣象局蕭乃祺博士發表有關地震預警的研究成果

檢討及建議事項：

1.每年出席美國地球物理聯盟秋季大會的台灣學者專家以及學生已超過百人，突顯台灣的國際研究能見度及研究能量，並增加團員間的交流及資訊的收集，並鼓勵台灣學者專家主動籌組特別議題，如今年汶川地震、東亞及南亞研究，均受到國際人士重視，對台灣研究能量及積極度給予肯定。

2.自 96 年起，每年均舉辦「台灣之夜」，促進台灣學者專家及研究生互相交流認識的機會，也帶動與國際人士的交流，大大提昇我國的國際能見度及展現研究能量，堪稱極具效益。除可展現台灣的研究現況及水準，有助於國際交流及合作研究，應持續維持此優良傳統。今年因父親治喪事宜，僅在美停留兩天參與會議，未能參加台灣之夜，甚為可惜。

3.地球暖化及氣候變遷議題已成為重要的熱門議題，從全球的觀測到區域性的環境、災害等均受到相當的重視，台灣應可再加強此方面的研究和國際合作，特別在颱風、土石流、地震、水資源等及氣候變遷研究因應。

攜回資料

1.2009 AGU Fall Meeting 議程資料及作者索引資料。

2.NASA 全球觀測（土地、大氣、水文、極地冰原等）研究圖表海報五幅。

附錄：

Session Title: T11A. Earthquake Geology and Seismotectonics of the 2008 Wenchuan Earthquake I Posters

Session Type: Poster

Chair: Yongkang Ran
Chair: Chung-Pai Chang
Chair: Wen-Shan Chen

Location: Poster Hall (Moscone South)

Start time: Mon, Dec 14 - 8:00 AM

T11A-1758. Holocene paleoearthquake activity along the 2008 Wenchuan Earthquake ruptures of the Beichuan and Pengguan faults, eastern Sichuan, China. *W. Chen; Y. Ran; X. Xu* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1759. The investigation of horizontal shortening and amount of reverse-faulting from trenching across the surface rupture of the eastern Sichuan Mw7.9 earthquake. *H. Wang; Y. Ran; L. Chen; X. Shi; R. Liu; X. Xu* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1760. Topographic characteristics of rupture surface associated with the Wenchuan earthquake of Mw7.9, in May 12, 2008. *Z. Wei; H. He; F. Shi; S. Dong* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1761. Structural heterogeneity of the Longmenshan fault zone and the mechanism of the 2008 Wenchuan earthquake (Ms 8.0) . *J. Lei; D. Zhao* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1762. Coupling between coseismic deformation of Wenchuan earthquake and the deep tectonics. *S. Zhang; F. Xie; Z. Huang; J. Ren* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1763. Near-field post-seismic deformation along the rupture of the 2008 Wenchuan earthquake and its implication. *H. He; Z. Wei; F. Shi; H. Sun* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected

T11A-1764. Estimation of Fault Slip Rates in the Vicinity of the 2008 Wenchuan Earthquake Using Viscoelastic Earthquake Cycle Models, GPS Data, and Geologic Uplift Rates . *S. Chatterjee; K. M. Johnson* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1765. Three dimensional surface slip partitioning of the Sichuan earthquake from Synthetic Aperture Radar.. *M. de Michele; D. Raucoules; J. de Sigoyer; M. Pubellier; C. Lasserre; E. Pathier; Y. Klinger; J. van der Woerd* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1766. Fault Slip Distribution of the Mw 7.9 Wenchuan Earthquake Estimated from GPS and ALOS/PALSAR Measurements. *G. Feng; E. A. Hetland; X. Ding; Z. Li* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1767. Slip Distribution of the Wenchuan Earthquake Estimated from InSAR Data. *M. Enomoto; M. Hashimoto; Y. Fukahata; Y. Fukushima* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1768. Coseismic fault slip of the 2008 Wenchuan Ms8.0 earthquake inverted jointly from InSAR and GPS measurements. *G. Zhang* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1769. Fault Geometry based on Coseismic Ground Displacements from Satellite Images for the 2008 Wenchuan Earthquake, Sichuan, China. *Y. Kuo; Y. Chen; M. Huang; J. Suppe; J. Avouac; S. Leprince; F. Ayoub; Y. Kuo* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1770. Dynamic modeling of stress evolution and crustal deformation associated with the seismogenic process of the 2008 Mw7.9 Wenchuan, China earthquake. *W. Tao; Y. Wan; K. Wang; Y. Zeng; Z. Shen* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1771. Numerical Modeling on Co-seismic Influence of Wenchuan 8.0 Earthquake in Sichuan-Yunnan Area, China. *L. Chen; H. Li; Y. Lu; Y. Li; J. Ye* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1772. Fault-scarp related features and cascade-rupturing model for the Wenchuan earthquake (Mw7.9), eastern Tibetan Plateau, China. *G. Yu; X. Xu; Y. Klinger; G. Diao; G. Chen; X.*	Mon, Dec 14 8:00	No itinerary selected

