Lithological control on the spatial evolution of fault slip
Longitudinal Valley Fault, Taiwan

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Mapping the creeping areas

The Longitudinal Valley Fault (LVF) runs parallel to the East coast of Taiwan and accommodates about one third of the 8 cm/yr convergence rate between the Eurasian and the Philippine Sea plates. Due to the thrust component of slip, the fault zone is exhumed in the Coastal range. Deformation of anthropogenic features shows that aseismic creep accounts for a significant fraction of fault slip near the surface, but large Mw > 6.5 earthquakes, like in 1951 and 2003 show that a fraction of the slip is also seismic. Surface strain across the fault is monitored by creepmeter at one site and 21 permanent GPS stations. The creepmeter measurements confirm that the fault creeps near the surface, and show in addition that the creep rate varies seasonally. In this project existing creepmeter, strongmeters, GPS, SAR and leveling data have been analyzed to precisely document the spatio-temporal evolution of slip on the fault. Data are inverted for the temporal evolution of slip at depth using the Principal Component Analysis Inversion Method (PCAIM) The focus was on the portion of the fault which is undergoing aseismic creep. This analysis aims at shedding light on the mechanical properties of the fault zone and how they relate to lithological factors and/or deformations processes.

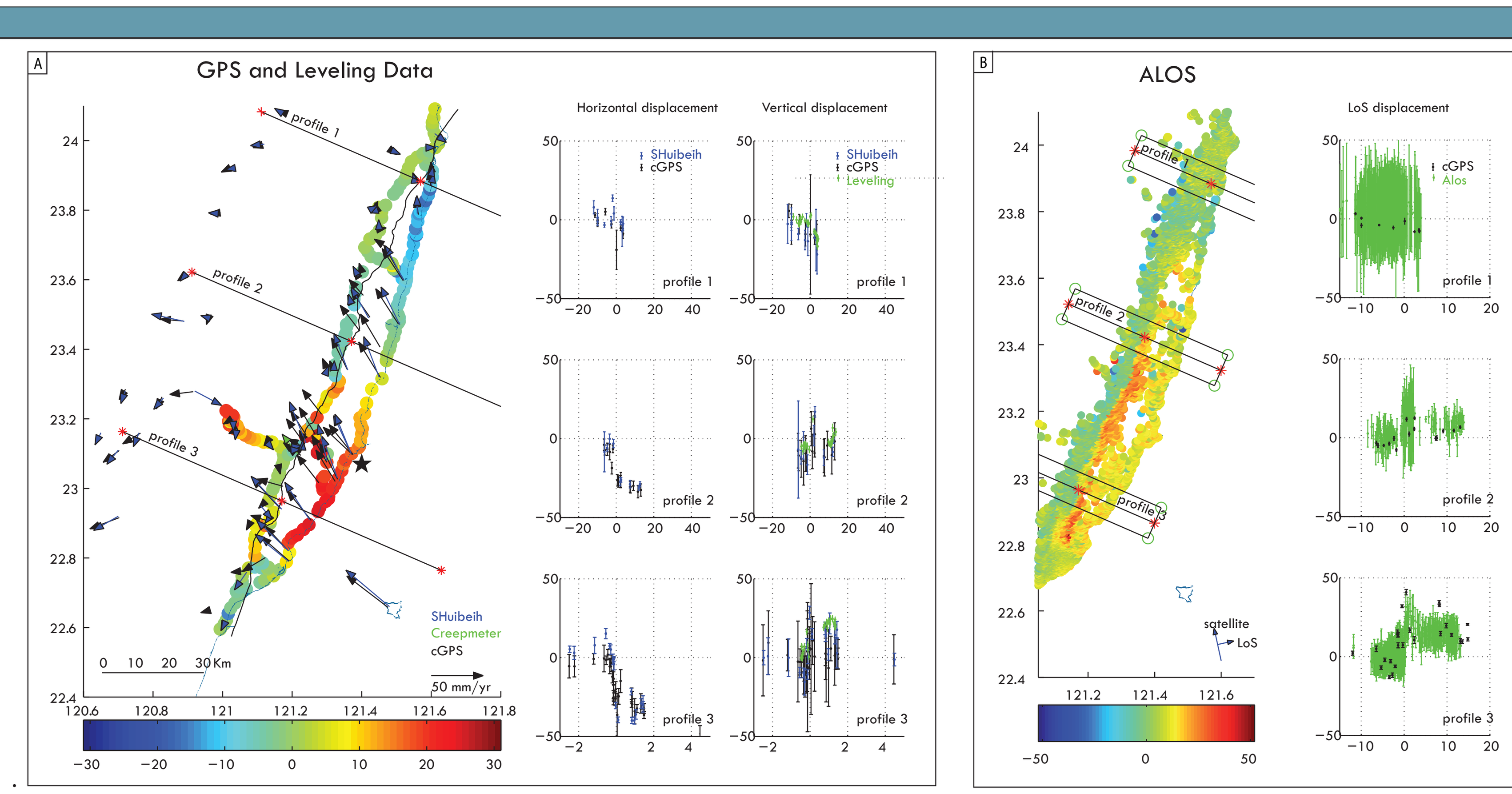
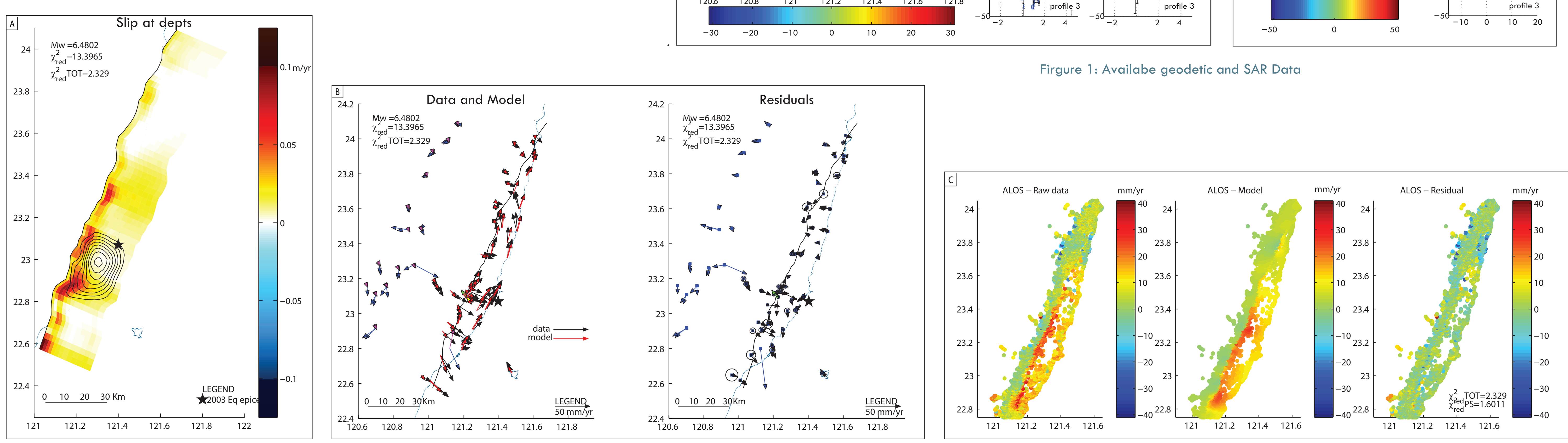


Figure 1: Availabe geodetic and SAR Data

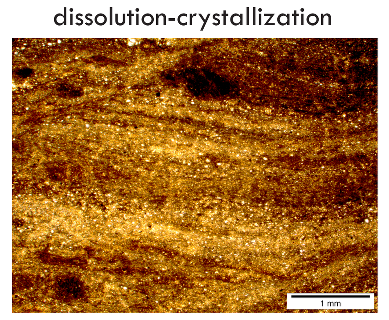
Figure 2: Inversion of geodetic data to get the slip at depth for the interseismic period



A] Displacement at depth during the interseismic. Results are obtained by joint inversion of PS ALoS data, cGPS, campaign GPS, creepmeeter and leveling data. Based on the model, subsurface aseismic slip occurs. mainly in south portion on the longitudinal valley. B] GPS data and prediction of the model. C] ALOS data, Model and Residuals.

