

大阿里山

地景之美

Allshan's Landscape Beauty



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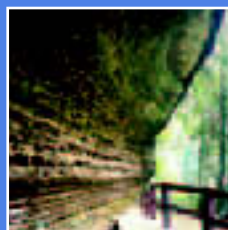
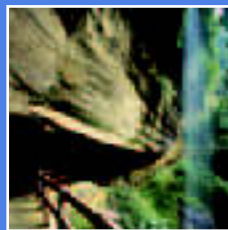
Alishan's Landscape Beauty

交通部觀光局

阿里山國家風景區管理處

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Translator's note: In Chinese, the word "shan" means mountain. It is retained here as an integral part of place names and names of mountains, following the Chinese pronunciation (e.g., "Alishan" rather than "Mt. Ali"). Notes explaining or translating other Chinese terms also appear elsewhere in the text.



處長的話

本人有幸在大阿里山國家風景區管理處工作，掌理範圍有四萬多公頃，海拔高度從數十公尺到二千多公尺不等，其中的自然與人文美景更是聞名遐邇。而這些美景不僅止於森林、日出、雲海、晚霞及小火車，還包括了山景、峽谷、瀑布、竹林、鄒族原住民等多采多姿的景觀。

走在風景區內欣賞一些著名景點時，例如：燕子崖、百年土石流遺跡、鐵達尼石、觀音瀑布、茶山大石壁等，讚嘆這些美景之際，我常常會有幾個疑問浮現：『這些景點到底是怎麼形成的？』、『為什麼會在這裡出現？』我想一定有許多遊客跟我有一樣的好奇心出現，又逢近年來遊客的旅遊需求也逐漸走向深度導覽，驅使了我們編輯這一本書。

本手冊是針對阿里山國家風景區內的地形、地質景觀資源，以深入淺出、圖文搭配的方式介紹阿里山地景之美，協助您在閱讀地景之餘，也能從陌生或熟悉的環境中感受新的事物。期盼在本手冊的導覽下，成為您在阿里山旅程中最深刻的印象之旅。

交通部觀光局阿里山國家風景區管理處

處長 鐘福松

A Word from the Director

It is my good fortune to work in the Alishan National Scenic Area office, managing over 40,000 hectares of land. The scenic Area ranges from a few meters above sea level to more than 2000 meters in elevation, with scenes of natural beauty and cultural interest known the world over. In addition to forests, sunrises and sunsets, cloud-shrouded valleys, and a famous narrow-gauge railway, even greater variety can be found in its mountains, valleys, waterfalls, and bamboo groves, and in addition, the culture of the aboriginal Tsou people.

As I walk in the scenic area and wonder at its sights—such as the Swallow Cliff, the Ancient Debris Flows site, the Titanic Rock, Guanyin Waterfall, and the Chashan Wall—I find questions coming to mind: "What formed these unique features?" "Why do they appear at this particular place?" I know many visitors have the same kind of curiosity, and their requests over the years have prompted us to provide more in-depth tours and to produce this guidebook.

This guidebook describes the topography and geology of the Alishan National Scenic Area in an easy-to-read style, with photographs and accompanying text. It will help you to "read the landscape", and even those already familiar with the area will be able to find something new. We hope this guidebook will help make your time in Alishan one of your most memorable travel experiences.

Alishan National Scenic Area Office
Tourism Bureau, Ministry of Transportation
and Communications

Jason Chung, Director

一、前言

阿里山國家風景區觀光資源豐富，具有山岳、河谷、瀑布、原住民文化、田野風光、新興活動等多樣化的遊憩資源，素以「青山綠水、日出饗宴、雲海漫遊」聞名。民國90年7月管理處正式成立後，即積極開發以主題遊程為導向的多元優質旅遊，並出版各種簡摺、手冊，以提供旅遊資訊和提升旅遊品質。

大自然的美通常不需要媒介，人們便能領會，但當念頭中興起了「是什麼」、「為什麼」或「為何如此」等疑問時，常常就需要更多的訊息才能滿足這份好奇！而地形與地質是構成自然美景的基本要素，也述說著大地的故事。

本解說手冊是針對阿里山國家風景區內的地形、地質景觀資源，以深入淺出、圖文搭配的方式加以介紹。首先說明本區所在位置與交通概況，進而介紹全區地質和地形背景，至於特定的地形、地質景點則按照本區四大旅遊系統編排，以便遊客按圖索驥的進行深度的地景之旅。如果讀者對本區自然環境頗為熟悉，可以直接翻閱景點解說部分，或者先瀏覽第二至四章，以了解本區整體的地景特色與主要作用。

這本手冊以呈現整體而非片斷的解說，協助遊客閱讀地景，從陌生或熟悉的環境中感受新的事物。期盼在此手冊的協助之下，遊客能同時體驗

到本區地景的知性之美，並自然而然地建立起地景保育的觀念，進而提昇風景區遊憩環境與經營管理品質。



1. Introduction

The Alishan National Scenic Area has a rich variety of tourism assets, with its natural scenery of mountains and river valleys, aboriginal cultures, and newly developed recreational activities. Alishan has always been famous among the Taiwanese for its sunrise, which they describe as "a feast for the eyes: sunrise among deep blue mountains, green rivers, and a majestic sea of clouds." Development of quality tour services, particularly oriented towards theme tours, began with the establishment of the Alishan National Scenic Area Office in July of 2001, along with publication of informative leaflets and guidebooks to further enhance the Alishan tour experience.





Few people need a guide to appreciate nature's beauty, but curiosity always sparks questions: "Why?" "What is that?" "What made it this way?" These questions can only be answered by a look at Alishan's geology and topography—they are the fundamental building blocks of the area's natural beauty and can tell us its story.

This illustrated and easily-to-read guidebook introduces the landforms and geological structures underlying the natural scenery of the Alishan region. First, we outline its location and transportation systems, followed by a description of its landforms, geological structures and related scenic spots, which are grouped in four main six main tourist systems to allow visitors to seek out their own points of special interest. Those already familiar with the area can turn directly to the descriptions of these points, or look at chapters 2-5 to learn more about how geological features relate to the region as a whole, with accompanying technical terms and concepts explained in simple language.

Rather than a piecemeal approach, this guidebook presents an overview that should help the visitor "read the landscape" and find something new in both familiar vistas and those experienced for the first time. We hope this guidebook will help visitors acquire both a new understanding of the beauty of this area and an accompanying desire to help in its preservation, so as to further enhance the quality of management in the scenic area and enjoyment of the leisure experience there.



二、位置、範圍與氣候

阿里山國家風景區位於嘉義縣的東半部丘陵及中高海拔山區，北回歸線穿過本區中部，總面積達41520公頃，遠大於早期開發的阿里山森林遊樂區。在地形分區上，本區位於阿里山脈的中北段，也是濁水溪、八掌溪、曾文溪等流域的上游地帶。

