

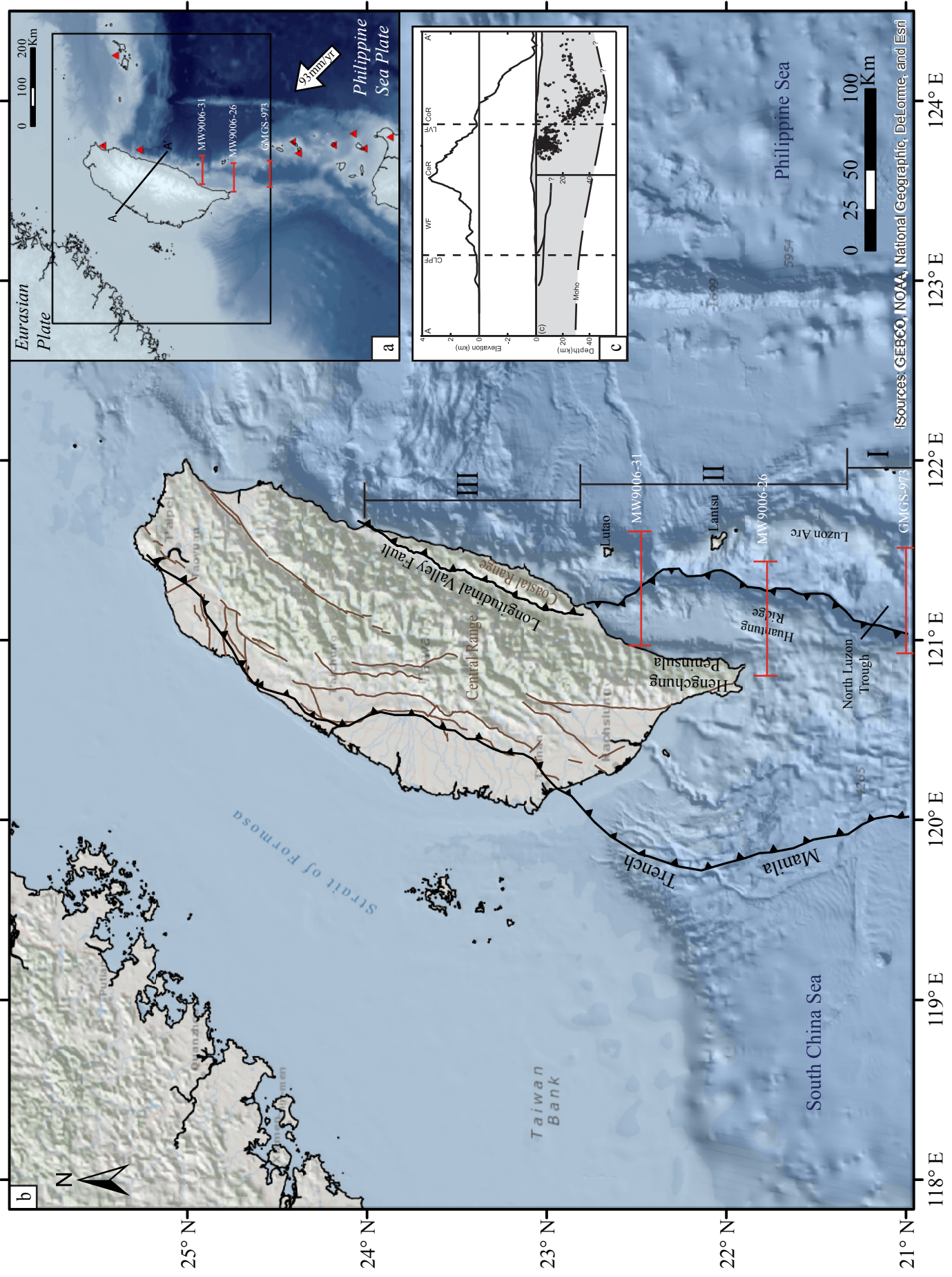
# Chapter 1

## Geological and plate tectonic setting of the Longitudinal Valley Fault

### 1.1 Tectonic setting of Taiwan

The Longitudinal Valley fault runs parallel to the East coast of Taiwan and is one of the major active faults accommodating the present day 9 cm/yr convergence rate between the Eurasian and the Philippine Sea Plate (Figure 1.1a). South of Taiwan this convergence is absorbed along the Manila trench by the eastward subduction of the oceanic crust of the South China Sea beneath the Philippine Sea Plate, leading to the creation of the Luzon volcanic arc (zone I in Figure 1.1b and section (a) in Figure 1.2).

Figure 1.1: Bathymetry (See next Page). Shaded relief map showing regional tectonic setting of Taiwan. (a) Off shore bathymetry. Location of the three E-W seismic profiles shown in Figure 1.3 (red lines). The black line A-A represents the topographic profiles shown in (c) and red triangles are the currently active volcanoes of the Luzon arc. (b) Regional Tectonic of Taiwan. The South China Sea crust subducts beneath the Philippine Sea Plate along the Manila Trench, leading to the formation of the Luzon arc. The Hengchun Peninsula represents the exhumed accretionary prism. North of 21°N, the North Luzon arc collided obliquely with the Eurasian continent. The collision resulted in deformation of the western part of the North Luzon Trough (fore-arc basin), creating the Hualien Ridge with backthrusting eastward. The Luzon arc and its forearc basin are ultimately accreting on eastern Taiwan, forming the Coastal Range. I-intraoceanic collision zone. II-initial arc-continent collision. III-advanced arc-continent collision. (c) Topographic and seismic profiles across Taiwan along line A-A line from *Shyu et al.* (2006).