Deformation Mechanisms

dissolution-crystallization

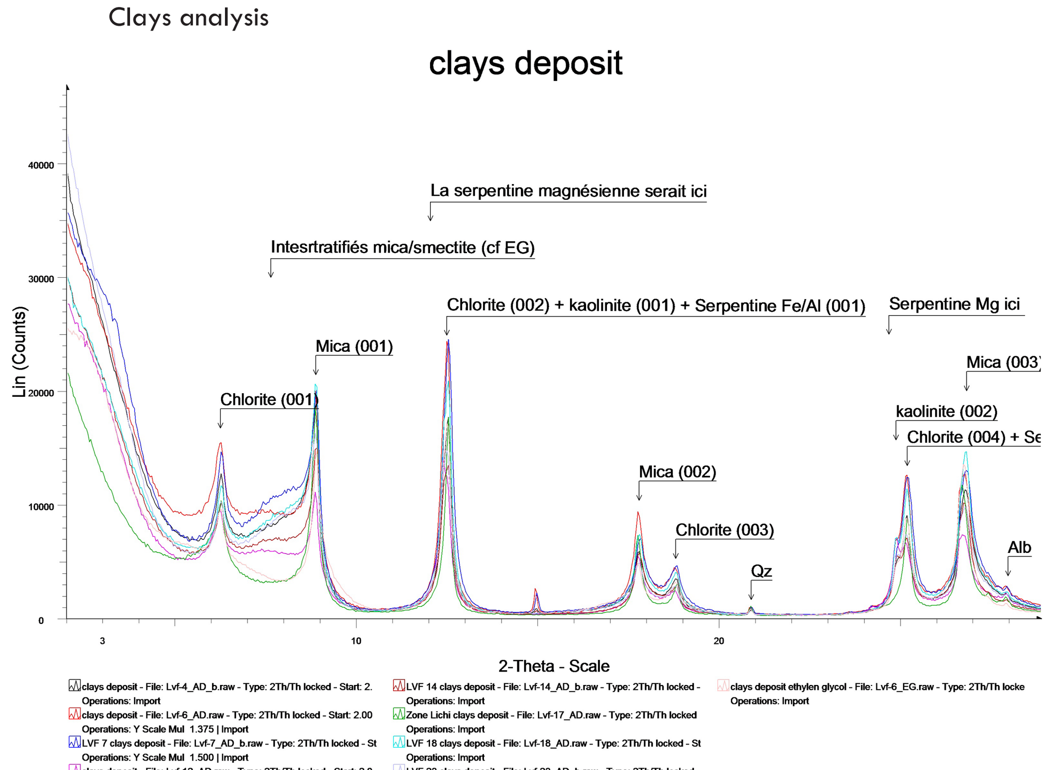


Thin section

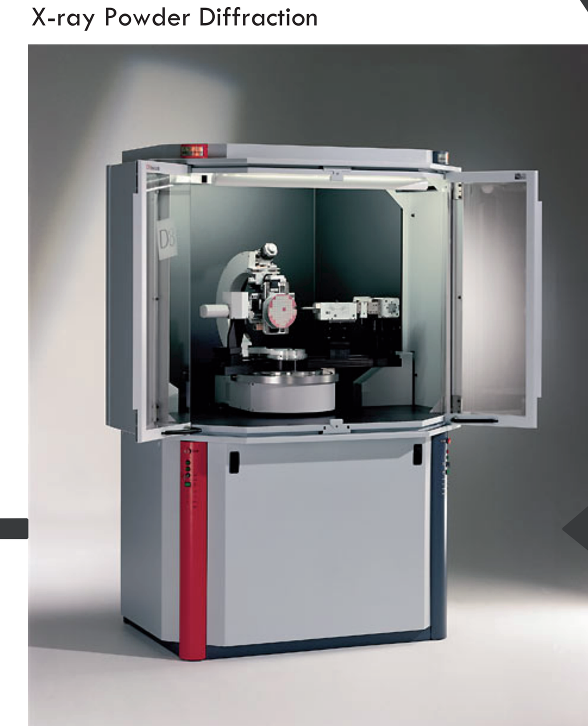
Lichi mélange

The Lichi mélange is a ~2km wide formation, cropping out on the western side of the Coastal Range, mainly south of Yuli. It is a characteristic block-in-matrix mélange with preferred foliation in scaly argillaceous matrix and extensional web and boudinage structures in the sandstone blocks . The exotics blocks inside the formation are various in size (millimeters to kilometers) and lithology (arc products, ophiolites, sedimentary rocks). Marine seismic investigations in the early 1990s combined with previous biostratrigraphic studies, clays composition and lithology of the exotic blocks inside the mélange lead to propose a tectonic collision origin

