# The Physical Geography of Eastern Taiwan: Its Natural Setting

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The formation of Taiwan is based on the collision of two tectonic plates, namely the collision between the Luzon Arc of the Philippine sea plate and the Eurasian continental plate. The Luzon Arc consists of a chain of volcanoes extending north-south across the Luzon Strait from Taiwan and includes Green Island, located about six miles off-shore of Taitung.

**Figure 1a: Looking east towards Green Island**

This collision is quite complex. For example, the westward movement of the Philippine sea plate results in its subduction underneath the Okinawa platelet (a minor continental tectonic plate that stretches to the northern end of Taiwan), and the Eurasian plate along a contact zone extending seaward (due east) from Taroko Gorge~~,~~ as shown in **(Figures 1b and c)**. The east side of the platelet forms an ongoing convergent boundary with the Philippine sea plate. Meanwhile, the Philippine sea plate strikes southeast Taiwan at an oblique angle and overrides the continental plate. Further south, the Eurasian plate subducts underneath the Philippine sea plate.

Taiwan is one of the few islands that has a convex surface that faces inland towards the Asian continent, comprised mostly of marine rock from the Tertiary period (Lin et al. 1974). As the two ongoing plates collide, they create cracks and fissures in the Earth's surface known as faults that possess varying degrees of vertical and horizontal movements.

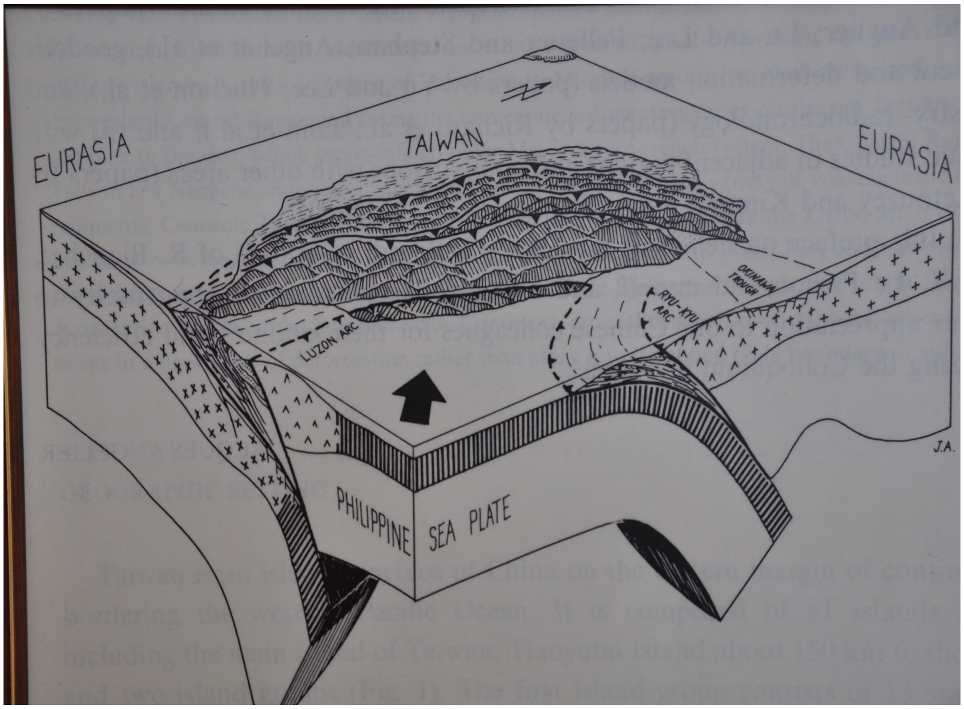


**Figure 1b. Taken from the "Southern Geology Museum of Taiwan." A tectonic cross-section of the Philippine sea plate undercutting the Eurasian continental plate. bending it in the north, subducting under the Okinawa platelet. The left lateral motion is shown in the graphic. Notice how the Central Mountain Range aligns with the fault zone.**


**Fig.1c: The red line is rough location of the subuction zone between the Okinawa Platelet and the Philippine Sea Plate. The train is heading north into a tunnel because the left lateral fault ends. Due west: Taroko Gorge (Mitchell 2019)**

Taiwan's Coastal and Central Ranges are an immediate result of these colliding plates. Metamorphism increases from west to east across the Taiwanese ranges due to the immense amount of compression from the Philippine sea plate with the marble formations at Taroko Gorge National Park being the most notable. This compression creates new mountains on the surface of Taiwan and has a maximum uplift of about 0.5 cm a year **(Figurea 2a and b).**