Sources: GEBCO, NOAA, National Geographic, DeLorme, and Esri

In Taiwan, the continental shelf of South China has now entered the subduction, resulting in a collisional orogeny, at the origin of the formation of the Taiwan Island (e.g., *Barrier and Angelier*, 1986; *Teng*, 1990; *Chang et al.*, 2001; *Malavieille et al.*, 2002; *Huang et al.*, 2006a; *Simoës et al.*, 2007b). The Hengchun Peninsula, at the southern tip of Taiwan, represents the exhumed accretionary prism. North of 21°N, the North Luzon arc collided obliquely with Eurasian continent. The collision has resulted in deformation of the western part of the North Luzon Trough (forearc basin), creating the Huatung Ridge with backthrusting eastward (see seismic profiles in Figure 1.3 and section (b) in Figure 1.2). The Luzon arc and the forearc basin have ultimately been accreted onto eastern Taiwan over the last 5 Ma (*Chang et al.*, 2001; *Huang et al.*, 2006a), forming the Coastal Range (Figure 1.4). As the collision developed, the deformation of the continental passive margin of the South China Sea led to the exhumation of its metamorphic basement, forming the core of the Central Range (section (c) in Figure 1.2). The Longitudinal Valley Fault marks the western border of the Coastal Range and is generally interpreted to form the suture zone between the continental margin of South China and the Luzon arc.

The next section provide some background information on the geography and stratigraphy of the Coastal Range.

## 1.2 Coastal Range

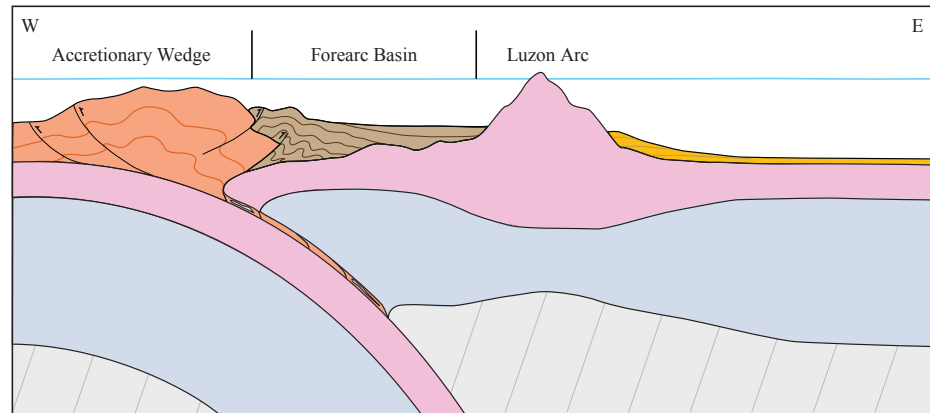
### 1.2.1 Physiography: location, relief and drainage system