就行政區域而言，位於嘉義縣阿里山、梅山、竹崎及番路鄉，包含阿里山鄉的所有村落與梅山、竹崎、番路鄉的部分村落。



【阿里山國家風景區範圍圖】

Geographical area of the Alishan National Scenic Area

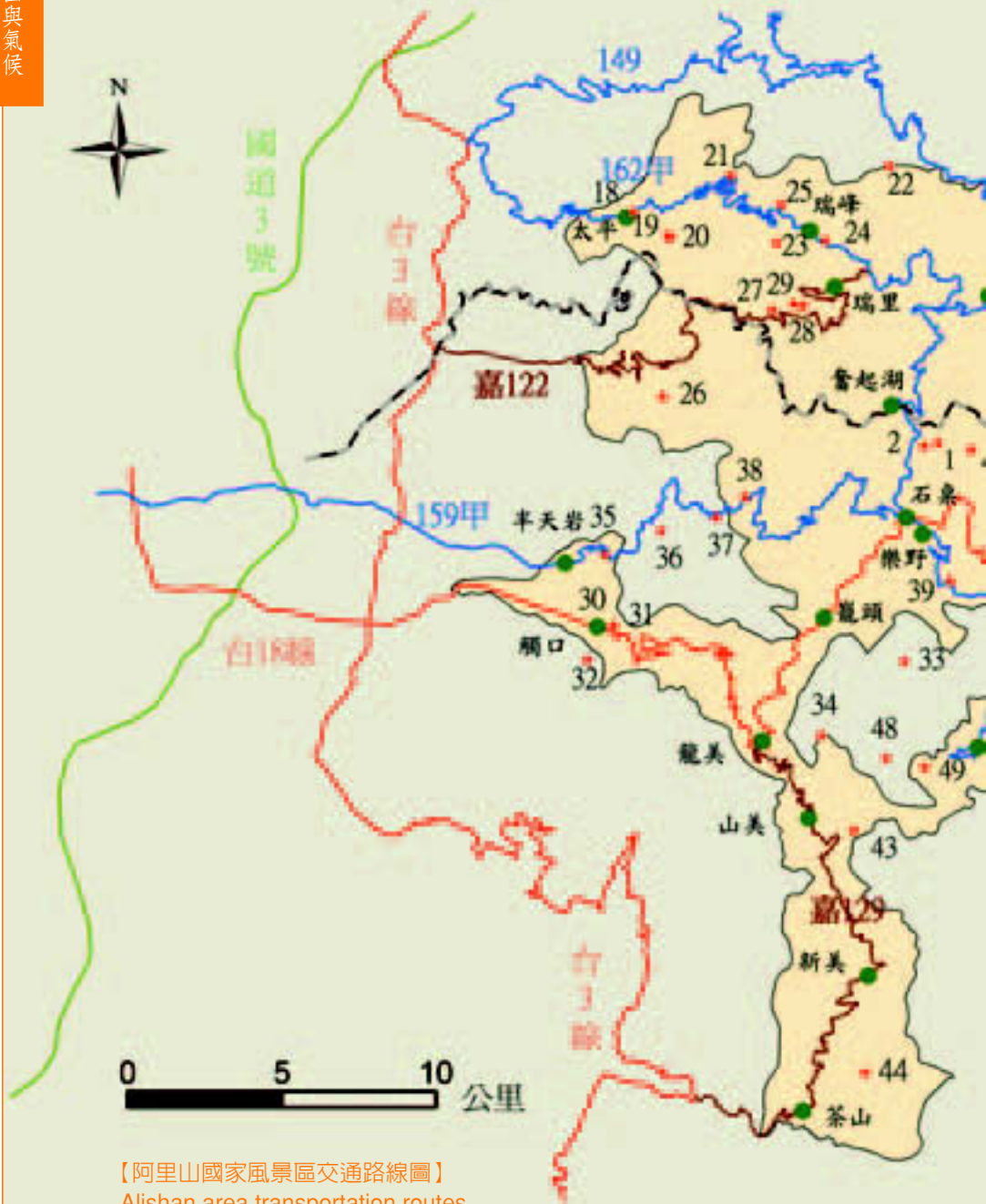


↑ 齊柏林 先生提供

2. Location, Area and Climate

The Alishan National Scenic Area is set among the hills and mid-altitude mountains of eastern Chiayi County. Bisected by the Tropic of Cancer, the area comprises about 41520 hectares, much larger than the original Alishan Forest Recreation Area. Topographically the area lies in the north-central section of the Alishan Mountains and is the origin of the headwaters of the Jhuoshuei, Bajhang and Cengwun Rivers.

Administratively, the area spans the Alishan, Meishan, Jhuci, and Fanlyu townships, including all the villages in Alishan Township and some of those in the latter three.



【阿里山國家風景區交通路線圖】

Alishan area transportation routes



- 1 明月窟、流星巖 Mingyue Cave, Liousing Cliff
- 2 十八羅漢洞 Eighteen Luohan Caves
- 3 阿里山溪河階 Alishan River Terraces
- 4 札基谷瀑布 Zhajigu Waterfall
- 5 來吉大峭壁 The Laiji Wall
- 6 天水瀑布 Tianshuei Waterfall
- 7 原始一百洞 The Primeval Caves
- 8 土石流紀念公園 Debris Flow Memorial Park
- 9 土石流複成扇 Debris-flow Fan
- 10 百年土石流遺跡 Ancient Debris Flow
- 11 石盤谷瀑布 Shihpangu Waterfall
- 12 石盤谷大岩壁 Shihpangu Wall
- 13 天雲谷瀑布 Tianyungu Waterfall
- 14 蛟龍瀑布 Jiaolong Waterfall
- 15 滴水成金 Huagang Suellian Cave
- 16 石夢谷壺穴 Shihmenggu Potholes
- 17 石夢谷瀑布 Shihmenggu Waterfall
- 18 仙人壩 Supernatural Potholes
- 19 萬坪石 Wuanping Rock
- 20 相逢瀑布 Twin Waterfalls
- 21 梅山峽谷 Meishan Canyon
- 22 新草嶺潭 New Caoling Lake
- 23 龍宮、雷音瀑布 Longgong and Lueiyin Waterfalls
- 24 南天峭壁 Nantien Cliff
- 25 神仙尿尿瀑布 ShihshianNiaoniao Waterfall
- 26 觀音瀑布 Guanyin Waterfalls
- 27 雲潭瀑布 Yuntan Waterfall
- 28 燕子崖 Swallow Cliff
- 29 蝙蝠洞 Bat Caves
- 30 觸口曲流河階 Chukou Amphitheater Terrace
- 31 八掌溪谷曲流 Bajhang River Incised Meander
- 32 情人瀑布 Lover's Waterfall
- 33 象山 Elephant Mountain
- 34 仙井瀑布 Sianjing Waterfall
- 35 八掌溪沖積扇階 Bajhang River Fan Terraces
- 36 鳳凰瀑布 Phoenix Waterfalls
- 37 光華砂頁岩互層 Guangha Sandstone-shale Alternations
- 38 濁水溪橋土石流 Jhuoshuei River Bridge Debris Flow
- 39 裸女瀑布 Luonyu Waterfall
- 40 頂湖巨石 Dinghu Rock
- 41 大塔山 Datashan
- 42 姊妹潭 Two Sisters Pools
- 43 曾文溪上游峽谷 Cengwen River Valley
- 44 茶山石壁 Chashan Wall
- 45 神秘谷瀑布 Mysterious Valley Waterfall
- 46 百人洞 Bairen Cave
- 47 拉拉喀斯瀑布 Lalakasih Waterfalls
- 48 里佳瀑布 Lijia Waterfall
- 49 福爾摩沙第一泉 First Formosa Spring
- 50 山崩窪 Scar

由於阿里山國家風景特定區大部分位於丘陵山地，聯外道路多盤旋於河谷山嶺之間，景色優美。本區交通主動脈是東西橫互的台18線（阿里山公路），它也是遊客進入本區的主要幹道。因為山嶺河谷的分割，區內各主要風景點之間的聯繫道路也常需翻山越嶺。雖然有地形阻隔，但區域內的縣道、鄉道與產業道路網已經形成，交通頗為便利。山區道路最大困擾就是颱風豪雨期較易坍方造成道路中斷，所幸除非狀況特殊，多能儘速修復通車，或有建議之替代道路。所以遊客在出發前最好洽詢本處或住宿處，以了解全區實際交通現況，做最出合宜的旅程規劃。