**Figure 2a: Exposed Marble at Taroko National Park**

**Figure 2b: Notice the sharp dip in the sedimentary strata of the Coast Range with the strike aimed north towards the subduction zone off Hualien (see Fig 1c)**

The mountain belt mostly grows by frontal accretion and internal thickening, caused by the imbricate thrust and fold belts. Accreted terranes, also known as suture zones, are fragments of crustal material formed on or broken off a tectonic plate and accreted to crust laying on a different plate. The zone of attachment, suture zone, is usually identifiable as a fault. In Taiwan's case, the suture zone of the two colliding plates is known as the Longitudinal Valley, shown in **(Figure 2c)** and is dominated by a left lateral strike/slip fault extending north/south along the interior base of the Coastal Mountain Range.  Several other faults branch off this left lateral fault creating a family of faults possessing varying amounts of vertical offsets (thrust faults) and horizontal offsets (lateral faults), a situation mimicking the San Andreas fault zone in western North America.


The trunk stream follows the left-lateral fault that separtes the Philippine Sea Plate from the Eurasian

**Figure 2c.  Photo showing a view of the Longitudinal Valley created by the left lateral fault, due to the collision of the Philippine Sea Plate and Eurasian Plate. This fault also controls the orientation of the trunk stream that flows to the south.**

The Taiwan Orogen is divided into four north-south tectonistraphic zones separated by faults. Starting from west to east these are: (1) Western Foothills, (2) Hsuehane Range, (3) Central Range, and the (4) Coastal Range. Located on the Asian side of the Taiwanese mountain belt, the Western Foothills are dominated by strike slip faults and consists of Eocene through Miocene clastic sediments (Brown 2012). The Hsuehane Range possesses a complex pattern of different fault types. For example, in northern Taiwan the range is made up of strike slip faults with minor thrusts consisting of thick bedded, coarse grained to pebble conglomerate, quartzite and argillite, which dates from the Eocene and Oligocene (Ramsey 2007).

The Central Range forms the main body of Taiwan. Maximum uplift rates occur in the northern part of the Central Range and decrease gradually to the south. West of the Central Range, meta-sediment metamorphic grades increase. The age of the metamorphic rock, consisting of marble and schist, is late Mesozoic and early Paleozoic (Brown 2012). Elevations in the Central Range crest at over 12,500 ft (3,860 m). Indeed, these mountain summits are high enough to result in vertical zonation (elevation substitutes for latitude) and some experience occasional winter snowfalls despite possessing a tropical and subtropical latitudinal location.

Dominated by sandstone, mudstone and turbidites, the Coastal Range that consists of accreted segments of the Luzon volcanic Arc.  The turbidites are sea bottom deposits formed by massive slope failures. Elevations are more modest, cresting at 5,500 ft (1,680 m) with highest elevations found in the southern part of the range.  Thickly vegetated, these slopes consisting of softer volcanic and sedimentary rocks, are easily eroded when the vegetation is removed yet form the basis for fertile soils in the intervening valleys of the Coast Range **(Figure 3)**.

**Figure 3a:  Coast Range of eastern Taiwan**

**Fig. 3b: An orchard amidst exposed slopes**

In between the Central Range and the Coastal Range lies the Longitudinal Valley, a narrow tectonic suture zone between the Luzon Island Arc and Eurasian continental margin **(Figure 4)**. This valley separates the Mesozoic meta-sediments of the Central Range from the turbidites and volcanoes of the Coastal Mountain Range. This suture zone follows the western edge of the Coastal Range, which is fronted by a series of small hills consisting of mélange. The Longitudinal Valley is dominated by a left lateral strike/slip fault that moves roughly 20 mm/yr per year (Shyu 2006). This fault controls the drainage of the two main truck streams, one of which flows north through about 2/3 of the valley and the other flows south **(Figures 3 and 5).** They are separated by a small interfluve, suggestive of how the San Joaquin River is separated from the Tulare basin in California's Central Valley. Possessing alluvial soils derived mostly from the Central Range, the Longitudinal Valley supports an agricultural base consisting of rice and sugarcane with limited amounts of tea grown on the slightly elevated mélange areas fronting the eastern margins and lower slopes of the Coastal Range **(Figure 6)**.