The Coastal Range is a narrow trending NNE between Hualien (north) and Taitung (south) along the eastern coast of Taiwan. The range, quite straight and uniform in width, is roughly 150 km long and the average width is about 15 km. The Coastal Range faces the Pacific Ocean to the east and is separated from the Central Range to the west by the narrow (about 4 km) Longitudinal Valley (Figure 1.5).

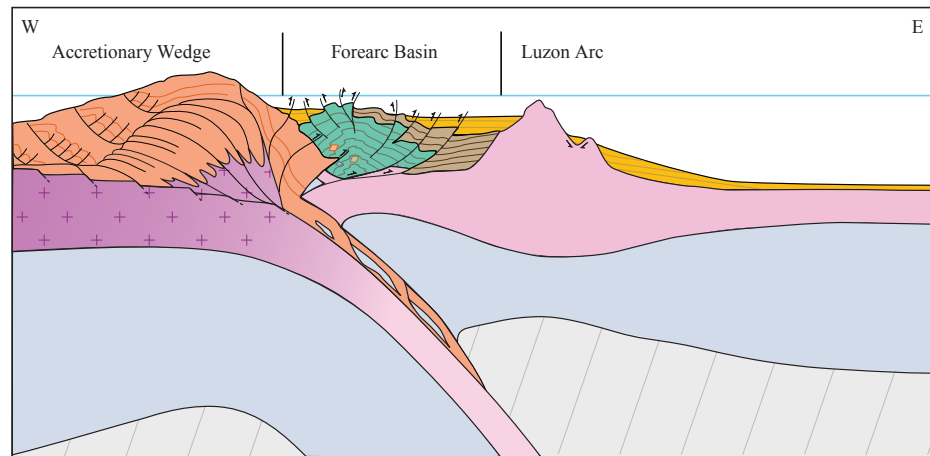
The Coastal Range, extending from 22°46'N to 23°56'N in latitude and 121°10'E (southern extremity) to 121°37'E (northern extremity) in longitude, can be subdivided into three main geographic domains (*Hsu*, 1956). The northern part, north of the Hsiukuluan river, is the lowest in elevation. The highest peak, Paliwanshan, reaches only 922 m in altitude. The central part, between the Hsiukuluan river and Chengkung city, encompasses the highest peaks of the Coastal Range, among which Hsinkangshan (1682 m) reaches the highest elevation in the whole range. The southern part extends from Chengkung to Taitung city. In this area, all the peaks but Tuluanshan (1190 m) are below 1000 m in elevation (*Hsu*, 1956) (Figure 1.5).

There are two main drainage systems in the area: the Longitudinal Valley system and the coastal system. The Longitudinal Valley system consists of several subsequent rivers with tributaries mainly from the Central Range. The three main rivers of this system are the Hualien River, the Peinan

