T12B-0461 1330h POSTER

Constraining the Extent and Duration of Low Temperature Alteration in Pacific Ocean Crust

Heather J Paul[1] (250-472-4048; hjpaul@uvic.ca)

Kathryn M Gillis[1] (250-472-4023; kgillis@uvic.ca)

[1]School of Earth and Ocean Sciences, University of Victoria, 3800 Finnerty Rd, Victoria, BC V8W 5C2, Canada

The generation, alteration, and subduction of oceanic lithosphere is one of the primary chemical cycles that occur on Earth. The circulation of seawater through ocean crust facilitates the exchange of elements and chemical compounds between the hydrosphere and lithosphere, ultimately having a profound effect on both the chemical composition of seawater and ocean crust. Our understanding of the chemical cycles that result from ocean crustal alteration and subsequent subduction is largely based on core recovered by the Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP). Basement holes drilled in the Pacific Ocean basin however, poorly represent the span of crustal ages that exist in fast-spreading Pacific Ocean crust. Thus, several pressing questions concerning the evolution of seawater-rock interactions and the extent of chemical exchange remain unanswered. The 46 Ma igneous basement that was drilled during ODP Leg 200 at Hole 1224F fills a key age gap in the drill core collection that falls between Holes 597C ($\sim$29 Ma) and 843B ($\sim$110 Ma) enabling a better understanding of how ocean crustal alteration proceeds. The secondary mineral assemblages identified in Hole 1224 cores are typical of low temperature alteration, consisting of Fe-oxyhydroxides, saponite, celadonite, carbonate, minor pyrite and quartz, and rare phillipsite. When compared to adjacent fresh rock, haloed rock samples have increases in Si, Fe and Cr and minor increases in Ca, CO_2, K, Mg, Mn, P, Na and Al. A significant finding thus far is that the extent of primary mineral replacement and quantity of secondary minerals filling voids is surprisingly low; much less than that found in younger crust (e.g. 6.9 Ma, Sites 504, 896). This suggests that crustal age may not be a controlling factor in the extent of crustal alteration. Hole 1224F also provides a critical constraint for understanding the controls on carbonate uptake in the Pacific upper ocean crust through time. Preliminary calculations show that the carbon content of Hole 1224F cores is less than that contained in younger crust, suggesting that age is not a dominant factor in regulating carbon uptake by the ocean crust.

T12B-0462 1330h POSTER

The Hawaii-2 Observatory: New Capabilities and Instrumentation

Alan D Chave[1] (508-289-2833; achave@whoi.edu); John W Bailey[1] (jbailey@whoi.edu); Stace Beaulieu[1] (stace@whoi.edu); Rhett Butler[2] (rhett@iris.edu); Fred K Duennebier[3] (fkd@hawaii.edu); Jean H Filloux[4] (jfilloux@ucsd.edu); Mioara Mandea[5] (mioara@ipgp.jussieu.fr); Ken Smith[4] (ksmith@ucsd.edu); Pascal Tarits[6] (tarits@univ-brest.fr)

[1]Woods Hole Oceanographic Inst, MS#7, Woods Hole, MA 02543, United States

[2]IRIS, 1200 New York Ave, Washington DC 20005, United States

[3]SOEST, Univ of Hawaii at Manoa, Honolulu, HI 96822, United States

[4]Scripps Inst of Oceanography, U of Cal at San Diego, La Jolla, CA 92093, United States

[5]Institut de Physique du Globe, 4 Place Jussieu, Paris 75252, France

[6]IUEM, Universite Bretagne Occidentale, Plouzane F-29280, France

The Hawaii-2 Observatory (H2O) is a permanent deep ocean research facility located about halfway between California and Hawaii. The H2O infrastructure consists of a submarine cable termination and junction box which provides two-way digital data communications and power for seafloor instruments. Prior to 2003, H2O instrumentation consisted of a buried broadband seismic sensor. In September 2003, a major upgrade to the H2O junction box was completed which changed the communications architecture to TCP/IP, making reconstruction of data streams on shore a system rather than a user task. A new biological experiment, two seafloor geomagnetic observatories (SGO; one US and one French), a high frequency hydrophone, and a Small Experiment Module (SEM) were also installed at the H2O site. The goal of the biological experiment is determination of the short and long-term responses of benthic fauna to a temporally-variable food supply in a very food-limited environment. An instrument platform was installed which includes cameras to photograph the activities of animals near the seafloor and a sedimentation sensor to monitor the seafloor flux of particulates and phytoplankton pigments. The SGOs each incorporate vector and scalar sensors for the relative geomagnetic field and its absolute magnitude, along with a gyrocompass-based method to measure the instantaneous absolute direction of the field. In addition, the SGOs measure the vector electric field, including removal of electrode drift. The hydrophone is suitable for high frequency seismic studies and whale monitoring. The SEM was installed to supply a secondary interface to experiments. It provides data interfaces and power for the H2O seismic system and up to eight additional low-data rate and low-power sensors

T12C MCC: Level 1 Monday 1330h

Earthquake Geology and Hazards of East Asia III Posters *(joint with S)*

Presiding: **Y Chen,** National Taiwan University**; K Mueller,** University of Colorado**; Y Sugiyama,** National Institute of Advanced Industrial Science and Technology

T12C-0463 1330h POSTER

Slip-rate Estimation of Active Fault by Luminescence Dating on Deformed River Terraces at Tsaotun, Central Taiwan

Ya-Wen Chen[1] (f90224212@ntu.edu.tw)

Yue-Gau Chen[1] (ygchen@ccms.ntu.edu.tw)

Wen-Shan Chen[1] (wenshan@ms.cc.ntu.edu.tw)

Chyi-Tyi Lee[2] (ct@gis.geo.ncu.edu.tw)

[1]Department of Geosciences, National Taiwan University, P.O. Box 13-318, Taipei 106, Taiwan

[2]Institude of Applied Geology, National Central University, No. 300, Jungda Rd., Chungli, Taoyuan 320, Taiwan

This study carried out luminescence ages of the deformed terraces located at Tsaotun in central Taiwan. These terraces are considered as a result of crustal deformation caused by recent activity of the Chelungpu fault, 1999 surface rupture. Since this active fault runs through urban area, it is urgently needed to figure out its neotectonic behavior, including slip-rate and recurrence interval. Based on new ages, we also discuss the terrace correlation and its related structures. The study terraces are all strath terraces with only a few meters of veneered fluvial deposits on top. Due to the strong stream-power, nearly all the outcrops are dominated by fluvial cobbles, which is worst condition to preserve the syndepositional carbonaceous materials. Alternatively, optical stimulated luminescence (OSL) dating uses sandy quartz as the material and even has longer dating upper limit (up to several hundreds of years). Fortunately, sandy layer are found intercalated within the fluvial cobbles in studying terraces. We adopted the Single-Aliquot Regenerative (SAR) dose protocol on large aliquots of 90-150μm quartz, which were cleaned using HCL, H_2O_2 and HF in the usual way. In case of incomplete bleaching during quick deposition, the OSL/TL ratio was adopted to approach the true De. Dosimetry is derived by ICP-MS and XRF analyses. For ascertainment of the initial bleaching of fluvial sediment, the modern samples collected in river bed of Wuhsi were also measured. Based on the results of modern samples, we believe that the residuals are inevitable in younger sediments, especially along the upper stream. On the contrary, the samples older than 10 kyr are little influenced due to the larger age error than the younger ones. The OSL age of the terrace samples in the hanging wall is dated ca. 13 kyr, which has been corrected for poorly-bleaching problem. Comparing to the ages collected down hole in the footwalls, we found out vertical displacements of ca. 67 and 37 m, has been cumulated by the slips of main and back thrust. Thus, the long-term slip rates of the main and back thrust are 3.8-6.5 m/kyr and 2.0-3.8 m/kyr, respectively. If we consider that the 1999 Chi-Chi earthquake is a characteristic event, a recurrence interval of 300-600 years is derived.

T12C-0464 1330h POSTER

Using optical dating to assess the recent activity of active faults in Hsinchu Area, northwestern Taiwan

Takuya Watanuki[1] (+886 2 23697647; wata@v7.com)

Yue-Gau Chen[1] (ygchen@ntu.edu.tw)

[1]Department of Geosciences National Taiwan University, No. 1, Sec. 4, Roosevelt Rd.,, Taipei 106, Taiwan

The aim of this study is to evaluate the recent activity of active fault systems mapped in Hsinchu area, northwestern Taiwan. Since it is the largest site of industrial park and highly populated, it is essential to assess potential of earthquake hazards. As a result of previous work, two active fault systems (Hsinchu and Hsincheng) were identified as active. However, they have not been included in dangerous active faults on published map because Holocene offset has not been confirmed yet. Relationship between five river terraces and faults were discussed by mapping on geomorphic features; both of these thrust faults contain active anticlines in their hanging walls based on folded terraces that are composed of young alluvial deposits. Neither long-term nor short-term slip rate has been reported due to lack of age control on development timing of the terraces mentioned above. We collected samples from these terraces and open-pit trench on the highest terrace, where intercalated sandy layers are found within cobbles. As literatures optically stimulated luminescence (OSL) dating method can directly measure the burial ages of sedimentary deposits that underwent a short period of sunlight bleaching. Therefore, OSL dating is applied via single aliquot regeneration method on sand size quartz extract from our study terraces. OSL ages about 46ka and 68-75ka are obtained from 4 fluvial deposits at trenching site. We tentatively suggest that the terrace was abandoned by the main channel after 68ka and then upper strata were subsequently deposited by local small creeks. The vertical displacements cross these Hsinchu and Hsincheng active faults are ca. 90m and 70m, respectively since 68ka. Consequently, the derived long-term rates of vertical slip are 1.3 and 1.0 m/ka respectively for both of them. The details of the other age results and discussion on recent structural behavior will be presented.