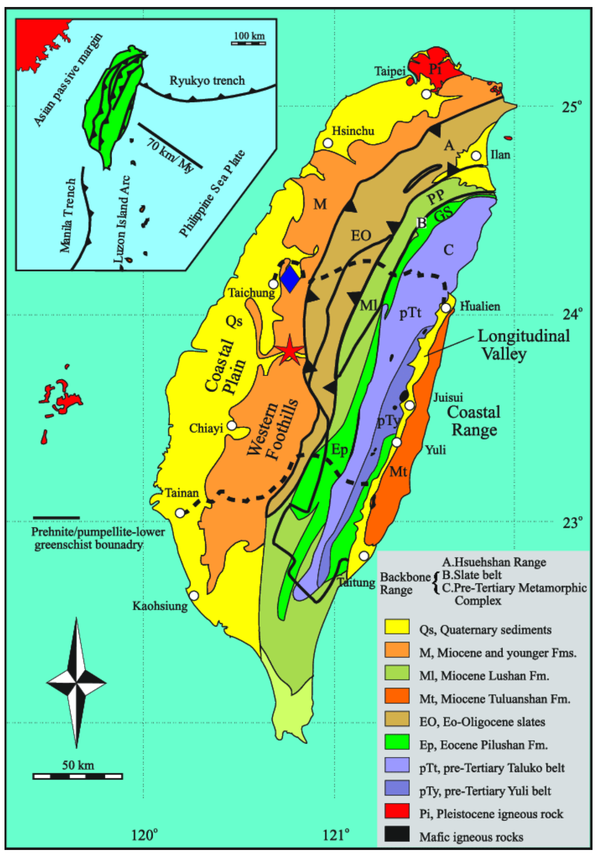


**Figure 4:_Map taken from Penn State, showing the location of the Western Foothills, Central Range, Longitudinal Valley and Coastal Range with the relative age of the prehistoric rock.**


**Figure 5: Trunk stream flowing north along the left lateral strike/slip fault in the Longitudinal Valley. Note the mélange and the Coast Range**

**Figure 6a: Planting Rice in the Longitudinal Valley.**

**Figure 6b: Sugarcane in the Longitudinal Valley.**

**Figure 6c: Tea on slightly elevated mélange**

**Figure 6d: Rice amidst the Longitudinal Valley**

Taiwan's climate is influenced by its latitude, elevation changes and a seasonal shift in the East Asian Monsoon (EAM), with the latter being superimposed the former. The island sits on the Tropic of Cancer, 23.5ºN, making the north and south have two different climatic zones **(Figure 7).** The region that lies south of the Tropic of Cancer, 23.5ºN, experiences a tropical climate, whereas Northern Taiwan possesses a sub-tropical climate zone. Overall, one would experience hot and humid summers, with cool to mild winters at elevations below 2,000 feet, which is where the bulk of the population resides. Affected more strongly by the winter monsoon, the northern winter season receives most annual precipitation with Taipei averaging 81.3" per year as compared to Taitung at 74" per year (en-climate.org). The eastern slopes of the island receive the most precipitation, making subtropical evergreen forests flourish in this environment. This environment is the first eco-region of Taiwan.


**Figure 7: Photo taken by GraphicMaps, showing the Tropic of Cancer intersecting Taiwan. Northern Taiwan has the coldest winters.**

As noted, Taiwan is affected by the East Asian Monsoon (EAM), which is divided into warm and wet summer and cold but drier winter. The summer version of the EAM starts in May and extends through October with the wintertime version running from November through April (Dunn 1993). The EAM is considered a “sea-breeze” monsoon because of the differential heating rates between the land and ocean. For example, during the summer months these differential heating rates result in a high-pressure cell forming over the cooler ocean and a thermally driven low- pressure cell forming over the land because of more intense convectional lifting (Tung 2020). Consequently, the pressure gradient extends inland and the prevailing wind blows onshore advecting high dewpoints (> 70°F) associated with the maritime tropical-unstable (mTu) air mass (Farnsworth 2019) **(Figure 8).**