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



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



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

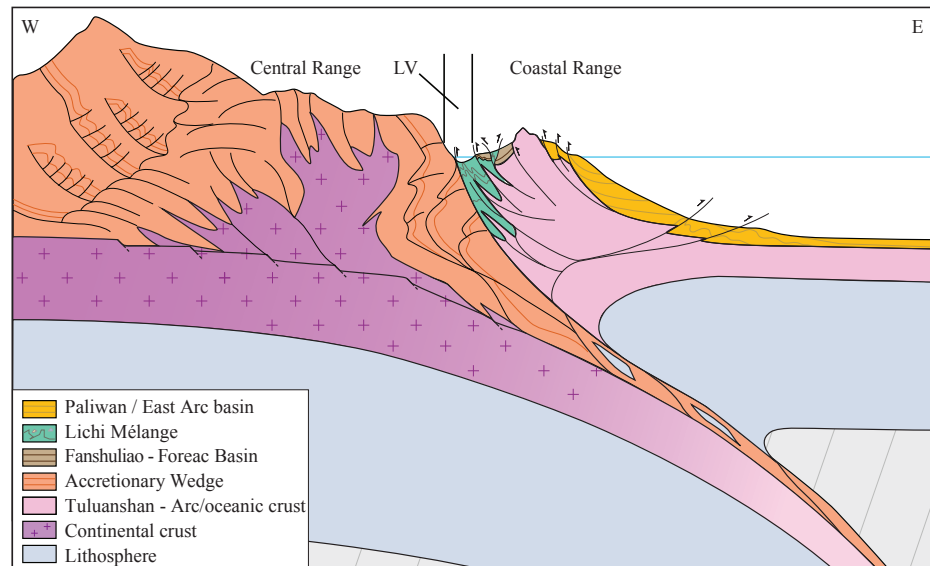


Figure 1.2: Tectonic sketching on the formation of the Coastal Range. (a) Tectonic setting at 12 Ma (or present south of 21°N): intra-oceanic subduction stage. (b) Tectonic setting at 5 Ma (or present 22°2'N): initial arc-continent collision. (c) Current tectonic setting (or present north of 23°N): advanced arc-continent collision. See chapter 3 for the stratigraphic and structural observation used to substantiate these tectonic scenari. The sections (a), (b) and (c) correspond, respectively, to zones I, II and III in Figure 1.1.