T12C-0465 1330h POSTER

Natural Occurrences of Surface Melting in the Slickensides of the Fault Zone in Miaoli Area, Western Taiwan

Sheng-Rong Song[1] (886-2-23630231 ext.2671; srsong@ntu.edu.tw)

Li-Wei Kou[1] (886-2-23630231 ext.2671)

[1]Institute of Geosciences, National Taiwan University, 245 Choushan Road, Taipei 106, Taiwan

Slickensides are non-penetrative smoothed or polished surface normally developed on movement planes of fault zone, or between rock layers folded by flexural slip. Experimental evidence suggests that naturally silckenside formation may be widely originated by surface melting in the relatively dry faulting (Spray, JSG, 1989). However, due to the modification by fluid alteration or via various co-seismic and interseismic events, evidence of melting has not yet been unequivocally found in natural slickensides. This research reports an unambiguous pseudotachylyte occurred in the slickensides formed by surface melting in the fault zone of Miaoli area, west Taiwan. Taiwan is located in the young orogenic belt, which the fault-related earthquakes were very common and severe in last few million years. The faults, especially for the thrust faults, thus, are widely distributed in the Island. The pseudotachylyte occurred in the slickenside surface of the fault zone have been found in the drilled core, about 500 meters in depth below the surface in the western foothill sedimentary sequences of Miaoli area, west Taiwan. Two types of surface feature, well-polished shiny surface as mirror and scrape furrow or striated coatings can be found in the surface of slickensides. The former mostly occurred in the fine sandstones to siltstones, while the later mainly found in the coarse sandstones. It clearly suggests that the surface features may be originated by the asperity during the comminution in the slickenside formation. Petrographically, the slickensides are dominantly composed of fault gouge and cataclasites with or without preferred orientated micas. The pseudotachylytes are thin, submillimeter to millimeter in thickness and dominantly occur on the surface of slickenside of fault zone. Optical and scanning and transmission electron microscopies reveal that the pseudotachylytes are very fresh and dominantly consist of black or dark brown, fine-grained to glassy aphanitic matrix with microlites, rounded or embayed clasts and numerous rock and mineral fragments. The presences of well fresh pseudotachylyte and surface melting in the slickensides strongly indicate that the fault zone in the Miaoli area, west Taiwan is very dry condition during or after rapid seismic faulting.

URL: http://www.gl.ntu.edu.tw/

T12C-0466 1330h POSTER

Tectonic Mechanisms Associated with Metamorphic P-T Paths: Alternatives to Thrusting-Thermal Relaxation Cycles

John Wakabayashi (wako@tdl.com)

Consultant, 1329 Sheridan Lane, Hayward, CA 94544, United States

Geoscientists commonly use metamorphic pressure (P)-temperature (T) paths to interpret the tectonic history of orogenic belts. Many studies and reviews relating P-T path development to tectonics have focused on thrusting-thermal relaxation cycles, generally associated with collisional processes. Most of the P-T paths interpreted this way have been 'clockwise' (P on the positive y-axis) paths. This emphasis may partly reflect the fact that collisional processes can account for an entire burial-exhumation cycle. P-T paths, however, generally do not record an entire burial-exhumation cycle, because metamorphic mineral growth did not occur at the lowest grade parts of the paths. In addition, many P-T paths may have formed from multiple, unrelated, tectonic events instead of a single event as commonly assumed. Many P-T paths interpreted in the last decade and a half differ markedly from clockwise P-T loops. Such paths include hairpin, isobaric hairpin, isobaric cooling, and anticlockwise P-T paths. The variety of tectonothermal processes affecting large parts of the Earth, in addition to the tectonic settings of many metamorphic terranes, suggest that P-T paths recorded in rocks result from a greater variety of tectonic processes than are generally considered. Some of these processes may include subduction initiation, continuous subduction, triple junction interactions, initiation and shut off of arc magmatism, subcontinental delamination, and hot spot migration. I will present examples of different types of P-T paths and their possible relationship to tectonic processes. Although thrusting-heating cycles have influenced metamorphic evolution in many orogenic belts, the potential impact of other types of tectonic mechanisms should not be overlooked.

T12C-0467 1330h POSTER

Crustal gravitational potential energy change at the convergent plate boundary near Taiwan

Chung-Liang Lo[1] (lo@oc.gep.ncu.edu.tw)

Shu-Kun Hsu[1] (hsu@oc.gep.ncu.edu.tw)

[1]Institute of Geophysics, National Central University, No. 300, Chung-da Rd., Chung-li City, Taoyuan, Taiwan 320, Chung-li 32054, Taiwan

The Taiwan orogen has formed due to the convergence between the Philippine Sea plate and Eurasian plate. Numerous earthquakes are occurring along the active convergent plate boundary in eastern Taiwan. To the northeast, the Philippine Sea plates is subducting northwards beneath the Ryukyu Arc. To the south, the Eurasian plate is subducting eastwards beneath the Luzon Arc. The plate interaction has caused crustal deformation and produced earthquakes. The earthquakes have caused radial permanent displacement of the crust and have altered the crustal gravitational potential energy. Here we use the earthquake source mechanisms, determined by the Broadband Array in Taiwan for Seismology (BATs) from 1995 to 2003, to calculate the crustal gravitational potential energy (GPE) change and discuss their tectonic implication along the convergent plate boundary. In Ilan Plain, the westernmost Okinawa Trough, it shows a crustal GPE loss. It is related to the crustal subsidence because of the backarc extension of the Okinawa Trough. In contrast, due to the Philippine Sea plate subucting northwards beneath Eurasian Plate, the Ryukyu convergent boundary shows systematic crustal GPE gain. Near Taiwan, the crustal GPE change is gained, indicating the collisional convergence of the Luzon Arc. To the south of Taiwan, along the Luzon Arc the crustal GPE is also gain, representing the initial uplifting of the Taiwan mountain belt.

T12C-0468 1330h POSTER

Preliminary ^{40}Ar-^{39}Ar thermochronological study of Dien Bien Phu Fault, northern Vietnam

Te-Hsien Lin[1] (886-2-23630231 ext.2387; f90224101@ntu.edu.tw); Ching-Hua Lo[1] (886-2-23635880; loch@ccms.ntu.edu.tw); Pei-Ling Wang[1] (p.wang@gl.ciw.edu); Tung-Yi Lee[2] (t44001@cc.ntnu.edu.tw); Sun-Lin Chung[1] (sunlin@ntu.edu.tw); Ching-Ying Lan[3] (kyanite@earth.sinica.edu.tw)

[1]Department of Geosciences, National Taiwan University, 245, Choushan Rd, Taipei 106, Taiwan

[2]Department of Earth Science, Naitonal Taiwan Normal University, 88, Sec.4, Tingjou Rd, Taipei 116, Taiwan

[3]Institute of Earth Sciences, Academia Sinica, 128, Sec.2, Academia Rd, Nankang, Taipei 115, Taiwan

The Song Ma belt, located along the suture zone between the South China and Indochina blocks, was offset by the Dien Bien Phu Fault (DBF) in northern Vietnam. Many previous studies suggested that the Dien Bien Phu Fault is one of the Tertiary shear zones, resulted from the Cenozoic extrusion tectonics due to the Eurasian-Indian collision. However, the timing of the movement of DBF is remained unclear due to lacking of age data. In the present study, schists and mylonitic granites from DBF, and undeformed granites from the granitic belt along the south China block, were analysed by ^{40}Ar-^{39}Ar method. K-feldspar, hornblende, and biotite samples form granite plutons along south edge of South China block displayed different age ranges between opposite sides of DBF. Samples from plutonic body which is located in west side exhibit plateau ages ranging form 207Ma to 229Ma. Whereas, hornblende separates from granites on the west side exhibit much older plateau dates at around 277Ma. More detail studies were required to get better understand about the discrepancy of dating results between granitic masses located in different sides of DBF. On the other hand, Laser ^{40}Ar-^{39}Ar single-grain analyses conducted on deformed biotites and muscovites separated from the schists in DBF, show ^{40}Ar-^{39}Ar ages ranging form 185Ma to 205Ma, which are much younger than the plateau dates of those undeformed granitic samples. In summary, K-feldspar, hornblende and biotite samples from the undeformed granites, exhibit plateau dates in the range of 207- 277Ma, reflecting the ages of plutonism during the Indosinian orogeny. Whereas, muscovites and biotites extracted from schists and deformed granites in DBF, display young ^{40}Ar-^{39}Ar ages in the range of 205-185 Ma. This may suggest that although the DBF might have been reactivated during the Cenozoic extrusion tectonics, but it was in fact active in the Mesozoic.