在氣候方面，北回歸線雖然橫跨本區，不過因為多山地，東側又有高山阻隔，全年頗為舒適、涼爽。在氣溫方面，由於海拔高度從數十公尺到兩千多公尺，氣溫與林相都有顯著的垂直變化，由熱帶、溫帶至寒帶。以阿里山測站代表本區，玉山、嘉義測站分別代表高山和平地，可以明顯看出本區夏季七月平均氣溫(14.3°C)比平地(28.4°C)低許多，冬季一月平均氣溫約(5.8°C)又比玉山(-1.5°C)高好幾度，相當宜人。不過早晚氣溫變化大，到此地旅遊仍應備妥禦寒衣物。

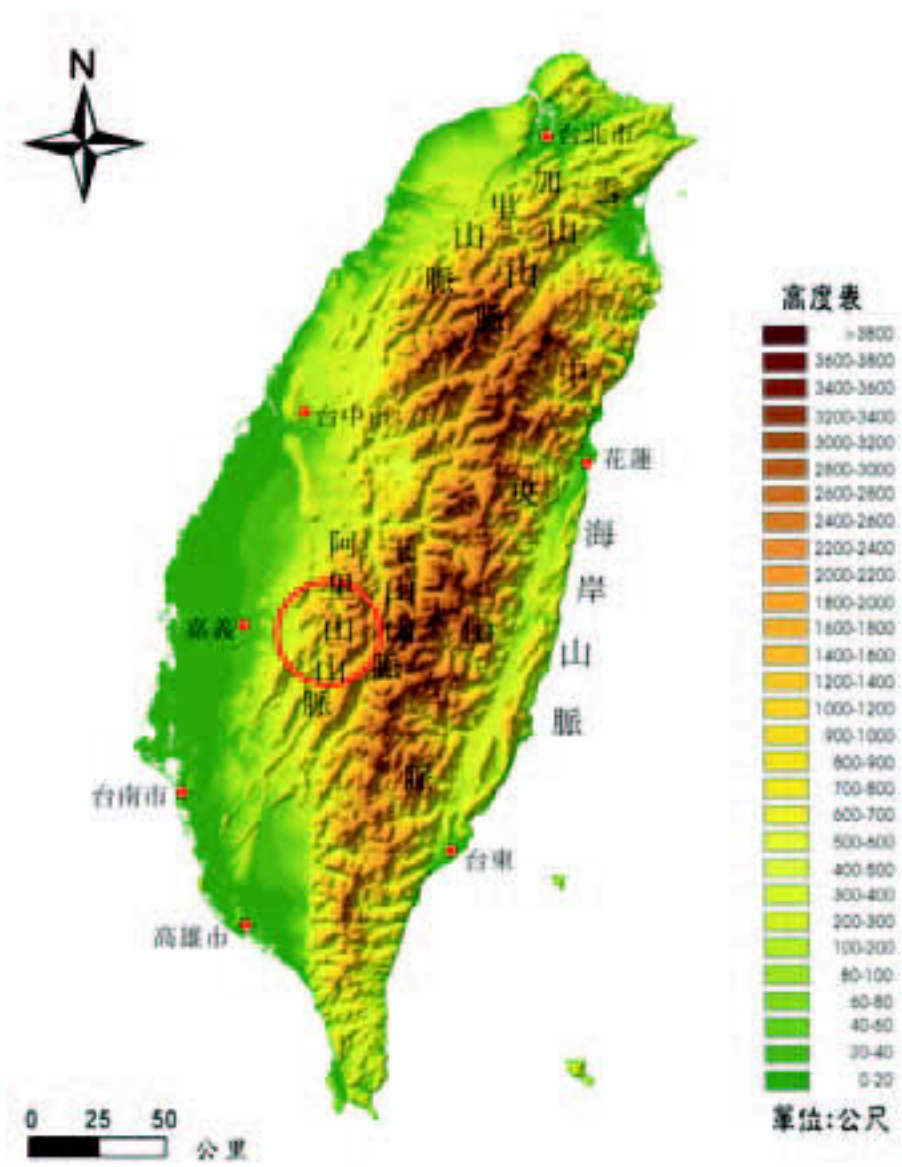
在降雨方面，冬季的東北季風南下時，本區受到山脈屏障，降雨有



限。夏季時，高溫及對流作用旺盛，常有雷雨；颱風來襲時常帶來豐沛雨量，為主要降雨季節。全區呈現冬乾夏雨的特性，年降雨量將近3900公釐，降雨日數全年達172天。



Being situated in mostly hilly and mountainous terrain, roadways providing access to the Alishan National Scenic Area tend to follow natural waterways and divides while offering the traveler many beautiful vistas. The natural layout of the terrain means that routes between scenic sites must frequently cross mountains and river valleys. Despite the physical impediments, a convenient network of county and township roads and feeder routes has grown up, its main artery being Tai 18 Highway (the Alishan Highway), the primary route through which visitors enter the scenic area. The only real obstacles to transportation are the landslides which sometimes block roads during typhoon seasons, though traffic usually resumes quickly after they are cleared away or alternate routes are found. Visitors are advised to check traffic conditions with the Alishan

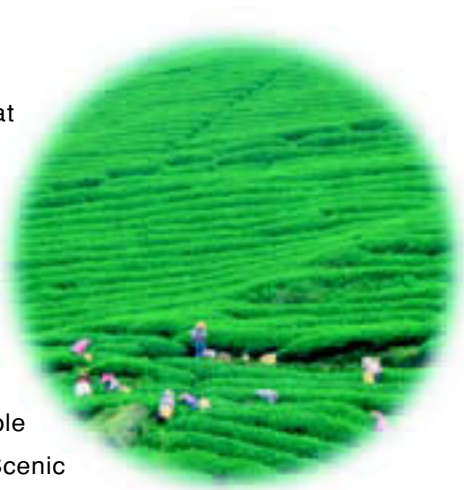


【臺灣島立體圖】

Relief map of Taiwan, Alishan area outlined

National Scenic Area office or at their lodgings in order to make appropriate arrangements.

Despite being located along the Tropic of Cancer in southwestern Taiwan, the mountainous terrain and the barrier ridge to the east create a cool and comfortable climate in the Alishan National Scenic Area. Along with the degree of forestation and the altitude—ranging from several score to 2000+ meters—temperatures vary from tropical to temperate and even frigid. Measurements from the Alishan weather station give clues to its pleasant climate: Alishan's summertime July average of 14.3°C is much lower than the 28.4°C on the plains (taken at Jiayi), while its wintertime average of 5.8°C remains higher than the average of -1.5°C in the high mountains (at Yushan, or "Jade Mountain"). Bringing some warm winter clothing is advisable, though, as temperatures can vary significantly on a daily basis and from morning to evening.



The mountain ranges of the Alishan area screen it from the northeast monsoons that move south in wintertime, and limit the amount of rainfall. Temperatures and atmospheric convection currents reach a high during the summer, making it the peak season for rain, especially the copious rainfall that accompanies the landfall of typhoons. Dry winters and rainy summers, with a total of 172 days of rain per year, add up to a yearly average rainfall of nearly 3900mm.