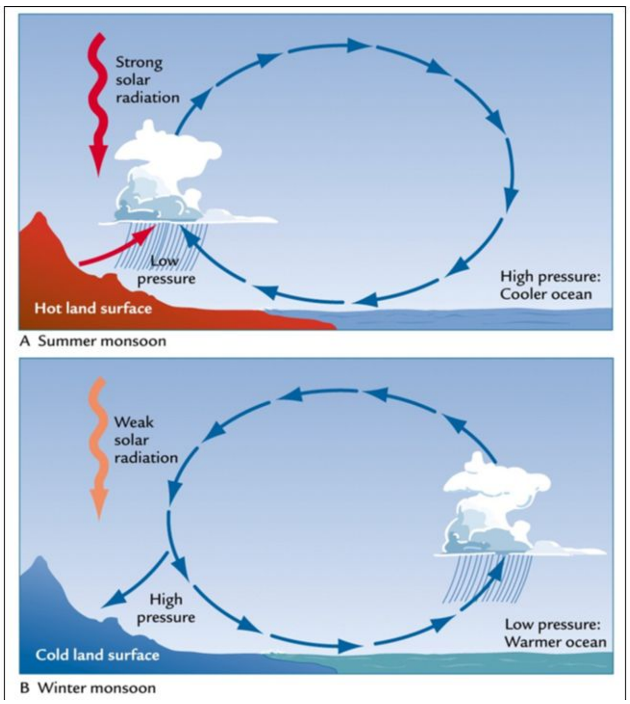


**Figure 8: A simple diagram showing the formation of a summer monsoon and a winter monsoon. The diagram helps explain the circulation of air flow and differing sea surface temperatures/land surface temperatures that generate strong monsoons.**

Typhoon season is also a factor during the summer, particularly from June through October with Taiwan averaging about 3-4 typhoons per year (Wu and Kao 1999). When making landfall, typhoons associated with the EAM result in the torrential rains as they are subjected to additional convective and orographic lifting. For example, from Taipei in the north through Taitung in the south, summer precipitation ranges from 53” to 58” which equates to 65% and 79% of the annual total, respectively (en-climate.org). Hualien is heavily impacted by typhoons in

September, which accounts for its long-term average of 385 mm/15.2” of rainfall (highest monthly total on the east coast).

The heavy rains due to the summer EAM bring flooding while Typhoon induced storm surges further disrupt the island. Precipitation rates are highly influenced by steep terrain, which is mostly dominated by the slopes of the Central Range. The southwesterly winds and mountain ranges produce more rainfall which results in rapid runoff. Possessing wide channels that are braided most of the year because of the course alluvium deposited by surges of runoff both during and immediately after heavy rain events associated with severe thunderstorm or typhoons, their stream profiles resemble Saharan wadis or desert arroyos of the U.S. Southwest **(Figure 9).** Indeed, stream channels in the uplands are often choked with heavy boulders and the like that can only result from episodic and intense fluvial dissection **(Figure 10)**.

The winter monsoon occurs during the months of October to April and occurs when the air current reverses, making it flow in the opposite direction (Dunn 1993) **(Figure 8)**. Generally, westerlies prevail. The winter monsoon is less powerful than the summer monsoon due to reduced surface convection and the presence of more stable air masses originating over the Asian continent. As such, Taiwan experiences a drier winter monsoon season with a stronger precipitation and temperature gradient extending from south to north. For example, the winter version of the EAM results in only 15.9” of precipitation in Taitung (21% of the annual total), as clouds, mist and light rains with moisture originating from the South China Sea. However, further north in Hualien and Taipei, the winter EAM yields 23.7” (30% of the annual total) and 28.4” (35% of the annual total), respectively as middle latitude circulation regimes strengthen, and frontal lifting becomes somewhat more dominant as an offset to reduced surface convection.

Southern Taiwan experiences a tropical climate zone (Koppen Am). This zone has mild pleasant winters with hot, humid and rainy summers, with conventionally driven thunderstorms, punctuated by typhoons. The surrounding ocean has a cooling effect along the east coast from the “sea-breeze” brought onshore. However, this breeze has limited impact inland because of the Coastal and Central Mountain Ranges. Strongly influenced by the East Asian Monsoon (EAM), southern Taiwan receives nearly 80% of its annual precipitation during the summer season. Consequently, the second ecoregion found in the southern tip of Taiwan consists of monsoon rainforests.