T12C-0469 1330h POSTER

Miocene Gaolingong faulting and its implications for extrusion tectonics in the eastern Himalayan syntaxis

Ching-Hua Lo[1] (+886-2-23635880; loch@ccms.ntu.edu.tw)

Fang-Reuy Hsu[1] (+886-2-23635880)

Sun-Lin Chung[1] (+886-2-83691242; sunlin@ccms.ntu.edu.tw)

Tung-Yi Lee[2] (+886-2-29347120; t44001@cc.ntnu.edu.tw)

[1]Dept. Geosciences, National Taiwan Univ., P.O. Box 13-318, Taipei 106, Taiwan

[2]Dept. Earth Sciences, National Taiwan Normal Univ., 88, Tingchou Rd. Sec. 4, Taipei 117, Taiwan

Thermochronological investigation of the Gaolingong Fault and its adjacent brench faults, provides constraints to the Cenozoic extrusion tectonics of Indochina and the tectonic evolution in the eastern Himalayan syntaxis. The results show that the main phase of the right-lateral shearing along the Gaolingong fault occurred in the period of 18 to12 Ma, which is synchronous with that of the Karakoram-Jiali Fault in southern Tibet and the Sagaing Fault in western Indochina. This evidently indicates that the Karakoram-Jiali Fault, the Gaolingong Fault and the Sagaing Fault form a long series of right-lateral shear zones that southerly bound for the eastward extrusion of northern Tibet. It is also suggested that the present-day dextral deformation along this deformation boundary may have a prolonged history starting from early Miocene in response to the continuing India-Asia collision. However, the synchronous timing for shearing of the adjacent fault zones may also indicate that the clockwise rotation of continental blocks may have played an important role in local scale despite of the long continuity of fault systems in board.

T12C-0470 1330h POSTER

Change of crustal gravitational potential energy in orogenic belts: example of the 1999 Taiwan Chi-Chi earthquake sequence

Shu-Kun Hsu[1] (hsu@oc.gep.ncu.edu.tw)

Chung-Liang Lo[1] (lo@oc.gep.ncu.edu.tw)

[1]National Central University, Institute of Geophysics, National Central University,, Chung-Li 32054, Taiwan

In orogenic belts, due to the plate convergence a gain of crustal gravitational potential energy (GPE) is generally associated with the mountain uplifting. In contrast, a loss of crustal GPE is associated with a post-collisional mountain collapsing. The Taiwan orogeny is actively undergoing on account of the convergence between the Philippine Sea Plate and Eurasian Plate. The direct consequences are the uplifting of the Taiwan mountain belt and the numerous earthquakes. The crustal GPE is therefore accumulated. Here we demonstrate the mode of crustal GPE change caused by the 1999 Chi-Chi earthquake sequence in the Taiwan mountain belt. During the earthquake sequence, the crust was in fact going up and down randomly, but overall a cumulative gain of the crustal GPE was rapidly stabilized in one month after the main shock. The crustal GPE gain is mainly distributed in central Taiwan, rather than in the more hazardous western Taiwan.

T12C-0471 1330h POSTER

Melting features along the western Ryukyu slab edge (northeast Taiwan) and Ryukyu slab tear (southernmost Okinawa Trough): Seismic evidence

Jing-Yi Lin[1] (33298224233; jylin@ifremer.fr)

Shu-Kun Hsu[2] (hsu@oc.gep.ncu.edu,.w)

Jean-Claude Sibuet[1] (33298224233; jcsibuet@ifremer.fr)

[1]Ifremer Centre de Brest, B.P. 70, Plouzane 29280, France

[2]Institute of Geophysics, National Central University, Chung-Li 32054, Taiwan

Behind the sedimentary Ryukyu arc lies the Okinawa Trough whose termination is located at the tip of the Ilan plain (northern Taiwan), just above the Ryukyu slab edge. The present-day active volcanic front, located 80-100 km above the Ryukyu slab, extends from Japan to Kueishantao Island, an islet situated 10-km offshore the Ilan plain. 3370 earthquakes recorded in northern Taiwan by 65 seismic land stations between December 1990 and May 1999 were used to determine the 3-D Vp and Vs velocity structures and Vp/Vs ratios. A low Vp, low Vs and high Vp/Vs sausage like body, about 20 km in diameter, lies within the Eurasian mantle wedge, on top of the western Ryukyu slab extremity, from depths ranging between 20 km and 100 km. We suggest that the friction of the Ryukyu slab edge against the Eurasian lithosphere and/or the upwelling of the underlying Philippine Sea plate lithospheric mantle around the slab edge would cause an abnormal heating resulting in the formation of partial melt. Part of this melt feeds obliquely the Kueishantao andesitic Island. An abnormal amount of volcanism occurs within the Okinawa Trough, east of a slab tear located 140 km from the Ryukyu slab edge. The power spectrum analysis of magnetic data shows the presence of a thick crust located above the slab tear, suggesting that a similar pattern to the one identified above of the Ryukyu slab edge might exist in the slab tear region, feeding obliquely this area of abnormal volcanism.

T12C-0472 1330h POSTER

Shortening deformation of the back-arc rift basin in the central northern Honshu, Japan

Naoko Kato[1] (naoko@eri.u-tokyo.ac.jp)

Hiroshi Sato[1] (satow@eri.u-tokyo.ac.jp)

[1]Earthquake Research Institute, Universty of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-0032, Japan

The Pacific plate is being subducted beneath northern Honshu, Japan, forms a classical example of trench-arc-back arc system. The compressional stress, perpendicular to the northern Honshu arc, has produced the shortening deformation in the Miocene back arc rift basins since the Pliocene. Two narrow up-rift zones run parallel to the arc: Dewa hills on the west and Ou Backbone range on the east in the central part of northern Honshu. Active reverse faulting and folding are widely observed in this area. In spite of the large amount of data, the mechanisms and processes of this crustal shortening is poorly understood. As the basic data to reveal above-mentioned problems, we made crustal scale, geologic cross sections across the Dewa hills, synthesizing available geologic and geophysical data, such as surface geology, drill core data and seismic sections. Reprocessing of industry seismic data also carried out to improve our sections. The geologic cross section were examined using balanced cross section technique. The shortening deformation is strongly controlled by pre-existing Miocene extensional structures. The uplift mechanisms of the Dewa Hills can be explained by the Miocene fault reactivation beneath the Dewa hills, using low-angle Miocene normal faults with shallow fat and deeper ramp. Due to the reverse faulting of Miocene pre-existed fault, asymmetrical structure was developed across the Dewa hills. On the western side of the Dewa hills 5-7 km of shortening was

accommodated with wedge and emergent thrusting and fault-propagation fold in the back arc sediments. Low-angle detachment faults produced fault-related folds on their hanging wall are located in the middle to late Miocene mudstones. On the eastern side of the gentle folds are dominated and ca. 3 km of horizontal shortening is estimated. Judging from the onset of the shortening deformation (ca. 3 Ma), the averaged 3 mm/y of shortening is estimated across the Dewa hills.

T12C-0473 1330h POSTER

Active Structure Evolutions Deduced from Geomorphic and Geodetic Evidence, from Hsinchu to Taoyuan, Northwestern Taiwan

Yue-Gau Chen[1] (886-2-23697648; ygchen@ccms.ntu.edu.tw)

Yu Wang[1] (886-2-23697648; piin1979@pchome.com.tw)

Chin-Shyong Hou[1,2] (hcs@linx.moeacgs.gov.tw)

Wen-Shan Chen[1] (886-2-23692594; wenshan@ntu.edu.tw)

[1]Inst. of Geosciences, NTU, No. 1, Sec. 4th, Roosevelt Rd., Taipei 106, Taiwan

[2]Central Geological Survey, 2, lane 109, Hua-Hsin St., Chung-Ho, Taipei 235, Taiwan

As we know, Taiwan fault-and-thrust belt is built up by the arc-continent collision that is related to polarity flipping of subduction. The flipping boundary, delineated from Hsinchu to Hualien, divides the mountain belt into northern as well as southern part. Looking at the current tectonic configuration surrounding Taiwan, the northern one corresponds to the Ryukyu arc-trench system and has recently been influenced by back-arc rifting of Okinawa Trough (OT), which reactivated during Quaternary. As a consequence, the stress currently executing in northern Taiwan must be different from the southern Taiwan, manifesting to different neotectonic features. It is governed by the extensional stress transferred from OT. Basins, such as Taipei and Ilan, are the evidence to confirm this point. Along the western Taiwan located to the south of Taipei basin is the Taoyuan-Hsinchu area, where the landscape is still characterized by those previously produced under compression. In Taoyuan, two subparallel blind fault-related folds with axes trending NNE were developed due to the reactivation of preexisting normal fault system in continental margin. The entire system remained active until later than 30 ka. To the Hsinchu, the neotectonics is characterized by another two duplex systems (each one is composed of a thrust and its related anticline). The structural orientation is similar to of the Taoyuan. There are two main drainages, i,e.,Touchien and Fengshan rivers, flow across and separate Taoyuan and Hsinchu. Evident linear scarps and lineations have been developed aside oblique to the above-mentioned orientations of compression structures but roughly following the flowing direction. We interpret that they are generated by wrench fault systems tearing apart the original structures to accommodate the recently adjusted stress field. As recognized by the relevant geomorphic evidence, they are suggested as strike-slip faults with possibly normal dip-slip component. The newly accomplished dataset derived from geodetic network shows that except for the Hsincheng fault nearly no detectable contraction occurs across the major structures in the study area. The most surprising phenomenon is that the Fengshan river geodetically plays a major boundary. The northern crust (Taoyuan) is moving due east relatively to the southern crust (Hsinchu) in a rate of ca. 2 cm/yr. This represents that the Fengshan river is currently a right-lateral strike-slip fault, confirming the former strike-slip suggested by geomorphic features. To probe the other details, more stations and precise measurements are needed in the future.