Clays analysis

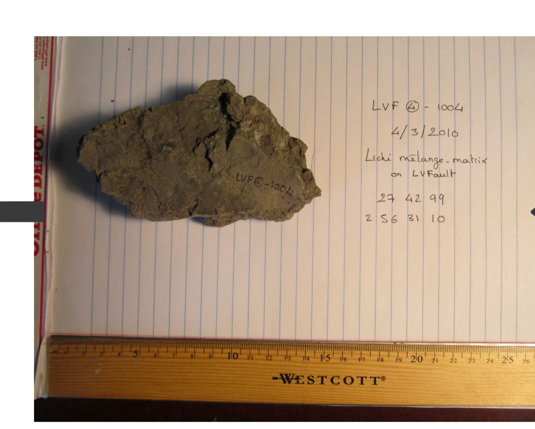


X-ray Powder Diffraction



http://serc.carleton.edu/research_education/geochemsheets/techniques/XRD.html

Lichi sample, on the fault



outcrop of Lichi

Tectonic Setting - Link with the Lihtology

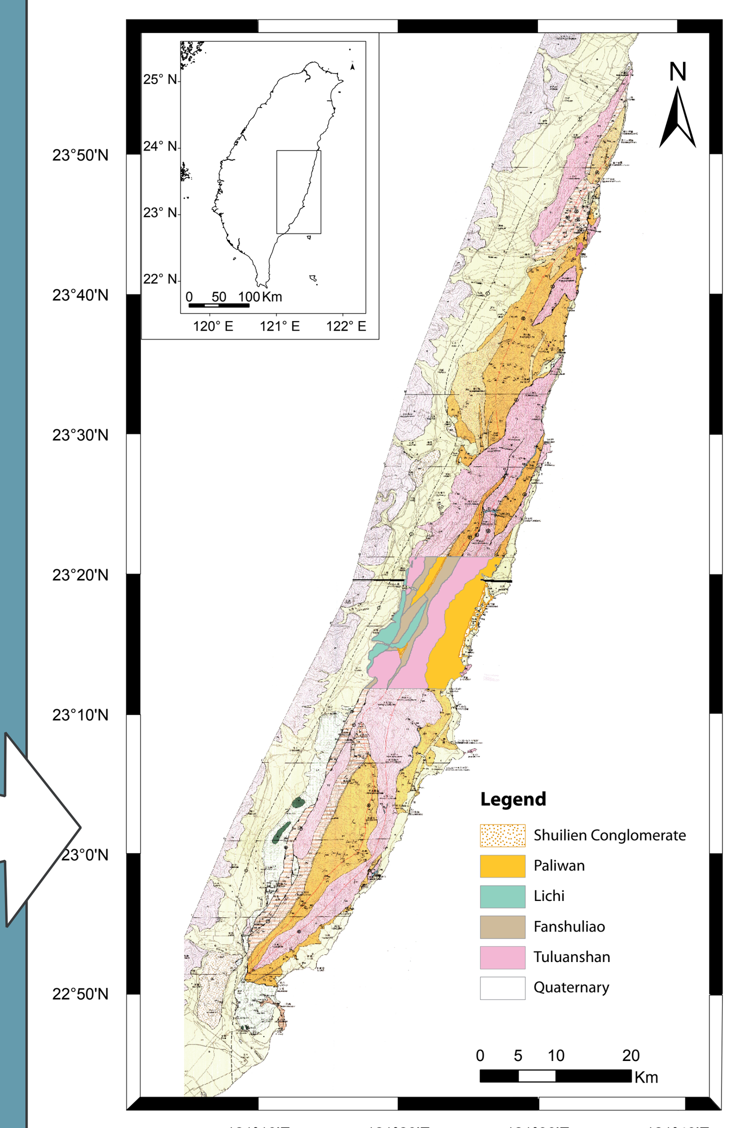


Figure 3: Geological map of Eastern Taiwan, modified from Y. Wang and W.S Chen, 1993

Stratigraphic and geochemical studies have shown that the Costal Range is composed of three accreted Miocene-Pliocene volcanic islands, three remnants of PLio-Plesitocene forearc basins, two intra-arc basins, and the Pliocene collision Lichi mélange. The accreted Miocene-Pliocene volcanic islands (north to south: Yuehmei, Chimei and Cheng-kuangao) are composed of andesite, agglomerates and tuff of the Tuluanshan Formation, whereas the remnant forearc basins (Shuilien, Loho and Taiyuan) and the intra-arc basins (Chingpu and Chengkung basin) are filled with turbidites derived from the accretionary prism and the volcanic islands. TheTakangkou formation, which represents the sedimentary facies of the Coastal Range is usually subdivided in two stratigraphic layers, the Fanshuliao and the Paliwan formations, reflecting the variation of sedimentary sources with time. Finally, the Lichi mélange is believed to have a tectonic collision origin, where the matrix is the intensely deformed forearc basin strata and the exotic are either coming form the surrounding formations (sedimentary facies and arc products) or represent the oceanic basement .