Feng; C. Li; A. Zhu; R. Yuan; T. Guo; X. Sun; X. Tan; Y. An View Pres.	AM	
T11A-1773. ANALYSIS ON THE GROUND DESTROYED FEATURES AND TECTONIC STRESS FIELD OF THE 2008 WENCHUAN EARTHQUAKE AND OUR TREATING TACTICS. *Y. Guo; H. Wang; Z. Deng; H. You* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1774. High-Velocity Friction Experiments on the Longmenshan Fault Gouge towards the Understanding of Dynamic Rupture Propagation of the 2008 Wenchuan Earthquake. *T. Togo; T. Shimamoto; S. Ma; X. Wen; T. Hirose; X. Lei* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1775. Estimate of thermal history within clayey characteristics from Hole-A of Taiwan Chelungpu fault Drilling Project (TCDP). *L. Kuo; S. Song; L. Huang; E. Yeh; H. Chen* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1776. Areal strain and hydrological changes in Taiwan induced by 2008 Wenchuan earthquake. *J. Hu; C. Chen; C. Liu; H. Huang; W. Liang; K. Lin* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1777. Groundwater Level Changes Associated with the Wenchuan Earthquake of May 12, 2008. *T. Lee; Y. Chia; R. Lee* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1778. A synthetic Cross Section of the Longmen Shan (PRC). *M. Pubellier; A. Robert; J. de Sigoyer; A. Billerot; R. Cattin; J. Zhu; J. Vergne; Y. Zhang; N. R. Chamot-Rooke* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1779. Ambient seismic noise tomography and radial anisotropy from a dense array in SW China . *H. Huang; Y. Li; Q. Liu; J. Chen; H. Yao; R. D. van der Hilst* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1780. Seismic Observations of Rock Damage and Heal on the Longman-Shan Fault of the M8 Wenchuan Earthquake and the Parkfield San Andreas Fault. *Y. Li; J. Sue; T. Chen; J. E. Vidale; E. S. Cochran; P. E. Malin* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1781. Monitoring of major aftershocks and probing deep	Mon,	No

structure of the Whchuan M8.0 earthquake by using electromagnetic measurements*. *W. Lifeng; Z. Yan* View Pres.	Dec 14 8:00 AM	itinerary selected
T11A-1782. Analyzing the characteristics of focal mechanism solutions of Wenchuan earthquake sequence. *X. Cui; X. Hu; F. Xie; C. YU; Y. Wang* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1783. Rupture Directivity Analysis for the 2008 Wenchuan (China) Earthquake Inferred from the Rayleigh-Wave Phase Velocity. *W. Chang; R. Hwang; J. Chang; J. Wu* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1784. Seismogenic Stress Field for the Wenchuan M8 Earthquake Affected by Regional Stress Field in the Yangtze Block . *J. Xu; Z. Zhao; Z. Zhao* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1785. Rupture Properties of the 2008 Mw=7.9 Wenchuan Earthquake: Analysis from Seismological and Geological Data. *Y. Wen; K. Ma* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1786. Electricomagnetic Coseismic signal associated with aftershock of Wenchuan Ms 8.0 earthquake. *J. Tang; Z. Yan; L. Wang; Z. Dong; Z. Guoze; X. Chen; X. Qibin; J. Wang; G. Xu* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1787. Seismotectonics of the Longmenshan Thrust Nappe Zone and the M8.0 Wenchuan Earthquake Sequence. *A. Zhu; X. Xu; G. Diao* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected
T11A-1788. Estimates of source parameters for the Mw7.9 Wenchuan earthquake of 12 May 2008 from near-field seismograms. *X. Chen; J. Wen* View Pres.	Mon, Dec 14 8:00 AM	No itinerary selected