T12C-0474 1330h POSTER

Reevaluation of 1935 M 7.0 earthquake fault, Miaoli-Taichung Area, western Taiwan: a DEM and field study

Y.N. Nina Lin[1] (b87305139@ntu.edu.tw)

Y.G. Chen[1] (ygchen@ccms.ntu.edu.tw)

Yoko Ota[2] (ota@iceice.com)

[1]Inst. of Geoscience, NTU, No. 1, Sec. 4th, Roosevelt Rd., Taipei 106, Taiwan

[2]Yokohama U., 2-11-13-201, Minamisenzoku, Otaku, Tokyo 240-8501, Japan

A large earthquake (M 7.0) took place in Miaoli area, western Taiwan on April 21st, 1935. Right to its south is the 1999 Chi-Chi earthquake fault, indicating it is not only tectonically but seismically active. As the previous study, the study area is located in the mature zone of a tectonic collision that occurred between Philippine sea Plate and Eurasia continental Plate. The associated surface ruptures of 1935 earthquake daylighted Tungtsichiao Fault, a tear fault trending NE in the south and Chihhu Fault, a back thrust trending N-S in the north, but no ruptures occurred in between. Strike-slip component was identified by the horizontal offset observed along Tungtsichiao Fault; however, there are still disputes on the reported field evidence. Our purposes are (1) to identify the structural behaviors of these two faults, (2) to find out what the seismogenic structure is, and (3) to reconstruct the regional geology by information given by this earthquake.
By DEM interpretation and field survey, we can clearly recognize a lot of the 1935 associated features. In the west of Chihhu Fault, a series of N-S higher terraces can be identified with eastward tilted surfaces and nearly 200 m relative height. Another lower terrace is also believed being created during the 1935 earthquake, showing an east-facing scarp with a height of ca. 1.5 2 m. Outcrop investigation reveals that the late-Miocene bedrock has been easterly thrusted over the Holocene conglomerates, indicating a west-dipping fault plane. The Tungtsichiao Fault cuts through a lateritic terrace at Holi, which is supposed developed in Pleistocene. The fault scarp is only discernible in the northeastern ending. Other noticeable features are the fault related antiforms that line up along the surface rupture. There is no outcrop to show the fault geometry among bedrocks.
We re-interpret the northern Chihhu Fault as the back thrust generated from a main subsurface detachment, which may be the actual seismogenic fault. Due to the bend geometry normally existing between ramp and detachment, stress accumulated and earthquake happened right on it. The fault tip of this main thrust may be blind on land or break out offshore, which explains why no surface ruptures related to the main thrust were found.

T12C-0475 1330h POSTER

Characterizing the Hsincheng active fault in northern Taiwan using airborne LiDAR data: detailed geomorphic features and their structural implications

Yu-Chang Chan[1] (yuchang@earth.sinica.edu.tw)

Yue-Gau Chen[2] (ygchen@ntu.edu.tw)

Tian-Yuan Shih[3] (tyshih@mail.nctu.edu.tw)

Chung Huang[2] (b90204045@ntu.edu.tw)

[1]Institute of Earth Sciences, Academia Sinica, Taipei 115, Taiwan

[2]Department of Geosciences, National Taiwan University, Taipei 106, Taiwan

[3]Department of Civil Engineering, National Chiao Tung University, Hsinchu 300, Taiwan

Neotectonic studies usually involve detection of minor elevation changes; high-resolution elevation data are needed for efficiently characterizing these small changes in topography. We apply airborne LiDAR data to study a segment of the Hsincheng fault, a well-known active fault near a science-based industrial park in northern Taiwan. The Hsincheng fault has received much attention and studies in the past; but high-resolution digital elevation models have not been applied to the study of the fault and its surrounding structures. We processed the newly acquired LiDAR data and produced upto 1m x 1m DEMs to investigate the active fault adjacent to the populated industrial park in Taiwan. Using the high-resolution LiDAR DEMs, aerial photographs and topographic maps, we show highly detailed geomorphic features around the study area of the Hsincheng fault. There are three major characteristics of the study area: three very well developed river terraces at varying levels, the fault/fold scarp of the Hsincheng fault, and a meander river system. Using the LiDAR DEMs, we were able to detect, with precision, several fault/fold scarps and very gentle NE-trending folds of the river terraces. Back-thrust appears to be present between two gentle anticlines of the river terraces. Along the Hsincheng fault scarp, several minor but obvious E-W trending scarps are present. Because the orientations of these scarps are quite different from the Touchien river, we interpret these scarps to be fault or fold scarps instead of terrace risers. Based on the above observations and analyses, we conclude that: First, airborne LiDAR data are important for detailed analyses of structural and geomorphic features, at a scale practical to people. Second, the area of the Hsincheng fault shows two structural systems – the major one trends about NNE, and the minor one trends about EW. The mixed structural systems may be resulted from the study area being adjacent to the Hsinchu thrust fault – an E-W trending high-angle thrust fault just to the north. Third, the Hsincheng fault may not have a large component of left-lateral movement as people argued previously. Judging from the alignment of the terrace risers and the Hsincheng fault, it is possible to have such apparent left-lateral movement even with pure thrust fault.

T12C-0476 1330h POSTER

Geomorphic Indicators and Tectonic Implications of the Active Chaochou Fault, Southern Taiwan

Jih-hao Hung[1] (+886 3 4275564; jhung@earth.ncu.edu.tw)

Ho-Sung Liao[2] (+886 3 4275564; jhung@earth.ncu.edu.tw)

[1]Institute of Geophysics, National Central University, Institute of Geophysics, National Central University, Chungli 320, Taiwan

[2]Institute of Applied Geology, National Central University, Institute of Applied Geology, National Central University, Chungli 320, Taiwan

The Chaochou Fault, lying on the easternmost edge of the Pingtung plain, is the major geologic boundary between the Slate Belt to the east and the Western Foothills to the west. According to previous studies, the Chaochou fault is a high-angle reverse fault dipping 75-80 degrees to the east. Along strike, several transverse rivers cut across the fault and form alluvial fans in the foothills, which provide unique morphotectonic features to study the activity of the Chaochou Fault. Digitized data from topographic maps of 1/5,000 to 1/25,000 scales and digital elevation data of 40m resolution were input into GIS software and analyzed to quantitatively evaluate geomorphic indicators such as hypsometric integral, stream length-gradient index and drainage basin asymmetry etc. Anomalies of these indices are further checked in the field on bedrocks, man-made structures and fold and faults, to clarify spatial variations of indicators. These, coupled with GPS data, field survey in the slate belt and uplifted terraces and subsurface seismic profiles, can further constrain spatial and temporal kinematics of the Chaochou fault and the relationship between topographic evolution and subsurface structures. Our preliminary results show that river landforms are highly related to the Chaochou Fault. Drainages were tilted to the west in response to uplifting in the east of the Chaochou Fault. Geomorphic indices indicate that the uplift rate is higher in the north and decreases progressively toward the south. The peak tectonic activity occurs in the area between the Chaochou and the Chishan Fault.

T12C-0477 1330h POSTER

Crustal Deformation of a Transition Zone Between Collision and Subduction: GPS Measurements in Southwestern Taiwan

Jyr-Ching Hu[1] (886-2-23634860; jchu@ntu.edu.tw); Li-Chung Shen[1] (886-2-23646179; li3s5@ms9.hinet.net); Chin-Shyong Hou[2] (886-2-29462793 ext. 261; hcs@linx.moeacgs.gov.tw); Yu-Chang Chan[3] (886-2-27839910 ext. 411; yuchang@earth.sinica.edu.tw); Ruey-Juin Rau[4] (886-6-2757575 ext. 65425; raurj@mail.ncku.edu.tw); Tien-Chang Lai[2] (886-2-29462793; tim@linx.moeacgs.gov.tw)

[1]Department of Geosciences, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 106, Taiwan

[2]Central Geological Survey, MOEA, No. 2. Lane 109, Hua-Hsin Street,, Taipei 235, Taiwan

[3]Institute of Earth Sciences, Academia Sinica, No. 128, Sec. 2 Academia Road, Taipei 115, Taiwan

[4]Deaprtment of Earth Sciences, National Cheng Kung University, No.1, Ta-Hsueh Road,, Tainan 701, Taiwan

Five to six years of GPS measurements have been carried out by Central Geologic Survey since 1996 in southwestern Taiwan. The Pingtung-Kaohsiung network consists of 43 stations for investigating the crustal deformation and the land subsidence. We used Bernese software to calculate the station velocity of above-mentioned GPS stations by using the three measurements form August 1996 to August 1999. These GPS surveys have provided the complete velocity field relative to the Paisha station (S01R) of the Penghu islands, which is considered as the stable continent shelf. We also calculated the principal strain rate, shear strain rate, rotation rate and dilatation rate by using QOCA software developed by JPL. GPS displacement velocities display the trends of variation in the investigated area. The station velocities are 42.2 mm/yr to 55.5 mm/yr in the azimuth from 245.4° to 272.5°. Station velocities decrease westwards and nearly increase southwards. In terms of velocity vector trends, there is a contrast in kinematics in study area. In the central and western part of the study area, GPS stations move nearly toward the west, whereas in the Kaohsiung and Pingtung coastal area, the displacement vectors demonstrate a clear counter-clockwise deviation

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toward SW. Our results clearly demonstrate that the tectonic escape may occur in southwestern Taiwan during the oblique collision. Chaochou fault is the major fault in studied area is considered as the thrust fault with left-lateral movement. Based on our studies, the velocity gradients of the GPS stations across the Chaochou fault are not significant. This implies that the Chaochou fault is locked and the mechanical coupling along the fault plane should be very strong. Furthermore, we divided the studied area into 15 subnets for strain rate calculation. The strain analysis demonstrate that the average maximum and minimum strain rate is 0.21±0.02 μstrain/yr and -0.46±0.02 μstrain/yr, respectively. The maximum compression axe is 99.7±1.2° in average. The maximum strain rate is 1.08±0.02 μstrain/yr in the azimuth 27.49±3.6°. The minimum strain rate is -1.26±0.17 μstrain/yr in the azimuth 120.9±3.1°. The strain rates in 4 subnets near Chaochou fault demonstrated significant transtensional deformation.