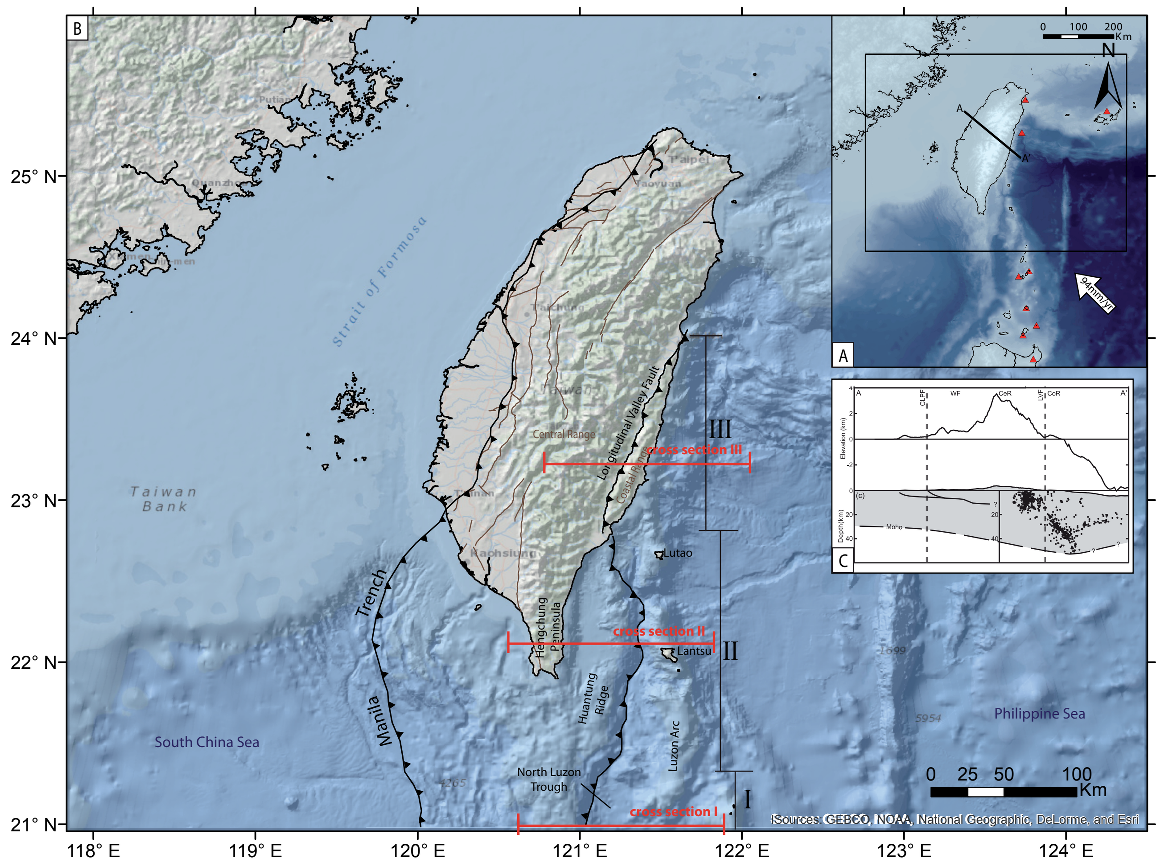


Figure 4: Shaded relief map showing regional tectonic of Taiwan.

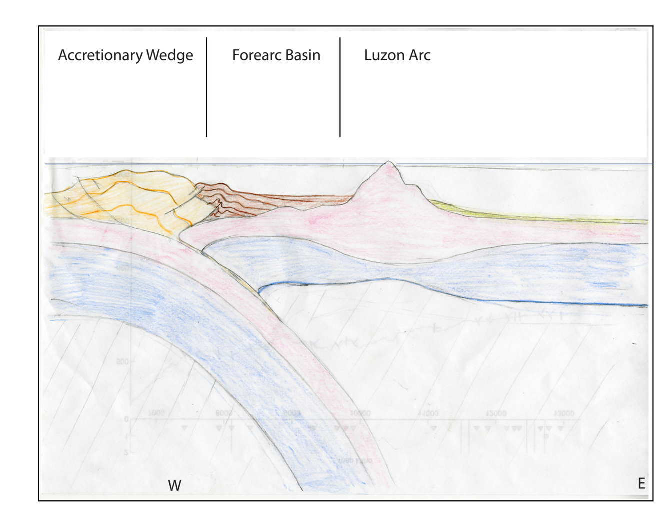
A] Off shore bathymetry. Location of the three tectonic profiles shown in Figure 5 (red lines). The black lines A-A' represents the topo profiles shown in C] and red triangles are the current volcanoes of the Luzon Arc.

B] Regional Tectonic of Taiwan. The South China Sea crust subducts beneath the sea plate along the Manila Trench, leading the formation of the Luzon Arc. The Henchung Peninsula represent the exhumed accretionary prism. North of 21°N the North Luzon