三、大地的故事

本區位於本島西南部中低海拔的山地區，東側是本島最高山嶺玉山山脈，西邊則鄰接斗六、嘉義丘陵。區域內所出露的地層大多是未變質的沈積岩，岩石種類以砂岩、砂頁岩互層為主。一個地區的地層特性是塑造地景的重要因素之一，所以本章將依序介紹本區的地質簡史、地層與地層構造的特性，最後則提醒初步觀察岩層露頭的幾個原則。

(一) 臺灣島與山脈的形成

與地球46億年的歷史相比，臺灣島是一個非常年輕的島嶼，根據研究，是因為數百萬年以來歐亞大陸板塊與菲律賓海板塊的持續推擠、碰撞，才在亞洲東部這個地區逐漸形成一個既狹窄又高聳的臺灣島。在本島五大山脈中，海岸山脈位於菲律賓海板塊上，其他各山脈則是位在歐亞大陸板塊上，花東縱谷是兩個板塊在陸地上的縫合線。在造山的過程中，由於推擠的力量來自東南方，科學家認為西邊的山脈是由東向西被依序抬升而起，最早是中央山脈，其次雪山和玉山山脈，最後才是阿里山脈。



【臺灣島橫剖面示意圖】
Cross section of the Taiwan Island

3. The Story of the Land

The Alishan National Scenic Area is set among the low to mid-altitude mountains in the southwest of the island. To its east is Taiwan's highest mountain range, the Jade Mountains, while to its west are the hills of Douliou and Chiayi. Most of the exposed strata within the Scenic Area are sedimentary rocks, primarily sandstone and sandstone-shale alternation. Since stratum characteristics are important in defining a region's landscape, this chapter provides a brief overview of the geological background, strata, and structure of the area, as well as offering some elementary guidelines for observing exposed geological strata.

(1) Formation of the Island of Taiwan and its Mountains

The island of Taiwan is young relative to the Earth's 4.6 billion-year history. Research shows that as the Eurasian Plate and Philippine Sea Plate continued to push against each other for millions of years, they formed a narrow but towering land mass—Taiwan island—in East Asia. Among the five major mountain ranges on the island, the Coastal Range is located on the Philippine Sea Plate while the other mountain ranges sit atop the Eurasian Plate. The East Longitudinal Valley (Huatung Zonggu) is the connecting line between the two plates. Scientists believe that since the tectonic stress originated from the southeast, the mountains on the east side of the island were raised progressively from east to west. The first to form were the Central Mountains, followed by the Syue Mountains and the Jade Mountains, and finally the Alishan Mountains.



板塊與東亞板塊配置

Tectonic Plate and Their Distribution in East Asia

地球表面是由多個板塊組合而成，由於板塊之間會做相對的移動，所以在交界處產生各種地質現象。在西太平洋或東亞、東南亞沿海，有一連串的島嶼出現，就是歐亞板塊、太平洋板塊以及它的副板塊菲律賓海板塊，和印澳板塊之間聚合、碰撞的產物。

The Earth's surface is made up of many tectonic plates. Tectonic movements produce various geological phenomena at the intersection of these plates. The islands in the west Pacific Ocean, including those along the coasts of East Asia and Southeast Asia, are products of tectonic activity by the Eurasian Plate, the Pacific Ocean Plate, the Philippine Sea Plate, and the Australian-Indian Plate.

(二) 岩石與地層

阿里山脈出露的地層以沒有發生變質的沈積岩為主，和東方已經發生變質的玉山山脈的地層不同。在本島形成過程中，當中央、雪山、玉山等山脈已經隆起成高山時，今天阿里山脈一帶仍然是一片海域，來自鄰近陸地上的土沙礫石持續的在此片海域堆積，所以它的地層比較年輕。

阿里山脈在隆起的過程中，雖然沒有變質但發生變形。加上山脈出露水面後，開始被風化、崩壞和侵蝕，所以原先堆積在比較下部的地層也會出露在地表。本區出露地表的地層主要為第三紀中新世晚期至第四紀更新世的沈積岩，出露岩層按地質年代為：

- 南港層 (Nk, 砂岩、砂頁岩互層, 中新世)
- 南莊層 (Nc, 砂岩、砂頁岩互層, 中新世) 及其相對地層
- 桂竹林層 (Kcl, 砂頁岩互層) 及其相對地層, 此層由下而上又可分為關刀山砂岩(Kts, 晚中新世)、十六份頁岩(Slf, 早上新世)和魚

(2) Rock Types and Geological Strata

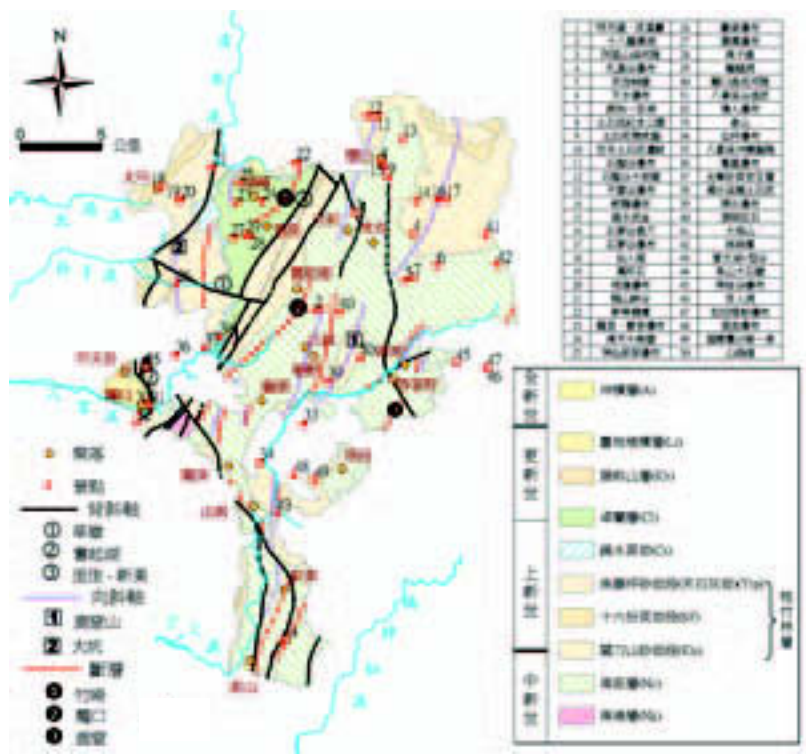
The exposed geological strata of the Alishan Mountains are composed mostly of sedimentary rocks, which, unlike those of the Jade Mountains, have not undergone metamorphosis. When the Central Mountains, Jade Mountains, and Syue Mountains had already been formed by uptrusts during the island's formation, the area of Alishan Mountains remained a body of water, where gravel and sand from neighboring areas continued to accumulate. Hence, the Alishan strata are relatively young.

During formation of the Alishan Mountains, the strata were deformed although tectonic movements did not result in metamorphosis. And, as the Alishan Mountains gradually emerged from the sea, they underwent weathering, collapse, and erosion. As a result, the accumulations of the lower strata sometimes show up on the surface. The exposed strata in the Alishan scenic area are sedimentary rocks from the late Tertiary Miocene period up to the Pleistocene period. Based on their geological age, the exposed strata are as follows:

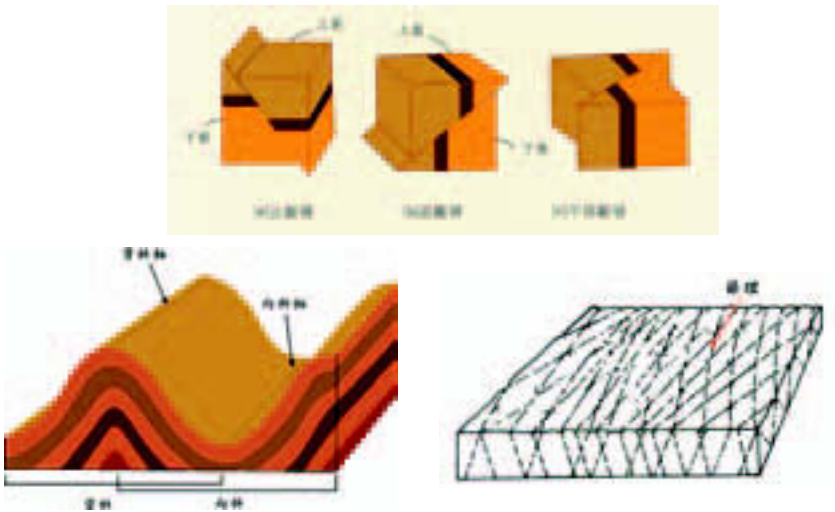
- The Nangang Formation (Nk, sandstone, sandstone-shale alternation; miocene)
- The Nanjhuang Formation (Nc, sandstone, sandstone-shale alternation) and its corresponding strata of the Miocene period.
- The Gueijhulin Formation (Kcl, sandstone-shale alternation) and its corresponding strata of the Miocene to Pliocene periods; This formation can be classified from the bottom up into the Guandaoshan Sandstone, Shihlioufenye Shale, and Yutengping

藤坪砂岩(Ytp, 中上新世)。

- 錦水頁岩層 (Cs, 頁岩、砂頁岩互層, 晚上新世) 及其相對地層
- 卓蘭層 (Cl, 砂岩夾頁岩, 早更新世)、
- 頭嵛山層 (Tks, 火炎山相—礫岩、香山相—砂頁岩互層夾礫岩, 更新世) 及其相對地層
- 紅土礫石層 (Qlt, 更新世)、階地堆積層 (Qte, 更新世) 與最近期的沖積層 (Qa, 全新世)



【本區地質圖】
Alishan area geological map



【地質構造圖：摺皺、斷層與節理】
Various types of geological structures

Sandstone.

- The Jinshuei Shale Formation (Cs, shale, sandstone-shale alternation) of the Pliocene period.
- The Jhuolan Formation of the Pleistocene Period (Cl, sandstone interbedded with some shale)
- The Toukeshan Formation (Tks, Huoyanshan facies — conglomerate rock stratum; Siangshan facies — sandstone-shale alternation interbedded with some conglomerate rocks) and its corresponding strata.
- The lateritic gravel strata (Qlt); the sedimentary layer (Qte); and the most recent alluvia (Qa)

整體而言，南莊層(Nc)是本區出露地表最廣的地層，而關刀山砂岩以塊狀厚層砂岩著稱，抗蝕力高，常構成山稜線。由於本區地層是在淺海到陸地的環境中堆積形成，所以在砂、頁岩和鈣質砂岩的岩層中，常可以見到海棲貝類化石，尤其是在南莊層中最为豐富。奮起湖背斜東翼的砂頁岩互層中，還發現陸相的植物葉片化石。

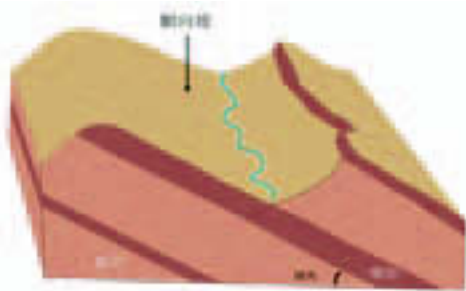
至於本區內主要的褶曲有（自北而南、自西而東）：草嶺背斜、大坑向斜、奮起湖背斜，主要的斷層有：觸口（大尖山）斷層、竹崎斷層。

（三）岩石與構造的觀察

本區地表雖然植樹茂密，但是在河岸、陡崖或道路旁仍然常常可以看到岩層的露頭，可以對岩石與地質構造或沈積構造做一些初步的觀察。本區常見的岩石有砂岩、頁岩或泥岩、礫岩。砂岩是由砂粒構成，觸摸起來大多有粗糙的感覺，頁岩或泥岩是指由非常細的顆粒所組成，觸摸起來幾乎沒有顆粒感；至於礫岩是指由大於0.2公分的礫石所組成，顆粒最粗。這類岩石顏色可能由灰白色到黑色，不過在野外山坡上的岩石表面大多已經風化而不夠「新鮮」，所看到的通常都不是岩石真正的顏色。

前面也介紹過，沈積岩最大的特徵就是有層次（層理），這可能是因為沈積時的短暫間斷、沈積物供應來源地的變化、礦物性質的改變，或搬運水流速度的變化等所造成。如果某一地區在某一段時間是砂粒沈積，過一段時間變成是極細的泥或黏土粒沈積，日後形成的就是砂頁岩互層。如果沈積顆粒變化的愈頻繁，所形成的互層就愈薄。

一般遊客也很容易就可以察覺到本區的岩層大多是傾斜



【順向坡圖】
Dip slope

As a whole, the Nanjhuang (Nc) Formation is the most extensive of the surface layers, while Guandaoshan Sandstone is known for its thickness, being highly resistant to erosion and often forming ridgelines. These strata were formed in shallow marine and terrestrial environments.

▶ 岩石與沈積岩

Rocks and Sedimentary Rocks

岩石是組成地殼的主要物質，種類繁多，是由一種或多種礦物組合而成。按照成因，岩石可以分為火成岩、沈積岩、變質岩三大類，本島都可以看到。簡單的說，沈積岩是由各種岩石或礦物的碎屑經沈澱堆積於海、湖、河流等水體中，再經壓密、膠結而成，或是由於生物的作用或其遺骸堆積而成，最常見的組成礦物是粘土、石英、方解石。

Rock is the major component of the Earth's crust. There are many types of rocks, which are composed of one or several kinds of minerals. Based on the means of their formation, rocks can be classified as igneous, sedimentary, or metamorphic, all of which can be found on Taiwan. In essence, sedimentary rocks are formed when pieces of rocks or minerals sink into a sea, lake, or river and are pressed and bonded together, or perhaps as the result of biological processes or the accumulation of the remains of living creatures. The most common mineral formations are clay, quartz, and calcite.

在臺灣最常見到的沈積岩是礫岩、砂岩、頁岩或泥岩和石灰岩。本島的石灰岩主要由珊瑚、藻類等生物遺體堆積而成，其他三類則是由不同顆粒大小的碎屑組成，依序是礫岩、砂岩和頁岩（或泥岩），這三類也是本區最常見的岩石。

In Taiwan, the most common sedimentary rocks are conglomerates, sandstone, shale (or mudstone), and limestone. The limestone found on the island is primarily composed of dead coral and algae. The other three types of sedimentary rocks are formed from sediments of different sizes. These are also common in the Alishan National Scenic Area.

岩層與岩層命名

Strata and Naming of the Strata

沈積岩最主要的特性是層理，也就是看起來一層一層可以沿之分離或劈開的層次，厚度從小於0.1公分到數十公尺。層和層之間的界面稱為層面。沈積岩形成過程中，最先沈積的在下部，時代較老，愈上面的時代愈新。

The principal characteristic of sedimentary rock is bedding or stratification. The layers in the rock look like they can be separated or split open. Layers range in thickness from 0.1 cm to tens of meters. A bedding plane separates the layers. During sedimentary rock formation, the first sediments are deposited at the bottom and are relatively older. The higher the layer, the more recent is its formation.

在相同的地質時代，不同地區的沈積環境與物質當然不盡相同，對同一地區而言，不同時代的沈積環境與物質可能有所改變。如果某一地區在某一段地質時期所沈積的碎屑都是砂粒，日後形成的就是砂岩層；如果一段時間是砂粒沈積，過一段時間變成是極細的碎屑沈積，日後形成的就是砂頁岩互層。

Even during the same geological period, different areas will vary in terms of the types of sediments and their deposition, while within a single region, there can be changes in sediments and their deposition during different geological periods. If all the sediments in an area in a given period are sand, there will be sandstone formation. If the first sediments are sand, followed later by finer materials, a sandstone-shale alternation will be formed.