T12C-0478 1330h POSTER

Feasibility Study on Earthquake Precursor Using GPS Data in Taiwan

Chin-Shyong Hou[1,2] (886-2-29462793 ext 261; hcs@linx.moeacgs.gov.tw); Yue-Gau Chen[2] (886-2-23697648; ygchen@ccms.ntu.edu.tw); Jyr-Ching Hu[2] (886-2-23634860; jchu@ntu.edu.tw); Chii-Wen Lin[1] (886-2-29462793; lincw@linx.moeacgs.gov.tw); Shui-Bei Yu[3] (886-2-27857648; yusb@earth.sinica.edu.tw); Chien-Liang Chen[1] (886-2-29462793 ext 261; hcs@linx.moeacgs.gov.tw); Jing-Suei Wang[1] (886-2-29462793 ext 261; hcs@linx.moeacgs.gov.tw)

[1]Central Geological Survey, MOEA, No. 2, Lane 109, Hua-Hsin St., Chung-Ho, Taipei 235, Taiwan

[2]Inst. of Geosciences, NTU, No. 1, Sec. 4th, Roosevelt Rd., Taipei 106, Taiwan

[3]Inst. of Earth Sciences, Academia Sinica, P.O. Box 1-55, Taipei 115, Taiwan

Taiwan mountain belt is located at the junction point between Eurasian continental and Philippine sea plates, where an arc-continent collision has been occurred since late Miocene and still on-going. It is unequivocally an earthquake condensed area. Fortunately, most of the earthquakes happen in offshore area and eastern Taiwan along the plate boundaries. Earthquake occurs on land of western Taiwan is seldom but always causes big loss if it strikes the high population district, such as that 1999 Chi-Chi earthquake (Mw7.6). Therefore, the precursor study is urgently needed in such a high earthquake risky area.
Among the potential earthquake precursors, GPS has been recently noticed by its improved precision and automation. This study analyzed the datasets of the campaign mode network as well as one station of continuous mode measured in the duration covering the Chi-chi earthquake. We assumed the Penghu islands are relatively stable to fold-and thrust belt of Taiwan, thus all the presented vectors are calculated against the station (continuous mode) set at Paisha of Penghu. On the vector amount, the crustal moving rates are higher in the hanging-wall of Chelungpu-Tachienshan fault (>10 mm/yr) than in the footwall (< 10 mm/yr), indicating the stresses are cumulating interseismically. By comparison of the corresponding vectors measured in August of 1997 to 1998 and 1998 to 1999, the moving directions clockwise changed from NW to somewhat due north. This probably represents a stress drop, related to coming large earthquake. If this is a common case, condensed occupations of campaign mode also can serve as an earthquake precursor.
On the other hand, we also analyzed the dataset from a continuous mode station (S103) located very close to the southern ending of 1999 surface rupture. Converted vectors consistently show a large annual rate with a direction toward NW during 1995 to 1997. We further found out that its N-S component has no seasonal variation, while the E-W component is obvious (i.e., 8 mm) only in first half of one year and relatively stable in the second half. Until 1998 the E-W shortening started decreasing since the spring and turned to extension (i.e., 6 mm in total) after the summer, which is entirely different from the former annual pattern. We suppose this change is probably a link to the stress drop occurring immediately before earthquake. This finding confirms the GPS monitoring can indeed forecast the earthquake ahead in a few months.

T12C-0479 1330h POSTER

Fractal Analysis of Seismicity: Before and After the Chi-Chi Earthquake

Wei-Hsiung Lin (chaos@linx.moeacgs.gov.tw)

Central Geological Survey, #2, LN 109, Hua-Hsin St. Chung-Ho, Taipei County 235, Taiwan

It is generally believed that an earthquake occurs on an intricate network of faults which have similar shapes on all scales. This property is a kind of scale invariance which results in a power law distribution of scales where the exponential coefficient is a constant. This constant is related to the topographic dimension and is also referred to as the fractal dimension. This dimension is then used as a quantity to describe scale-invariant phenomena. In this study, the fractal dimension represents the fractal clustering of seismicity in a fracture system. The larger the fractal dimension is, the higher is the fractal density distribution of seismicity. In addition, an experiment on fractures shows a gradual decrease in the fractal dimension after fracturing with the passing of time. This strongly implies that a decrease in the fractal dimension over time may well lead to a large earthquake. To carefully monitor a change in the fractal dimension in a fracture system is, therefore, critical with regard to earthquake prediction. By studying the temporal and spatial distribution of earthquakes before and after the Chi-Chi earthquake. The present results, indeed, confirm the proposed theory.

T12C-0480 1330h POSTER

How to explain the coseismic slip distribution of the 1999 Chi-Chi (Taiwan) earthquake ?

Rodolphe Cattin[1] (33 1 44 32 22 64; cattin@geologie.ens.fr)

Anne Loevenbruck[1] (loeven@geologie.ens.fr)

Xavier Le Pichon[1,2] (lepichon@geologie.ens.fr)

[1]Laboratoire de Geologie, Ecole Normale Superieure, 24 rue Lhomond, Paris 75005, France

[2]College de France, 6 place Marcelin Berthelot, Paris 75005, France

The Chi-Chi 1999 earthquake ruptured the out-of-sequence Chelungpu Thrust Fault (CTF) in the fold-and-thrust belt in Western Central Taiwan. An important feature of this rupture is that the calculated slip increases approximately linearly in the SE-NW convergence plate direction from very little at its deeper edge to a maximum near the surface. Taking into account the dip angle of the CTF, asperity dynamic models can qualitatively explain the general features of coseismic slip distribution. In particular, recent works show the importance of heterogeneous spatial distribution of stress prior to the Chi-Chi earthquake. However our analysis of seismicity shows that previous large historic earthquakes cannot explain the amplitude of this heterogeneity. We propose here an alternative explanation based on the study of both stress and displacement over the long term as well as over a seismic cycle. Over the last 0.5 Myr the convergence rate in the mountain front belt is accommodated by the frontal Changhua Fault (Ch.F), the CTF and the Shuangtung Fault (Sh.F). Based on previously published balanced cross sections we estimate that the long term slip of the Ch.F and of the CTF accommodate 5-30 % and 30-55 % of the convergence rate, respectively. This long term partioning of the convergence rate and the modeling of interseismic and postseismic displacements suggest that the peculiar linear coseismic slip distribution is accounted for by a combination of the effect of the obliquity of the CTF to the direction of interseismic loading, and of increasing aseismic creep on the deeper part of the Ch.F and CTF.

T12C-0481 1330h POSTER

Deformation Mechanism of the southern ending of the Chi-Chi earthquake

Yuan-Hsi Lee[1] (886-5-2722820; dawn.forest@msa.hinet.net)

Shih-Ting Lu[2] (ding@linx.moeacgs.gov.tw)

Tung-Sheng Shih[2] (loose@linx.moeacgs.gov.tw)

Chin-Hsiung Ho[2] (hcs@linx.moeacgs.gov.w)

Ruey- Juin Rau[3] (raurj@mail.ncku.edu.tw)

[1]National Chung-Cheng University, 160, San-Hsing Min-Hsiung Chia-Yi Taiwan, R.O.C. 2Geological Survey, R.O.C., P.O. Box 968, Taipei, R.O.C., Chia-Yi 621, Taiwan

[2]Central Geological Survey, Geological Survey, R.O.C., P.O. Box 968, Taipei, R.O.C, Taipei 235, Taiwan

[3]National Chen-Kung University, No.1, Ta-Hsueh Road, Tainan 701, Taiwan., Tainan 701, Taiwan

The 1999 Chi-Chi earthquake, Mw 7.6, which resulted a nearly 100-km length surface rupture, was caused by the activation of the low angle thrust Chelungpu fault. Previous studies show that in the southern segment of the Chelungpu fault, the N-S trending surface rupture turns into SW trending and becomes dominantly right lateral strike-slip faulting along the pre-existing Tachienshan fault. However, according to the coseismic GPS slip vector data and field surveys, we found that the NW-trending Luliao fault was also activated during the Chi-Chi earthquake and the SW trending surface rupture (Tachienshan fault) could extend to the west and along the Meishan fault, which was active at 1906, M=7.1. Therefore, we separate the southern end of the Chi-Chi earthquake into three blocks bounded by three coseismic active faults: the N-S trending Chelungpu fault with thrusting dominantly, SE trending Luliao fault with left-lateral strike slip faulting dominantly, and SW to EW trending Tachienshan-Meishan fault system (T-M fault) with right-lateral strike slip faulting dominantly. The strain compatibility of these three faults could explain the southern ends of the Chi-Chi earthquake. Furthermore, the deformation process could be derived according the characteristics of slip vector of surface rupture and GPS data. At first, the Chi-Chi earthquake ruptured southwestward and activated the Chelungpu fault and Tachienshan fault. Then, the Chi-Chi earthquake rotated clockwise to the NW direction and slipped northward accompanying the NW trending Luliao fault's development as the lateral ramp of the Chi-Chi earthquake. Finally, one month later the Meishan fault was triggered at October 22th, 1999.