Arc collied obliquely with Eurasian continent. The collision resulted in deformation of the western part of the North Luzon Trough (forearc basin) creating the Huatung Ridge with backthrusting eastward. The Luzon Arc and its forearc basin are ultimately accreted on eastern Taiwan, forming the Coastal Range.

I : intraoceanic collision zone. II : intial arc-continent collision. III : advanced arc-continent collision

C] Topographic and seismic profiles across Taiwan along line A-A' from Shyu et al., 2006.

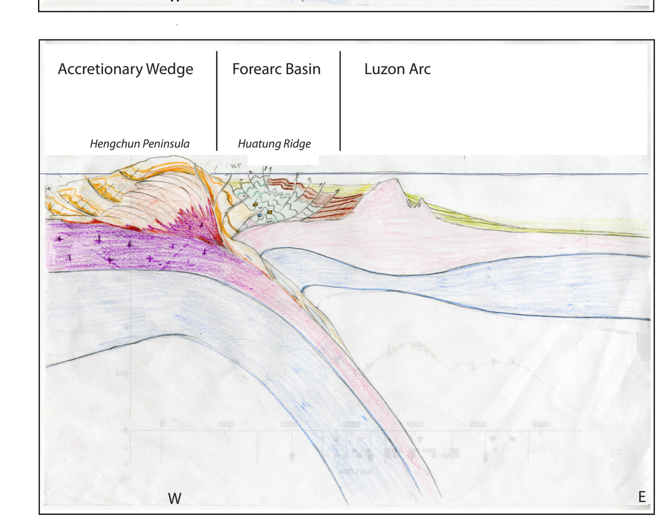
Figure 5: Tectonic sketching on the formation of the Coastal Range