為了方便指稱各地層，所以地層都有名字，大多是以地層保存最完整及最具代表性的那一地點的地名來命名。例如，本區出露極廣的南莊層，就是以苗栗的南莊來命名的。

For convenience, different strata are given names, which generally refer to the places where the strata are most completely preserved or are most typical of the given type. For instance, the name of the extensive Nanjhuang Formation in the scenic area is taken from Nanjhuang, in Miaoli.

For this reason, mollusca fossils are often found in the sandstone, shale, and calcareous sandstone layers, and are especially abundant in the Nanjhuang Formation. Plant fossils can also be found in the sandstone-shale alternations on the eastern flank of Fencihu.



The major folds in the Alishan scenic area include (from north to south, and west to east): the Caoling anticline, the Dakeng syncline, and the Fencihu anticline. The major faults include the Chukou (Dajianshan) fault and the Jhuci fault.

(3) Observing Rock Types and Structures

Although there is abundant vegetation within the Alishan scenic area, there are often outcroppings of rock strata along riverbanks, precipices, or roads. These can be used for initial observation of rock types and structures or sedimentation. The most common rocks in the scenic area are sandstone, shale or mudstone, and conglomerates. Sandstone, formed from sand, is often rough to the touch. Shale or mudstone, on the other hand, is formed from very fine particles and does not have a similarly grainy feel. As for conglomerate, it is formed by gravel larger than 0.2 cm, and has the coarsest grain. Rocks of this type can be greyish to black in color. But rock surfaces found on outdoor slopes are often no longer "fresh" due to the effects of weathering, and often do not show their true color.

As explained earlier, the most remarkable characteristic of sedimen-

而非水平的。本區有許多大石壁的景點其實是沿著層面發展的山坡，來吉、石盤谷、茶山大石壁均屬此類（景點5、12、44）。如果就近仔細觀察岩層的露頭，通常都會發現岩面被節理切割，這些也都是本區地層曾經受到外力干擾的證據。傾斜的岩層常常是一個更大褶曲的一部份（前一節所提到的地質構造），因為規模較大，通常不是一眼可以望盡，在野外可能需要比較專業人員的引導，才能有所體會。

▶ 地質構造

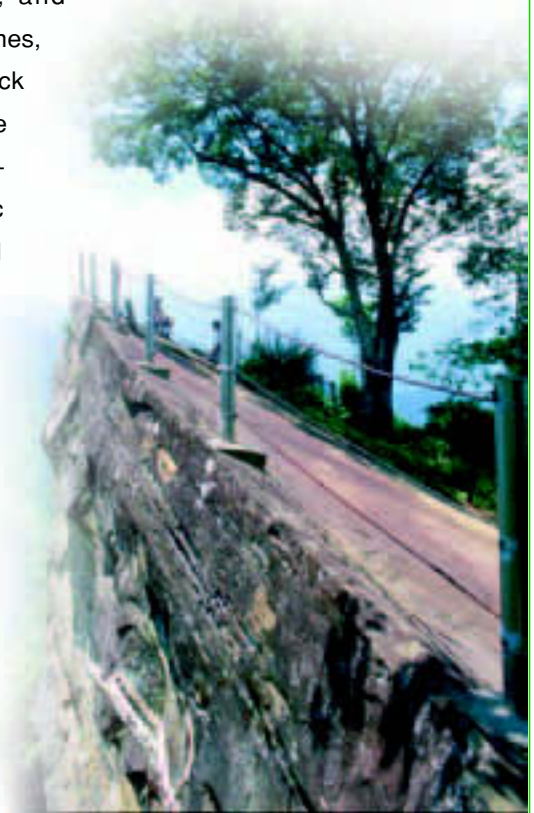
Geological Structures

在沒有受到干擾的情況下，沈積岩層大多是水平的，受到外力作用後就可能發生傾斜、彎曲、破裂，甚至斷裂。如果岩層受到擠壓發生傾斜或呈波浪狀的彎曲，稱為褶曲或褶皺；若岩層向上凸出，稱為背斜，向下凹入，則稱為向斜。如果岩層變形發生破裂，但是破裂面兩側的岩層沒有發生相對的移動，這種裂面稱為節理。節理很少單獨出現，通常是一組或多組彼此間略相平行的節理一起出現。岩層如果已經斷裂，並且沿著裂面有明顯的移動，就形成斷層。斷層按照移動的方式可以分為正斷層、逆斷層和平移斷層。至於一般口語所說的「斷崖」是指高而陡的峭壁，請大家不要和「斷層」弄混了喔！

Unless disturbed, most sedimentary formations are horizontal. When external forces are involved, there may be inclination, curving, breaking, and even splitting. If the rock stratum is subject to pressure the resulting inclined or wave-like curvature is called a fold. Folds may protrude upward or extend downward. An upward protrusion is called an anticline, while a downward extension is a syncline. If a rock stratum breaks due to deformation, with no relative motion between the strata along the break, it is called a joint. Breaks usually do not occur singly; often they develop in groups of parallel joints. If there is a break in a rock stratum and distinct movement occurs along the break, it becomes a fault. Faults may be classified as normal faults, reverse faults, and strike-slip faults based on the type of motion along the fault. The word "fault" should not be confused with "scarp" or "cliff"!

tary formations is their bedding (or stratification). This may be due to temporary discontinuities in deposition, changes in the source of sediments, changes in mineral composition, or changes in the flow speed of water carrying the sediments. If the sandy sediments of an area later change to very fine mud or clay, it will result in a sandstone-shale alternation. The layers are thinner where the changes in sediment particle size were more frequent.

Visitors to Alishan can readily observe that most strata in the scenic area are inclined and not horizontal. Many giant rock walls in the scenic areas are mountain slopes that developed along the lines of the rock strata. Those in Laiji, Shihpangu, and Chashan are of this type. Often times, joint cuts can be seen on the rock surface when the outcrops are observed up close. These are evidence that the strata in the scenic area were subjected to external disturbance. Inclined strata are usually parts of larger folds (the major structure explained in the previous chapter). Because they are larger in size, they usually cannot be seen in entirety at a glance. Professional guides are probably needed to help understand these structures in the field.



四、山地、瀑布與奇岩

本區在地形分區上絕大部分屬於阿里山脈，境內高度大多介於500～2500公尺之間，山勢險峻、坡陡谷深，配合出露的地層，本區地景可以「山嶺秀、溪谷幽、斷崖險、飛瀑盈、奇岩絕、化石珍」十八字加以形容。本章首先介紹本區地形的主體～山地與水系，以及區內特別顯著的河流與風化、崩壞地形，最說明本區地景的整體性。

(一) 山地與水系

阿里山脈北起濁水溪南岸，南抵高雄縣鳳山，全長約135公里。山勢東高西低，鹿林前山一帶數個高於2800公尺的山峰構成阿里山脈的最高點，烏松坑山一棚機山山嶺也都高於2000公尺。此線以西也有數條呈東北—西南走向的山嶺，高度級級下降，最西邊的山列高度約在1000公尺左



4. Mountains, Waterfalls, and Rock Formations

Most of the scenic area is part of the Alishan Mountains. The area ranges in elevation from about 500 to 2500+m, and is characterized by precipitous drops and deep valleys. Along with its exposed strata, the scenic area also possesses graceful mountains, remote river valleys, steep cliffs, flying waterfalls, extraordinary rock formations, and rare fossils. In addition to an overview of the main parts of within the scenic area, its mountains and bodies of water, this chapter also explains the major fluvial, weathering, mass-movement landforms.