T12C-0482 1330h POSTER

Active deformation front delineated by a blind thrust underneath the coastal plain, Southwestern Taiwan

Chih-Cheng Barry Yang[1] (d91224003@ntu.edu.tw)

Wen-Shan Chen[1] (wenshan@ccms.ntu.edu.tw)

Chii-Wen Lin[2] (lincw@linx.moeacgs.gov.tw)

[1]Department of Geosciences, National Taiwan University, No.1, Roosevelt Rd., Sec. 4, Taipei 106, Taiwan

[2]Central Geological Survey, MOEA, 2. Lane 109, Hua-Hsin Street, Chung-Ho, Taipei 235, Taiwan

We discovered a blind thrust underneath the Chaiyi coastal plain, which may indicate the deformation front of the fold-and-thrust belt of Taiwan, which is created by arc-continent collision between Eurasian continent and Philippine Sea plate. By using the geomorphic and drainage pattern analysis, we can divide the study area into three distinct N-S geomorphic domains. From shoreline mountainward, they are coastal plain, uplifted tableland, and low hill. The coastal plain domain is characterized by meandering rivers. The surface slope (Ss) and river gradient (Rg) are relatively low, but river sinuosity (S) is high [i.e., Ss: 0.7 m/km, Rg: 0.2 m/km, S: 1.3], showing no tectonically uplifting in this domain. The middle uplifted tableland domain is dominated by tablelands with surfaces slightly titled to the west and meanders on the top but more tributaries developed [Ss: 11.8 m/km, Rg: 2.4 m/km, S: 1.5]. Anomaly high river sinuosity in this domain implies that there is an influence driven by active structure. To the east of low hill, scraggly relief landscape with higher surface slope is dominant. The river gradient increases but the sinuosity deceases [Ss: 89.2 m/km, Rg: 59.3 m/km, S: 1.2], indicating it has been uplifted for a while and is probably undergoing. To accommodate the strain of the crustal deformation among the geomorphic domains, we infer that a blind thrust exists between the coastal plain and uplifted tableland. Independently, we calculated the long-term uplifting rates by determining the terrace ages via the radiocarbon method. Our results reveal that the hanging-wall of the blind thrust is uplifting in rates of 0.2-3.1 mm/yr, while the footwall is subsiding in rates of 0.1-5.2 mm/yr. We also suggest that the blind thrust may be indicative to the active deformation front of the orogeny belt and foreland basin tectonic units in western Taiwan.

T12C-0483 1330h POSTER

Paleoseismology of the Chelungpu Fault During the Past 1900 Years

Wen-Shan Chen[1] (wenshan@ccms.ntu.edu.tw); Kun-Jie Lee[1] (oldr123@yahoo.com.tw); Long-Sheng Lee[1] (contractor@pchome.com.tw); Chih-Cheng Barry Yang[1] (d91224003@ntu.edu.tw); Yue-Gau Chen[1] (ygchen@ntu.edu.tw); Hui-Cheng Chang[2] (chang.huicheng@seed.net.tw)

[1]Department of Geosciences, National Taiwan University, No. 1, Roosevelt Rd., Sec. 4, Taipei 106, Taiwan

[2]Central Geological Survey, MOEA, 2. Lane 109, Hua-Hsin Street, Chung-Ho, Taipei 235, Taiwan

The 1999 earthquake brought about 80-km-long surface ruptures along the Shihkang, Chelungpu, and Tajienshan Faults, central Taiwan. Several trenches have been excavated across the Chelungpu Fault of the middle segment. The surface ruptures display clear scarps ranging from 0.2 m to 4 m high, showing a complex geomorphic pattern due to coseismic faulting and folding. In the study, measurement of the vertical offset or structural relief was taken with reference to the hanging wall beyond the trishear deformation

zone. Therefore we suggest that, for the measurement of offset, we should leave out the trishear zone, and that structural relief on the hanging wall should be represented as a real vertical offset. The net slip is then calculated from the structural relief and dip angle of the thrust on a vertical plane along the slip direction. By the excavation of the pineapple field across the Chelungpu Fault, we are able to first provide evidence of at least four earthquake events for the past about 1900 years, including the 1999 earthquake. Furthermore, based on the radiocarbon dates and historical record, the timing of the penultimate event is bracketed to be between 430 and 150 years ago, and the average recurrence interval smaller than 700 years. These data indicate that the average slip rate is about 8.7 mm/yr for the past 1900 years.

T12C-0484 1330h POSTER

Crustal Structure Beneath Taiwan Using Local and Teleseismic Travel Times Observed by the 2001 Linear Array Observation

Fuminori Honda[1] (fuminori@eri.u-tokyo.ac.jp); Naoshi Hirata[1] (hirata@eri.u-tokyo.ac.jp); Eiji Kurashimo[1] (ekura@eri.u-tokyo.ac.jp); Shin'ichi Sakai[1] (coco@eri.u-tokyo.ac.jp); Bor-Shouh Huang[2] (hwbs@earth.sinica.edu.tw); Horng-Yuan Yen[3] (yenhy@earth.sinica.edu.tw)

[1]ERI,Univ.of Tokyo, 1-1-1 Yayoi,Bunkyo-ku,Tokyo, Tokyo 113-0032, Japan

[2]Institute of Earth Sciences Academia Sinica,Taiwan, 128 Academia Road Sec. 2,Nankang Taipei 115 Taiwan, ROC, Taipei 115, Taiwan

[3]National Central University,Taiwan, Chungli,Taiwan,32054,R.O.C., Taipei 32054, Taiwan

In the northeastern area of Taiwan, Philippine Sea Plate is subducting northward, and in the southern area of Taiwan, Eurasian Plate is subducting eastward. These two plates are colliding each other beneath Taiwan. About mountain building mechanism, there are two representative theories, that is, the thin skinned model (Suppe, 1981) and the collision model (Wu et al., 1997). These models have not been resolved yet by well constrained dataset. Based on this background, we deployed a 150-km linear array in central Taiwan from March 2001 to May 2001. The array, which consisted of 55 seismographs spacing at about 2 km, recorded 47 local events that occurred between 23.5° N and 24.0° N and 11 teleseismic events. First, we examined teleseismic events to see travel time delays due to lateral heterogeneity in the crust and the uppermost mantle. Delays of the relative travel time of two teleseismic events from Solomon and China reached 1.3 s at the Central Range, which were approximately explained by the preliminary model based on the refraction survey (Yeh et al., 1998). In this model, the shape of the mid-crust is upward convex and the deepest part of the Moho is located east of the Central Range. Next we analyzed crustal structure in detail by using local events. Based on the modified preliminary model which could explain the observations of 5 events located on the array or the extension of the array, we estimated the structure and the hypocenters by using a three-dimensional tomography method (Matsubara, 2001). We modeled the area from 21.0° N to 26.0° N in latitude, from 119.0° E to 124.0° E in longitude, and from -4.0 km to 72.0 km in depth. The intervals of grids are 1 degree in latitude, 0.2° (0.1° from 120.4° E to 122.2° E) in longitude, and 4 km in depth. In the checkerboard resolution test, velocities in the crust beneath the array shallower than 20 km were recovered well. The root mean square of travel time residuals, which was 0.66 s for the initial model, was reduced to 0.38 s. The result shows there is a high-speed crust in the eastern coast of Taiwan. We will check if this model can explain the relative travel times of teleseismic events and clarify the structure of the lower crust and the upper mantle

T12C-0485 1330h POSTER

Deformed Structures Revealed by Deep and Shallow Seismic Reflection Surveys Around an Inferred Active Fault in the Southern Kyoto Basin, Japan

Takanobu Yokokura[1] (81-29-861-3729; taka.yokokura@aist.go.jp); Tomio Inazaki[1] (81-29-861-3734; inazaki.t@aist.go.jp); Kazuo Yamaguichi[1] (81-29-861-2413; yamaguchi-k@aist.go.jp); Naomi Kano[1] (81-29-861-3870; n.kano@aist.go.jp); Akiko Tanaka[1] (81-29-861-3962; akiko-tanaka@aist.go.jp); Toshiki Ohtaki[1] (81-29-861-3849; t-ohtaki@aist.go.jp); Shinobu Ito[1] (81-29-861-3832; s.ito@aist.go.jp); Masao Komazawa[1] (81-29-861-3890; komazawa-m@aist.go.jp)

[1]Institute of Geoscience, Geological Survey of Japan, AIST, Tsukuba Central 7, 1-1-1 Higashi, Tsukuba, IB 305-8567, Japan

Kyoto is one of the most famous old cities, which attracts many tourists from all over the world. Although Kyoto has frequently been attacked by large earthquakes as written in many old archives, the area has been abnormally quiet since 1830, except small damages by the 1995 Hyogo-ken Nanbu earthquake. The Kyoto basin is surrounded by many faults. The southwestern end of the basin is limited by a lineament. It is not known whether the lineament is still active or not. To know the detailed geological structure around the lineament, we conducted deep and shallow seismic reflection surveys, collection of boring data and gravity survey in the southern Kyoto basin. Deep reflection surveys revealed that the pre-Neogene basement lies at about 700-800m in depth at the basin side, and becomes rapidly shallow toward the Yawata hillside. We found some faults around the lineament stated above. By correlation with the 800m deep boring KD-0 drilled by the Kyoto City, some marine clay beds of the Plio-Pleistocene Osaka Group, which is named Ma3, Ma4, Ma5, Ma6 and Ma9, can be identified on all seismic sections. Ages of these clay beds are dated very precisely, e.g. Ma3 is about 900ka and Ma9 is about 400ka. The vertical slip rate of the faults can be estimated using these ages as about 0.1m/ky between 400 and 900ka, and negligibly small before 900ka. Shallow high-resolution reflection surveys were conducted using SH-wave type land-streamer. The processing results have shown detailed shallow structures down to 30-40m deep and have revealed distribution of a sand-gravel layer that has N-value of about 30-40 and corresponds to a bearing layer for construction in this area. The sand-gravel layer has some deformed structures with displacements of a few meters, which suggests that the upper extensions of a fault found by deep seismic survey may cause these near-surface displacements. This indicates that the faults may be still active and may migrate toward the basin side.