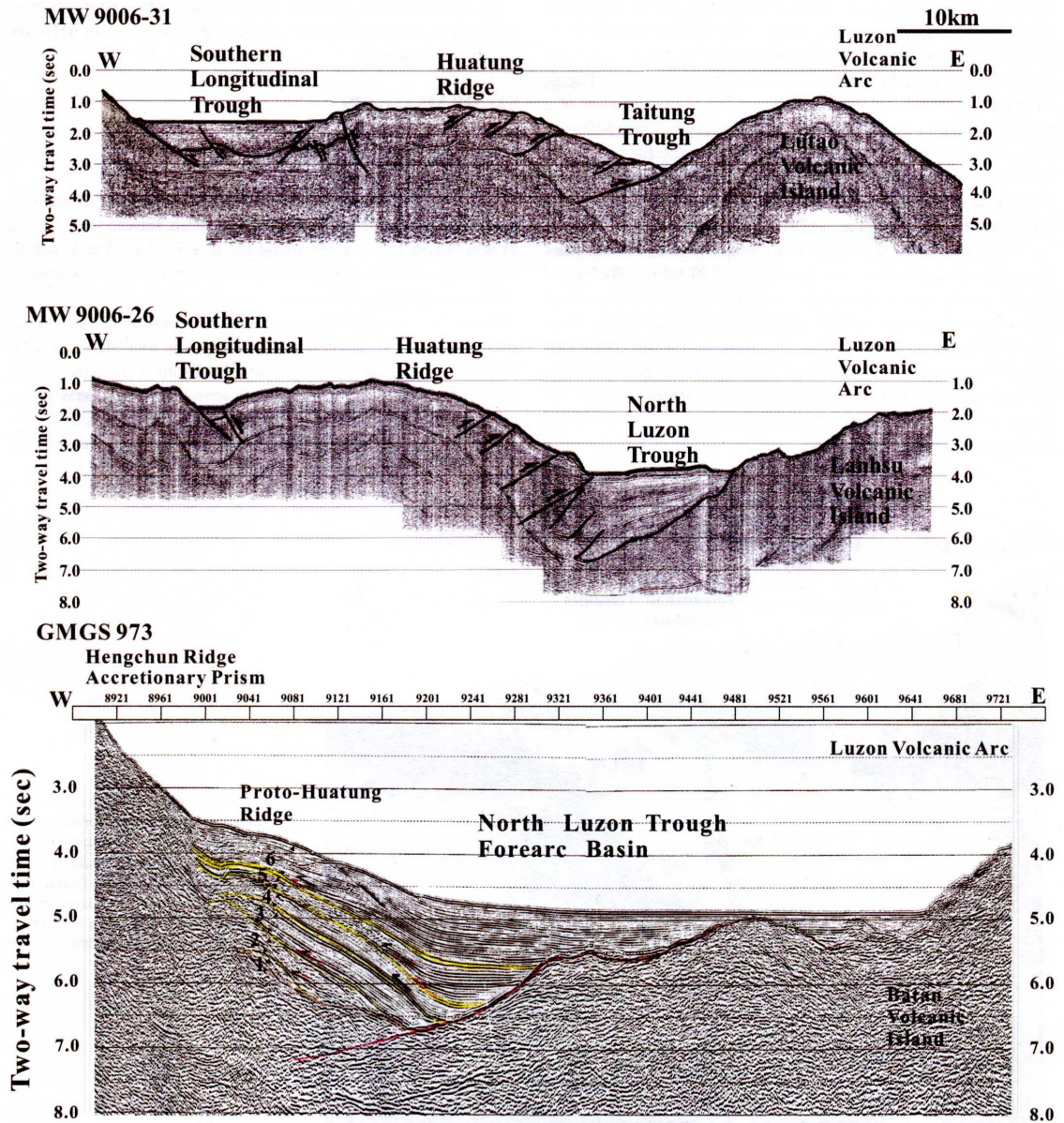


Figure 1.3: Three seismic profiles, from north to south (see Figure 1.1 for location) showing progressive formation of the Huatung Ridge and closure of the North Luzon forearc basin. Line GNGS973 further revealed syndeformational sedimentation in the North Luzon Trough, with six sequences of strata separated by five unconformities. Profiles from *Huang et al.* (2008)

River and the Hsiukuluan River (Figure 1.5). The Hualien River flows north along the valley until it reaches the Pacific Ocean in Hualien while the Peinan flows south to Taitung. The Hsiukuluan River, which drains the middle part of the valley low into the Pacific Ocean at Takangkou. The rivers on the eastern slopes of the Coastal Range form the Coastal Range drainage system and flow directly toward the Pacific Ocean.