(1) Mountains and River Systems

The Alishan Mountains stretch for approximately 135 kilometers from their northern border on the southern bank of the Jhuoshuei River to Kaohsiung County's Fangshan on the south. The mountains descend in elevation from east to west. The Lulinciashan area has several peaks over 2800 meters, the highest of the Alishan Mountains. The Wusungkengshan and Pengjishan ridges are both over 2000 meters high. West of this line, there are several ranges running in the northeast-southwest direction. Here the height of the ridges begins to drop; the mountains to the extreme west are approximately 1000m in height. The typical tourist route through the scenic area allows easy observation of Datashan (2663meters), the highest mountain along the route.

The major ridges usually also form the main divides. Taking the Jhushan and Shihdatianwangshan ridgeline as boundary, the area to the

▶ 本島主要山脈

Major Mountains in the Island

臺灣島是一個高山島，山地位置較為偏東，走向大致與島軸平行，由數條山脈組成。根據學者林朝榮教授的劃分，中央山脈（脊梁山脈）延伸最長，是本島河流的主要分水嶺；雪山山脈、玉山山脈（玉山山塊）位於中央山脈西側，兩者以濁水溪為界。這三座山脈的地層有不同程度的變質，有許多山峰超過三千公尺，是本島的屋脊。緊鄰雪山、玉山山脈以西的丘陵性山地，地層都沒有變質，統稱為阿里山脈（廣義），或以濁水溪為界分為加裡山脈和阿里山脈（狹義）。加裡山脈中超過一千公尺的山峰不到30座，超過二千公尺的山峰更是寥寥無幾。阿里山脈（狹義）山勢比較高，一般人所熟知的阿里山區只是本山脈中北部較高的一段。至於位居東臺的海岸山脈，最高點為新港山1682公尺。

Taiwan is an island of high mountains. Its mountainous regions are composed of several ranges parallel to the island's axis and concentrated toward its eastern side. According to conventions established by Professor Lin Chao-Chi, the Central Mountains (Backbone Ridge) are the longest and also form the island's major divide. The Syue Mountains and Jade Mountains (the Yushan Block) are located west of the Central Mountains and separated from them by the Jhuoshuei River. The three ranges have undergone different degrees of metamorphosis. Many of their peaks are higher than 3000 meters; they are the chief ridges of the island. The strata in mountainous areas west of the Syue Mountains and Jade Mountains have not undergone metamorphosis. They are generally referred to broadly as the Alishan Mountains, or, using the Jhuoshuei River as boundary, can be more narrowly defined as the Jiali and Alishan Mountains. The Jiali Mountains have less than 30 peaks above 1000 meters, and even fewer over 2000 meters. The Alishan Mountains have higher peaks than the Jiali range. The Alishan area familiar to the general public is made up of the higher central and northern portions of the range. The highest peak among the Coastal Ridge on Taiwan's eastern side is Mt. Singang at 1682 meters.

north is the Cingshuei river basin; with the Dadongshan and Toudongshan ridgeline as boundary, the area to its south is the Cengwun River basin. The area between these two river basins is made up primarily of the Bajhang River basin, and to a lesser extent, the headlands of the Beigang and Pujih Rivers.

- Cingshuei River is the third largest tributary of the Jhuoshuei River, originating from the northwestern foot of the Alishan Mountains. Upstream, the Shihgupan River and Alishan River converge near Shehouping and flow westward for approximately 8km. The river then converges with the Shengmaoshu River, which comes from the south, at Shuangsizuei. The river then turns sharply northward and leaves the Alishan National Scenic



右。以一般遊客在本區較常行經的路線而言，較容易見到的山峰中以大塔山(2663公尺)最高。

主要山嶺也常是主要的分水嶺，本區以祝山、四大天王山一線山嶺為界，以北為清水溪流域；而以大凍山、頭凍山一線山嶺為界，以南為曾文溪流域。夾在此二流域之間的主要是八掌溪流域，和小部分北港溪、朴子溪的源流區。

- 清水溪是濁水溪的第三大支流，發源於阿里山脈的西北麓。本溪上游的石鼓盤溪和阿里山溪在社後坪附近會合後，向西行約8公里，在雙溪嘴處生毛樹溪自南來會。之後流路突然北折，就離開了阿里山國家風景區，最後在竹山匯入濁水溪。
- 八掌溪主流發源於阿里山脈西側奮起湖山，全長約81公里，中上游地區都屬於本區範圍。河流上游陡峻，切割旺盛，支流眾多，水潭、深谷、瀑布與峭壁的景觀隨處可見。
- 曾文溪發源於阿里山脈之萬歲山，全長約138公里，屬於本區的是曾文水庫以上的河段，呈縱谷形態，坡陡流急。

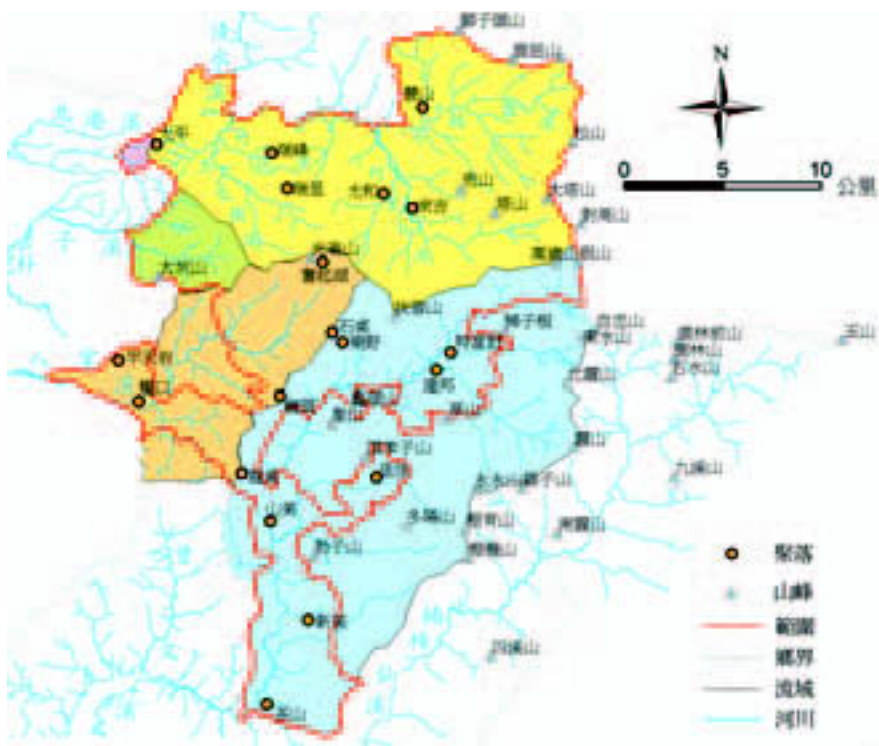
本區各河流的共同特色是流量變化極大：乾季時各月流量多低於每秒10立方公尺，河道枯竭，常呈涓涓細流；濕季時一般狀況河川流量平穩，一旦上游山區下起大雨，則水位快速上升。盛夏之時，遊客最喜歡在清涼溪水中嬉戲，應特別留心山區是否下雨。颱風豪雨時，山洪爆發，最大瞬時流量可能超過每秒1000立方公尺，應避免從事戶外活動。

(二) 河流地形

本區境內溪流眾多，河谷密布，深谷、峭壁與瀑布的景觀非常發達。根據主流河道與主要山嶺延伸方向的關係，河谷可分為縱谷與橫谷兩類。當河流與山脈走向平行時，稱為縱谷，例如曾文溪在曾文水庫以上的河

Area. It ultimately converges with the Jhuoshuei River at Jhushan.