T12C-0486 1330h POSTER

A New Look for the Cause of the 1906 Meishan Earthquake in Southwestern Taiwan From Shallow Seismic Reflection Images

Ruey-Chyuan Shih[1] (88652428118; seirock@eq.ccu.edu.tw)

Wen-Shan Chen[2] (wenshan@ms.cc.ntu.edu.tw)

Chii-Wen Lin[3] (lincw@linx.moeacgs.org.tw)

[1]National ChungCheng University, 160 SanHsing, MinHsiung, Chiayi 621, Taiwan

[2]National Taiwan University, P.O. Box 13-318, Taipei 106, Taiwan

[3]Central Geological Survey, 2, Ln. 109, HuaHsin St., ChunHo, Taipei 235, Taiwan

In 1906, an earthquake of magnitude 7.1 shocked the Meishan area in the southwestern Taiwan, and caused very severe damages. Formerly, the earthquake was thought related to a NE-SW trend, left-lateral strike-slip fault, called Meishan fault. Since the Meishan fault runs in the plain area, without visible outcrops, the followed up study of the fault was difficult. Using the high resolution shallow seismic reflection data, in this paper, we will show not only the Meishan fault, but a N-S trend thrust fault, named Chiochiunken fault, in the foothill front area also played a more important role in that earthquake. From the shallow seismic reflection images, we have been able to detect the detailed locations for both of the faults and show their characteristics in near surface. The two faults were connected probably in the northeast of the Meishan area. The Chiochiunken fault consists of a sharp and narrowed fault zone in the Meishan area and dipping to the east at about 25 degree. Down to the south in the Chuchi area, the fault zone was widely spread to about 800m, and many smaller faults exist within the zone. The Meishan strike-slip fault consists of a clear wide fault zone along the fault trace. The flower structures were also clearly imaged in the shallow seismic reflection sections. According to the relation of the two faults and the known tectonic movement of Taiwan, we believed that the 1906 Meishan earthquake was first occurred along the Chiochiunken fault and then the Meishan fault was triggered as well.

T12C-0487 1330h POSTER

Deep Seismic Reflection Profiling Across the Northern Fossa Magna: the ERI 1997 and the JNOC 1996 Seismic Lines, Active Faults and Geological Structure

Driss Elouai[1,2] (81-3-5841-5710; driss@eri.u-tokyo.ac.jp)

Hiroshi Sato[2] (satow@eri.u-tokyo.ac.jp)

Naoshi Hirata[2] (hirata@eri.u-tokyo.ac.jp)

Shinji Kawasaki[3] (kawasaki@jgi.co.jp)

Toru Takeshita[1] (toru@letitbe.geol.sci.hiroshima-u.ac.jp)

[1]Department of Earth and Planetary Systems Science, Hiroshima University, 1-3-1 Kagamiyama, Higashi-Hiroshima 739-8526, Japan

[2]Earthquake Research Institute, University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-0032, Japan

[3]Japan Geosciences Institute, JGI, Inc. Meikei Building 1-5-21, Otsuka Bunko-Ku, Tokyo 112-0012, Japan

View the fact that Japan is situated on a puzzle of tectonic plate boundaries; it is considered one of the most countries threatened by hazardous phenomena, mainly volcano and earthquakes. The Itoigawa-Shizuoka tectonic line (ISTL) is one of these boundaries, which separate the NE Japan from the SW Japan. In between these parts of Japan, the Neogene Fossa magna basin has been developed since the Miocene and is considered an active tectonic area, thus it has attracted different research groups. Our research group has conducted this research in order to investigate the geometry of the active faults and to get a better understanding of the relationship between the Pre-Neogene basement and the subsequent thick package of the sediments and the accompanied igneous rocks. Reprocessing the NF-97 line (17km in length) of the Earth Research Institute of Tokyo University (ERI) and the NS96-A line (19km) of the Japan National Oil Company (JNOC), has improved the quality of these lines. Despite of the difference in their strikes, EW for the former and NE-SW for the latter, we could merge both of them in a single line. Applying the migration process, we could partially filled in the 4km gap in between the two lines. Thus we could visualize the main structures, faults and folds existing in this area with their extension in the deep part. In the western part of the seismic line, the Itoigawa-Shizuoka active fault and the Otari-Nakayama fault appear as thrusting faults. These thrusts are dipping towards the East, with a westward vergence. The ISTL constitute a detachment fault system, which probably has played a key role of the tectonic evolution of the whole Fossa magna. In the East part of the seismic line, two backward reverse faults have been observed, the active fault of the West Nagano Basin and the Saigawa fault.

T12C-0488 1330h POSTER

Holocene Multiple Movement of the Hsinhua Fault in Southwestern Taiwan

Chyi-Tyi Lee[1,2] (886-3-4253334; ct@gis.geo.ncu.edu.tw)

Chi-Wen Liao[2] (886-3-4253334; app601@gis.geo.ncu.edu.tw)

Po-Shen Lin[2] (886-3-4253334; person@gis.geo.ncu.edu.tw)

Shu-Ching Wen[1] (886-3-4253334; wsc@gis.geo.ncu.edu.tw)

[1]Institute of Applied Geology, National Central University, ChungLi 320, Taiwan

[2]Institute of Geophysics, National Central University, ChungLi 320, Taiwan

Four trenches were excavated at the Hsinhua Fault in Napalin, Tainan. Rupture zone and multiple-paleoearthquake phenomena have been discovered in these trenches. In trenches NBL-2 and NBL-3, we have recognized the rupture plane and fissure-fillings which belong to the 1946 event. We shall extend the length of trench NBL-1 northward so that the 1946 rupture zone can also be opened there. These trenches involved several reference layers which include paleo-channel deposits, peat and paleosol at the vicinity of fault rupture zone. The channel deposits have been offset by the 1946 event, and also preserved older paleoearthquake events. At the base of the channel, open fissure and peat filling, which indicate an older earthquake event, were observed. Below the channel deposit, a layer of paleosol exists at top of the Holocene Tainan Formation. Cut relations and other phenomena indicate many much older events can be further analyzed. To give an overview, the Hsinhua Fault in the study area was situated at a transtensional tectonic environment. Apparent normal-fault features as shown on the trench walls might be a flower structure that often occurs in a strike-slip fault zone. Depression of present-day ground surface as well as paleo- topography in the vicinity of the fault rupture zone, and the development of paleo-channel may closely relate with the transtensional environment. Evidences show that at least three recent events have occurred during and after the Niauhsung cultural age (400-2000y.B.P.). More detailed results may come out after the age of reference materials have been dated.

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T12C-0489 1330h POSTER

Preliminary Report Of Paleoseismological Study On The Kuromatsunai Lowland Fault Zone, Southwest Hokkaido, Northern Japan.

Koichi Shimokawa[1] (k.shimokawa@aist.go.jp); Takashi Azuma[1] (t-azuma@aist.go.jp); Yuichi Sugiyama[1] (sugiyama-y@aist.go.jp); Akira Sangawa[1] (sangawa.a@aist.go.jp); Takuichiro Kuwabara[1] (t-kuwabara@aist.go.jp); Koji Okumura[2] (kojiok@hiroshima-u.ac.jp); Hideki Kurosawa[3] (kurosawa-hideki@oyonet.oyo.co.jp); Atsushi Miwa[3] (miwa-atsushi@oyonet.oyo.co.jp)

[1]Active Fault Research Center, GSJ/AIST, site7, 1-1-1 Higashi, Tsukuba 305-8567, Japan

[2]Hiroshima University, 1-2-3 Kagamiyama, Higashi-Hiroshima 739-8511, Japan

[3]OYO Co., 2-2-19 Daitakubo, Minami-ku, Saitama 336-0015, Japan

The Kuromatsunai lowland fault zone in southwest Hokkaido is one of the major active faults in Japan. This 30-km-long and 5-km-wide fault zone consists of many N-S-trending, several-km-long thrust faults, which are closely related to the folding structure of the thick sediments of late Miocene to early Pleistocene age. The folding structure has been formed by E-W compression due to the plate convergence after E-W extension related to the opening of the Japan Sea. However, there is no historical document that recorded large earthquakes in this area. To reveal the recent activity of the Kuromatsunai lowland fault zone, we conducted paleoseismological study including trenching and coring in the northern and southern parts of the fault zone. A trench on the Shirozumi fault, one of the main fault strands in the northern part, exposed a nearly horizontal, sharp contact between an eastward-dipping silt bed of 45,000 years BP and an overlying weathered aeolian volcanic ash layer. It is not clear, however, whether the contact is a low-angle fault of tectonic origin or a slip surface of landslide origin. Another trench on a dissected flexural scarp of the Oshamanbe fault in the southern part exposed the unconformity between an eastward-dipping silt layer of 45,000 to 50,000 years BP and an overlying gravel layer of 4,000 to 9,000 years BP. Liquefaction traces were also found in the gravel layer. The coring survey near the trench site shows that the vertical displacement of the silt layer attains about 10 m. We are planning to conduct seismic reflection survey to image the subsurface structure of this fault zone.