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ID# T11A-1783
Location: Poster Hall (Moscone South)
Time of Presentation: Dec 14 8:00 AM - 12:20 PM

Rupture Directivity Analysis for the 2008 Wenchuan (China) Earthquake Inferred from the Rayleigh-Wave Phase Velocity

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The rupture directivity for the 2008 Wehchuan (China) earthquake is analyzed by examining travel-time differences of 100-s Rayleigh-waves between the main shock and the reference earthquake. The Rayleigh-wave travel times for the reference earthquake are calculated from a known global Rayleigh-wave phase-velocity map. Variations of travel-time differences with station azimuths demonstrate apparently the rupture directivity for the 2008 Wehchuan (China) earthquake. The maximum travel-time difference (~125 s) appears in an azimuth of about 130 degree; whereas the minimum one (~20 s) locates in an azimuth of about 33degree. By the rupture directivity analysis, the optimal rupture azimuth is about 48 degree, and then we obtain the average source duration of ~83.3 sec and the propagation time, ~50.9 sec, with which the 100-s Rayleigh-wave passed through the fault. Providing the phase-velocity of 4.15 km/sec in the source area, we estimate the rupture length from the propagation time to be about 211.2 km, and then the rupture velocity estimated from the entire source duration is about 2.54 km/sec. Because the entire source duration includes the rupture time and rise time of source, we analyze the spectral-node periods of Rayleigh waves to judge the reasonable rupture time. The estimated rise time is about 18 sec. Thus, the rupture velocity is estimated afresh to be 3.23 km/sec, probably approaching to the S-wave velocity in the upper crust.

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ID# S33B-1765
Location: Poster Hall (Moscone South)
Time of Presentation: Dec 16 1:40 PM - 6:00 PM

3D Velocity Structure of Chukou Fault Area, Taiwan from Seismic Tomography

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In this study, we used the seismic data that recorded by the broadband stations which deployed around the Chukou fault area, Taiwan. We have chosen 1661 earthquake events with high quality records in this research. The waveform cross correlation technique is applied to calculate the 143086 pairs of waveform data. By combining with data from the seismic catalog, there are 342202 absolute travel-time pairs through the double difference tomography method to relocate the seismicity and invert the 3D velocity structures beneath the Chukou fault area. Due to Taiwan Island is located in an active boundary zone between the Eurasia continental and Philippine Sea plates, the violent collision between the two plates which causes a series of imbricate fold-thrust belts to form between the western foothills and the coastal plain. The Chukou fault is just the boundary between the fold-thrust belts and the coastal plain in the Chia-Nan area, Taiwan. The seismotectonic structure beneath this area is more complex. From many studies, velocity structure can be used as an indicator of the geometry of fault and the general aspect of tectonics. Therefore, the first goal of this research is to analyze the degree of correlation between the velocity structure and the characteristics of seismicity and the tectonic implications of the area. The second intention is to study the distribution of seismic events and its association with fault activities.
Our results indicate that the variation of velocity structure beneath fault area is caused by local geological structures, complex fault crossing. We also find that most earthquakes occur in the area that has Vp/Vs gradient varying rapidly. Finally, both using catalog and cross-correlation data in the inversion procedure are not only exhibit better resolution, but also can obtain the detail 3D velocity structure beneath the fault zone.

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