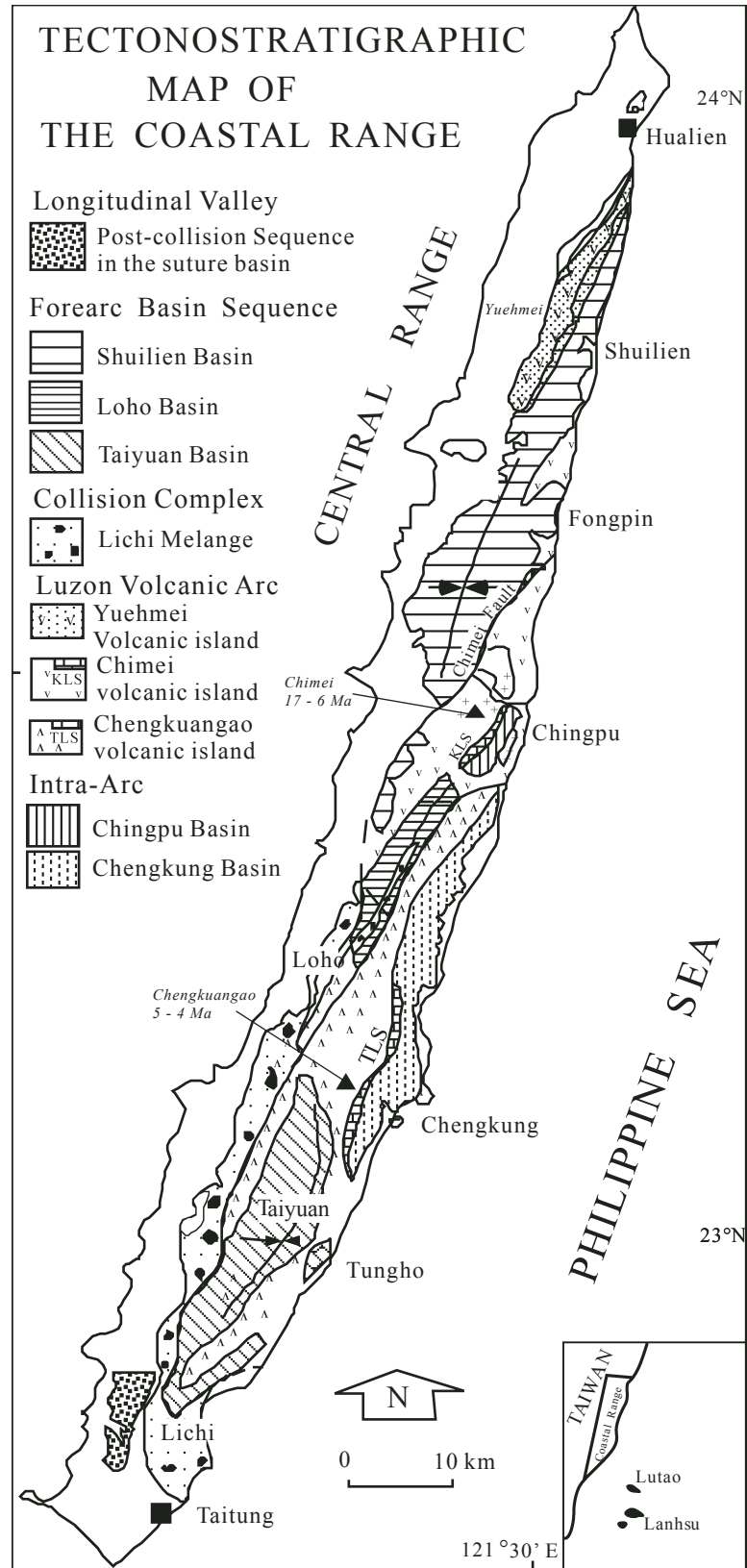


Figure 1.4: Tectonostratigraphic map of the Coastal Range, showing three accreted volcanic islands, three remnant forearc basins, two intra-arc basins, and the Lichi Mélange (modified from *Huang et al.* (2006a)). Age data on the volcanic sequences compiled from *Yang et al.* (1988), *Chen et al.* (1990) and *Lo et al.* (1994).