T12D MCC: Level 1 Monday 1330h

Observational and Theoretical Insights Into the Structure and Dynamics of Mid-Ocean Ridges II Posters *(joint with V)*

Presiding: **J Escartin,** Laboratoire de Geosciences Marines (IPGP/CNRS)**; O Engen,** University of Oslo

T12D-0490 1330h POSTER

Deep Crustal Structure of Fast-Spreading Crust Near Hess Deep

Daniel S Brothers[1] (303-499-0761; brotherd@colorado.edu)

Gail L Christeson[2] (512-471-0463; gail@ig.utexas.edu)

Kirk D McIntosh[2] (kirk@ig.utexas.edu)

[1]University of Colorado-Boulder, Department of Geological Sciences, Boulder, CO 80310, United States

[2]Univ TX Institute For Geophysics, 4412 Spicewood Springs Rd, Bldg 600, Austin, TX 78759, United States

We present the results of a wide-angle seismic survey conducted near Hess Deep in the equatorial East Pacific. Hess Deep is a rift velley in 1 Ma crust formed at the fast-spreading East Pacific Rise (EPR). Rifting is characterized by north/south extension and the westward propagating Cocos-Nazca spreading center. Geologic investigations of the northern wall of the valley using deep-sea submersibles have mapped the lithologic boundaries exposed here. The experiment took place on top the northern wall of the rift valley and consisted of three scarp parallel lines of ocean bottom seismograph (OBS) receivers. The instruments were separated by 7.5 km on two of the lines and 3.5 km on the third. We used two-dimensional ray-tracing to constrain velocity structure in the region and then made comparisons with the geologic structure observed by the submersible teams. For each profile we present a four layer crustal velocity model consisting of layer 2A (2.85-3.15 km/s), 2B (5.1-6.7 km/s), layer 3 (6.35-7.35 km/s) and mantle (8.0 km/s). It has been suggested that the seismic layer 2/3 boundary may correspond to the lithologic contact between dikes and gabbros. However, the velocity structure closest to the fault scarp indicates seismic boundary 2/3 is nearly 1 km below the observed dike/gabbro layer. Overall, the seismic boundaries of the two lines further from the scarp are very similar, but the line closest the scarp presents a slower than expected velocity at the top of layer 3 (6.25-6.35 km/s). The average crustal thickness in the region is 5.9 km.

T12D-0491 1330h POSTER

Off-axis seismicity along the Mid-Atlantic Ridge at 12°-14°N and the North America - South America -Africa triple junction

Javier Escartin[1] (+331 44274601; escartin@ipgp.jussieu.fr)

Deborah K. Smith[2] (dsmith@whoi.edu)

Mathilde Cannat[1] (cannat@ipgp.jussieu.fr)

[1]Laboratoire de Geosciences Marines (IPGP/CNRS), Case 89 4 Pl. Jussieu, 75252 Paris, France

[2]Dept. of Geology and Geophysics Woods Hole Oceanographic Institution, MS 22 Woods Hole, MA 02540, Woods Hole 02540, United States

Seismicity along the MAR, monitored with the Autonomous Underwater Hydrophone (AUH) array, shows an anomalous band of events 70 km west of the axis (5.5 My-old crust), and between 11.9 and 14.2°N. Available focal mechanisms from teleseismic events along the off-axis band show extension directions consistent with North American-South American relative plate motion as predicted by the REVEL plate model. Near the north end of this band events trend towards the axis, and in proximity to the axial seismic gap at14°N. This gap coincides with the shallow and robust 14°N segment, which is also associated with a prominent *hotspot* geochemical anomaly. Axial focal mechanisms are consistent with spreading of the African (AF) and the NA or SA plates. We propose that the off-axis seismicity could be caused by an active westward jump and the formation of an incipient ridge, or by the presence of a microplate bounded by the axial and off-axis seismicity. Multibeam data show sediment ponds among irregular faults scarps locally covered by massifs that may correspond to recent volcanic edifices. This area also shows higher acoustic backscatter than nearby sedimented terrain. Additional data (magnetics, seafloor samples and direct observations is required to determine if there is recent volcanic activity associated with the intraplate seismicity. We speculate that the triple junction between the AF, NA and SA plates is close to the 14°N seismic gap, and is responsible for the large rotation of stress in the area recorded by the teleseismic events. We cannot constrain the position of the NA-SA plate boundary extending west towards the Caribbean subduction zone. If this boundary were continuous, we expect it to initiate at the southern end of the off-axis seismicity band, coinciding approximately with the trace of the Marathon FZ. Alternatively, the plate boundary may be diffuse along the corridor defined by the Fifteen-Twenty and the Marathon FZs, with the possible presence of a microplate at the axis.

T12D-0492 1330h POSTER

Crustal Structure of the Northern and Southern Jan Mayen Ridge Segments, Norwegian Sea, Based on Ocean Bottom Seismometer Data.

Asbjorn J. Breivik[1] (+47 22857026; a.j.breivik@geologi.uio.no)

Rolf Mjelde[2] (rolf.mjelde@geo.uib.no)

Hideki Shimamura[3]

Yoshio Murai[3]

Yuichi Nishimura[3]

[1]Department of Geosciences, University of Oslo, PO Box 1047 Blindern, Oslo N-0316, Norway

[2]Department of Earth Science, University of Bergen, Bergen N-5007, Norway

[3]Institute for Seismology and Volcanology, Hokkaido University, Sapporo 060, Japan

The Jan Mayen Ridge (JMR) is a submarine ridge trending south from the volcanic Jan Mayen island in the Norwegian Sea, towards Iceland. In the north, it is a distinct, single ridge, but in the south it is divided into several smaller ridges. JMR is interpreted as a micro-continent, being part of Greenland during the volcanically active rifting off Norway in the latest Paleocene. In the late Oligocene, JMR was rifted off Greenland when seafloor spreading shifted from the now extinct Aegir Ridge, to the presently active Kolbeinsey Ridge. The southern termination of the micro-continent is uncertain, though it may extend into the Icelandic shelf. Earlier studies of the northern ridge found extrusive volcanism, and an asymmetrical crustal root, displaced to the east. Two OBS profiles were shot across the northern and southern part in year 2000. The northern ($\sim$ 69°N) terminates in the Jan Mayen Fracture Zone, and the southern ($\sim$ 66.5°N) crosses the Aegir Ridge. The vertical and horizontal components were modeled by ray-tracing into two-dimensional velocity transects. In the north, a maximum crustal thickness of 16 km was found in a narrow root below the eastern part of the ridge. The P-wave velocity at the bottom of the eastern part of the root (7-7.2 km/s) indicates igneous rocks, while the western part (6.8 km/s) is typical for continental rocks, with a 40 km wide transition zone between. The supposed extrusive basalts do not stand out in the data, but may have a low velocity contrast to underlying pre-breakup sedimentary strata. The top oceanic basement is very rough near the Jan Mayen Fracture Zone, with upper basement P-wave velocity of 3.5-4 km/s. A slight increase in the Vp/Vs ratios indicates an increase in fracturing of the deep crust here. Adjacent to the JMR, the top oceanic basement becomes very smooth, and the velocity increases to 5.5 km/s. Average oceanic crustal thickness is 5.3 km. For the southern profile, the average thickness is 5.2 km around the Aegir Ridge. West of that, the crustal thickness increases smoothly to 12 km over a $\sim$90 km distance, and the crust appears to be of mafic, igneous composition. This is similar to the thick oceanic crust created immediately after continental breakup on the complementary Moere Margin in Norway. West of that region, a crustal root with a relief of up to 3.5 km is associated with a mid-crustal region (5-12 km depth) having a slight drop in P-wave velocity (-0.4 km/s), and Vp/Vs ratios (-0.03), is interpreted as a continental fragment. Towards the Iceland shelf, the results indicate a predominantly mafic igneous crust, with a Moho depth oscillating around 16 km. Relief to the Moho surface and mid-crustal velocity layers indicate that smaller continental fragments may be embedded in the igneous crust also here.

T12D-0493 1330h POSTER

A Wide-Angle Survey of the Mid-Atlantic Ridge at 5° South

Lars Planert[1] (lplanert@geomar.de)

Frederik Tilmann[2] (tilmann@esc.cam.ac.uk)

Wilhelm Weinrebe[1] (wweinrebe@geomar.de)

Ernst Flueh[1] (eflueh@geomar.de)

Tim Reston[1] (treston@geomar.de)

[1]GEOMAR, Research Center for Marine Geosciences, Wischhofstr. 1-3, Kiel 24148, Germany

[2]Bullard Laboratories, Department of Earth Sciences, University of Cambridge, Madingley Road, Cambridge CB3 0EZ, United Kingdom

Slow spreading mid-ocean ridges are characterized by along-axis segmentation where crustal composition and structure varies significantly within a segment and across transform faults and other ridge axis discontinuities. In 2000, the GERSHWIN experiment investigated two spreading segments adjacent to the 5°S transform fault. A set of intersecting wide-angle profiles were acquired running both parallel and perpendicular to the median valley and extending from the center of one segment across the transform well into the next segment. The lines focused on a number of topographic features (median valley, inside corner high, outside corner, transform fault) in order to resolve related velocity variations inside the crust and the uppermost mantle. This ridge transform intersection is unusual in that the inside corner high south of the 5°S fracture zone has been split by a change in location of active seafloor spreading resulting in an outside corner massif and the absence of a volcanic ridge in the northernmost part of the median valley. For assessing velocity models we chose a combination of forward modeling and first-arrival tomographic inversion. For profiles with sufficient Moho reflections a joint refraction and reflection travel-time tomography was used. Energy propagation varies strongly but in most cases reaches for more than 40km, sometimes up to 90km. Modeling results show a velocity structure which differs significantly from normal oceanic crustal structure. In the median valley of the southern segment models show an unusual thin crust of about 4km thickness (shallowing towards the transform fault in the north) underlain by a low velocity upper mantle (Vp$\sim$7.5km/s). North of the fracture zone, median valley seafloor depths show a bathymetric high near the middle of the segment. Here, velocities reach up to 7.5km/s within depths of 6.5-7.5km below seafloor (starting with beneath seafloor velocities of about 3km/s). In contrast, velocity depth profiles in the region of the inside corner high and the outside corner massif in the southern segment show either very