**Figure 9: Braided stream in the Longitudnal Valley, Central Range background**

**Figure 10: Large boulders amidst a Coast Range stream (about 20 miles north of Taitung)**

Climate in Taiwan affects the ecosystems that thrive on the slopes of the mountain ranges. Vertical zonation is a term used to describe how elevation substitutes for latitude as one moves up or down a mountain. Moving upslope temperatures and absolute humidity decrease as precipitation increases. Climate, soil and natural landscape types tend to occur in altitudinal zones that are generated by the atmospheric circulation system and the impacts of elevation on the climatic variables just noted. As Taiwan is a mountainous island, it experiences an abundant amount of vertical zonation. Taiwan experiences two bio-climates consisting of: (1) Warm tropical and temperate evergreen broad-leaved forests, also known as "Laurel Forests," and (2) Temperate deciduous forests with conifers, which are found in the humid uplands of the mountain ranges (Box 2013). Tropical and temperate evergreen forests dominate the lowlands of the Taiwanese mountains, including the whole of the Coastal Range with its lower summits. Ascending the slopes of the Coast Range, the laurel forests sits immediately above the tropical evergreens.

Taiwan can be further divided into six categories of forests based on whether they are zonal or azonal. Zonal forests are influenced by climatic factors, hence the role of elevation, while azonal forests are influenced by non-climatic factors. A mangrove forest is a good example of an azonal forest, where soil and water conditions comprise the primary locational factors (Box 2013). Ascending the Taiwan's higher Central Range where temperature drops about 6°C/km (11°F/3,3000 Ft), the forest zones based off of these five climatic ranges, yield the following vertical zones: (1) Tropical (sea level- 2,000 ft), (2) Subtropical (3,000-5,000ft), (3) Warm Temperate (5,000-7,000ft), (4) Temperate (7,000-9,000ft), (5) Cool Temperate (9,000-10,500 ft) and (6) sub-alpine (10,500-13,000 ft) **(Figures 11 and 12).**

Compared to the United States, at a 10,500 ft elevation on a Taiwanese mountain would equate to similar climate and ecosystem in the Colorado Rockies at roughly 7,500 feet. Elevations in Taiwan of around 6,000-7,000 ft, mimic a pleasant spring day in upstate New York. At elevations below 4,000 ft (especially in the summer), the climate is suggestive of an August day in Florida with very warm temperatures and dew points averaging 70º-80ºF. The highest peaks at nearly 13,000 ft will have a modest and short-lived winter snowpack, a situation not unlike the southern Appalachians of TN/NC.

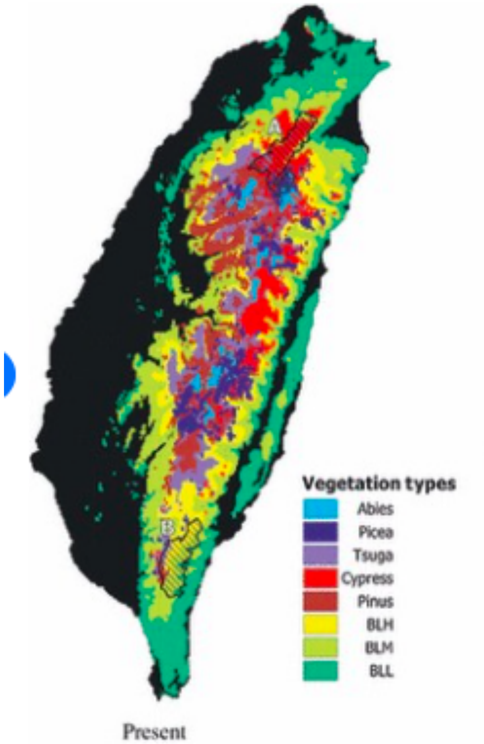


**Figure 11.** ***M*****ap taken from researchgate.net, it is displaying the differing vegetation types as you ascend the Taiwanese mountain belt. The forest type abbreviations used: (1) Lowland-broad leave forest (BLL), (2) Mid-land broad-leaved forest (BLM), (3) Highland broad-leave forest (BLH), (4) Cypress forest, (5) Pinus forest, (6) Tsuga forest, (7) Pica forest and (8) Abies forest.  Sub alpine conifer forests would contain the Abies and Picea. Shorter woodlands in drier areas would consist of the Cypress. Tsugas form at higher elevations with the Picea and Abies. The lowlands consist of laurel forests to subalpine conifer forests.**

**Figure 12: Entering the Pine forest at 7,000 feet, Upper Taroko Gorge**

**Figure13: Timberline at 10,000 feet along the Taroko summit**

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*All photographs taken by Martin Mitchell in 2014, 2016 and 2019

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