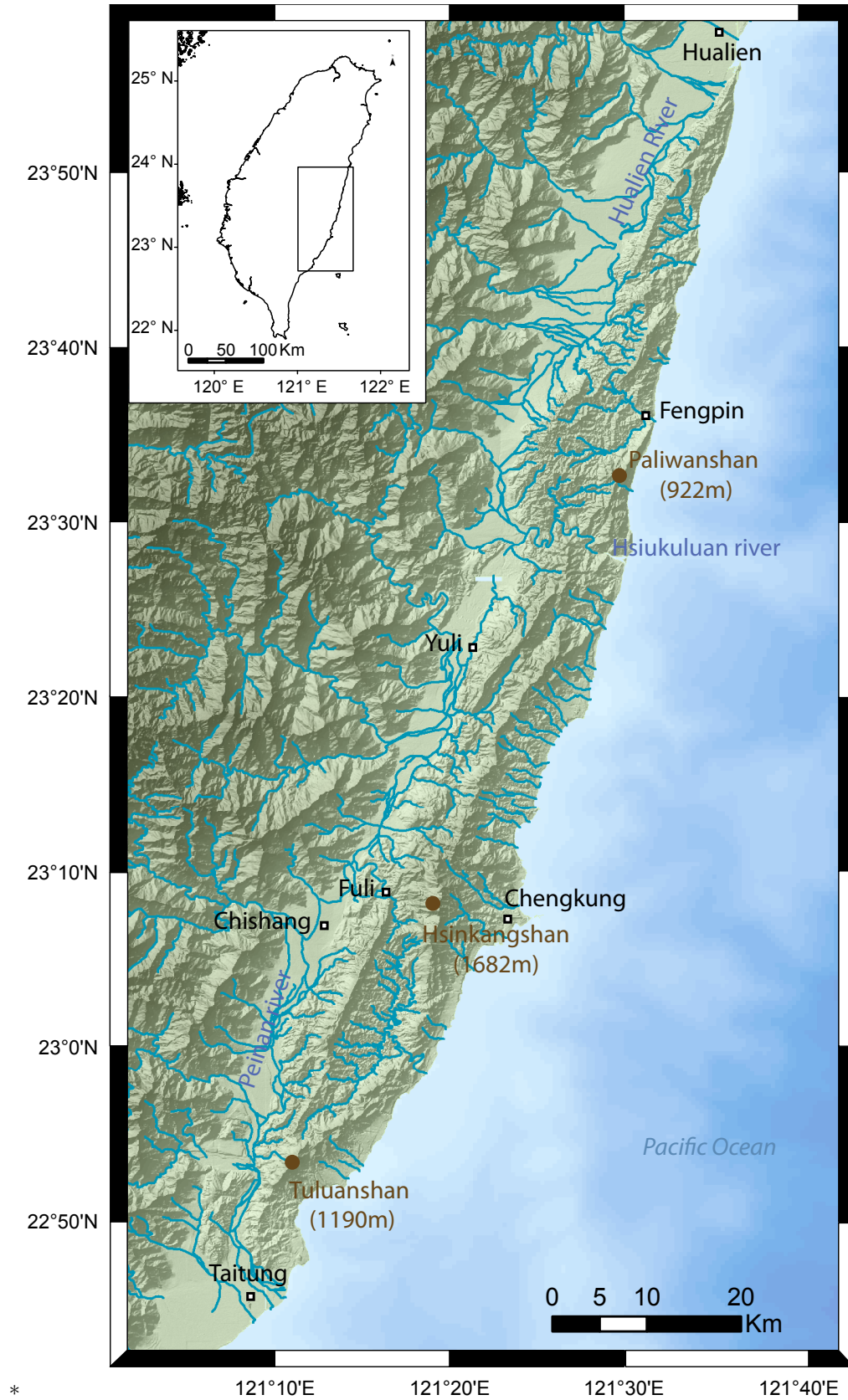


Figure 1.5: Geographic map of the Longitudinal Valley in Taiwan. Main towns are located by black squares, and the highest peaks in the Coastal Range are indicated on the map through brown circles. Blues lines correspond to the drainage system.

### 1.2.2 Stratigraphy of the Coastal Range

Stratigraphic and geochemical studies have shown that the Coastal Range is composed of formations from three accreted Miocene-Pliocene volcanic islands, three remnants of Plio-Pleistocene forearc basins, two intra-arc basins, and the Pliocene collision Lichi Mélange (*Huang et al.*, 2006a, 2008) (Figure 1.4). Five rock units can be distinguished in the Coastal Range: the Tuluanshan arc formation, the Fanshuliao volcanoclastic deposits and the Lichi Mélange can be grouped as the pre-collision island-arc lithofacies, whereas the Paliwan lithic flysch and the Peinanshan and Wuho conglomerates (molasse) are the latter two syn/post-collision lithofacies (Figure 1.6).

The accreted Miocene-Pliocene volcanic islands (from 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 (*Huang et al.*, 1992, 1995, 2008) (Figures 1.4 and 1.6). The Takangkou formation, which represents with the Lichi Mélange 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.