(I) 12 Ma : Intra-Oceanic Subduction Stage
(or present south of 21° N)

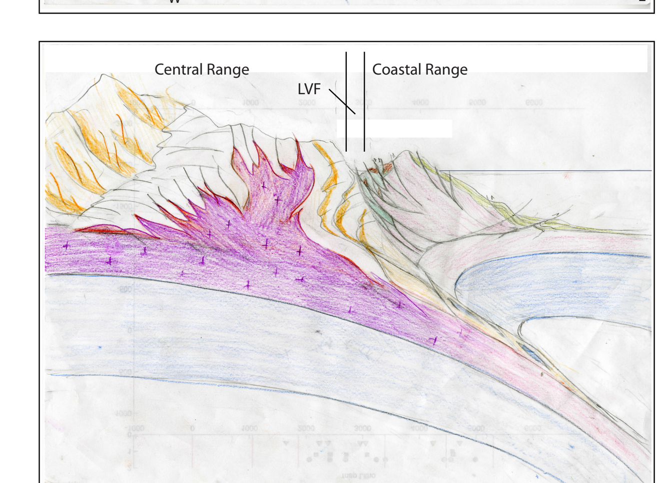
Rifting of the Eurasian continent in Oligocene to middle Miocene (opening 32-17 Ma) gave rise to the formation of the South China sea. According to radiometric dating, it was quickly followed by the eastward subduction of this basin, beneath the Philippine Sea plate along the Manila Trench, leading to the creation of the volcanic Luzon Arc. From Early Miocene (perhaps late Oligocene) to late Miocene, arc magmatism brought thick sequences of Tuluanshan volcanics and sediment off-scraping, filling up the forearc basin. As observed now south of 21° N, once the sediments are deposited in the Luzon trough, the sequence is synchronously deformed and then unconformably overlain by new sequences.

Legend
- East Arc basin
- Lichi Mélange
- Foreac Basin
- Accretionary Wedge
- Arc / oceanic crust
- Continental crust
- Lithosphere



(II) 5 Ma : Initial Arc-Continent Collision
(or present 22° 2'N)

The initiation of the arc-continent collision starts with the closure of the forearc basin leading to the formation of the Lichi mélange. As the same time, as the subduction continues, more and more continental sediments are added in the accretionary prism which is finally exhumed, providing a new source of deposits for the forearc basin. Cessation of volcanism is also a good marker of the earliest stages of the collision. We observe a progradation north to south : Chimei 8-5 Ma based on nanofossils and 3.3 for Chenkuangao based on fission track. Consequently fringing reefs start to grow on volcanic islands providing a good maker for the termination volcanism. The oldest Kankgou limestone on Chimei volcanic island has been dated to 5.2 Ma and Tungho Limestone in the south, on the Chengkuangao complex returned an age of 2.9 Ma. Based on those observations, it is reasonable to think that the initial arc-continent collision must have begun ~ 8 Ma ago and at 5.2 Ma it had already reached 23°5N.



(III) Present : Advanced Arc-Continent Collision
(or present north of 23° N)

The westward thrusting and accretion of the Luzon Arc and forearc sequences onto the Asian continent conjointly with the exhumation of meta-morphic basement in the Central Range mark the final stage of the arc-continent collision. This stage should be younger than the youngest strata found on the forearc basin sequences. Bio- and magnetostratigraphic tell us that Coastal Range formations must have been accreted roughly 1.5 Ma in the north and 1.1 Ma in the south.

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