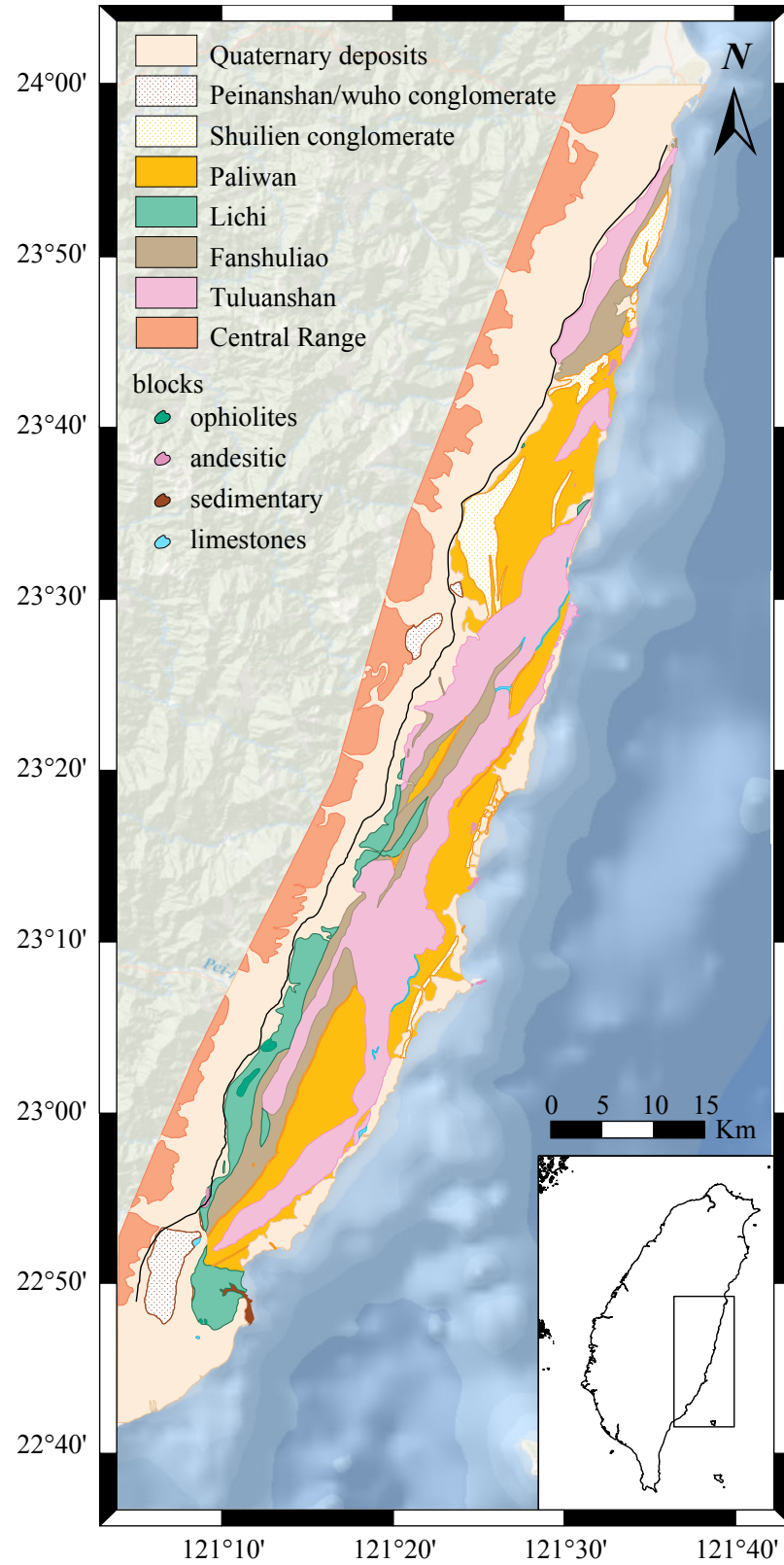


Figure 1.6: Geological map of Eastern Taiwan, modified from *Wang and Chen (1993)*, based on field work detailed in chapter 3. Continuous black line shows trace of Longitudinal Valley Fault.