- The main stream of the Bajhang River, approximately 81 km long, originates from Fencihushan on the western side of Alishan Mountains. The mid and upper stream areas of the river lie within the scenic area. The upstream flow traverses a steep channel with many channels and much downcutting. As a result, pools, deep valleys, waterfalls, and cliffs can be observed everywhere in the area.



【本區流域圖】
Alishan area river basins

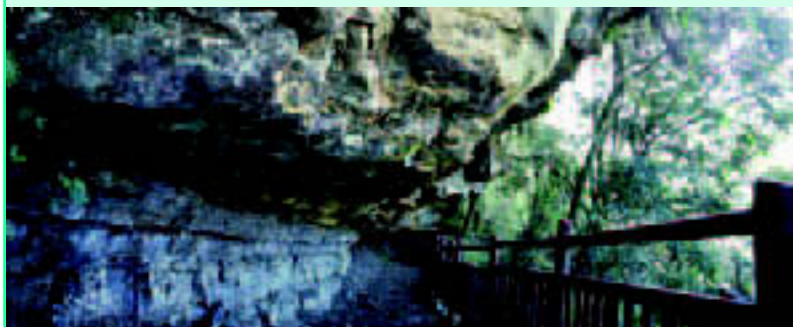


知道自己在哪裡

多數的遊客是乘坐遊覽車或自行駕車進入本區，山區道路蜿蜒曲折，遊客常不能掌握自己身在何方！其實只要手中有一份地圖，或者留心道路在何處翻山越嶺，很快就可以培養成這樣的能力，這樣以後在野外可就不容易迷路囉。

山區道路大多循著河谷修建，但本區河谷大多下切很深，所以道路常需盤旋到源流區河谷較窄或較淺處才較容易架橋過河。如果要到另一個河谷區，則道路常需選擇山嶺相對較低處（鞍部）跨越，例如本區的石桌和龍美就是聯絡八掌溪和曾文溪流域之間的孔道，又如縣道169是在奮起湖北方，跨越八掌溪與清水溪流域。

以遊客經常取道進入本區的路線來說，阿里山公路在觸口以東是沿八掌溪的支流修建，在龍美越過分水嶺（二延平山—龍頭坪山—石桌山）進入曾文溪流域，公路沿此山稜線附近而行，展望頗佳。縣道159甲大致沿著八掌溪主流河谷修建。若是從梅山取道162甲縣道進入本區，在太平以西是屬於三疊溪的源流區，過了太平則進入清水溪的範圍，瑞里、瑞峰、太和、豐山一帶的溪谷美景都屬於這個系統。也有部分遊客是由曾文水庫附近取嘉129（新美產業道路）進入本區，則一路所見都是屬於曾文溪水系的河谷。

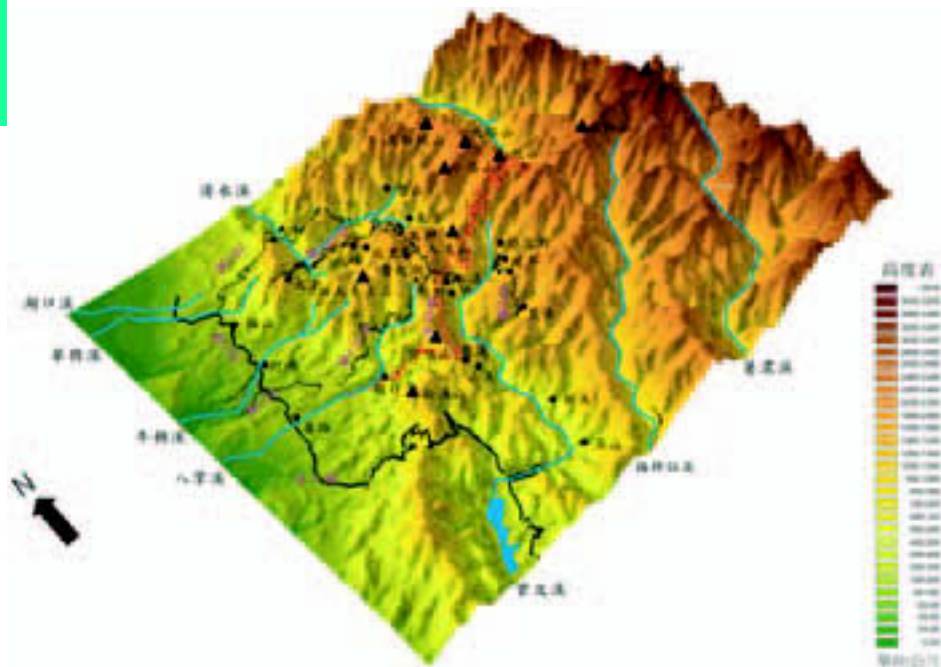


Finding Your Location

Most tourists enter the scenic area in tourist buses or their own vehicles. It is easy to lose one's way among intricately winding roads in the mountain areas, but such problems can be avoided by using a good map and by carefully noting the twists and turns along the way.

Most road construction follows river valleys in mountainous areas. Due to the sharp downcutting by the river in many of these valleys, roads have to wind their way up to the areas where the rivers are narrower or shallower in the river headlands before bridges can be built across them. To reach other river valleys, roads usually cross the ridges at low mountain passes (or saddles). Shihjhuo and Longmei, for instance, are passes connecting the Bajhang and Cengwun river basins, and north of Fencihu, County Road 169 connects to the Cingshuei river basin from the Bajhang River.

The Alishan Highway was constructed from Chukou east along the Bajhang River channel. It passes the divide ridge (Eryanpingshan — Longtoupingshan — Shihjhuoshan) at Longmei and enters the Cengwun River basin. The highway offers an outstanding view as it runs along the crest line. County Highway 159A mainly runs along the main channel of the Bajhang River. From Meishan, tourists can take County Highway 169A to the scenic area. The area west of Taiping is the headlands of the Sandie River. Beyond Taiping, the Cingshuei River begins. The beautiful scenery around Rueili, Rueifong, Taihe, and Fongshan is all part of this drainage system. Some tourists enter the scenic area taking County Road 129 near the Cengwun Reservoir, and along that route can observe the scenic sites in the Cengwun River valley.



【本區河流與主要道路圖道路圖】
Major rivers and road system in Alishan area

段。當河流與山脈走向直交或接近直交時，稱為橫谷，例如清水溪在流經本區北界的河段。由於地層走向常與山脈延伸方向一致，所以當河流橫切山脈與地層時，河谷的開展性較差，較易形成峽谷。

溪流在橫谷段時常流經軟硬不同的地層，當切穿軟岩時，河床大多平緩，當穿越硬岩時則常形成瀑布和急湍，差別侵蝕的效應相當明顯。此外，當地盤隆起後，河流會加速下切，但主支流流量不同所以侵蝕能力也不同，而常使支流與主流河道間有很大的高度落差，這種位置也常形成瀑布，例如雷音瀑布群（景點23）。這些都是本區或本島瀑布特別發達的重要原因。

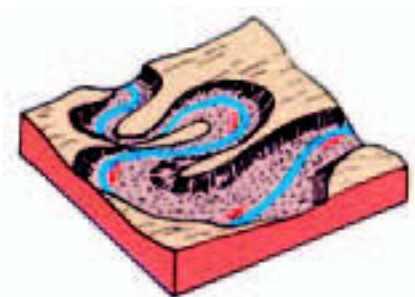
河流上游水流特別湍急，也會挾帶碎石挖鑿河床，如此在硬岩處常形

- The Cengwun River, approximately 138km long, originates from Wansueishan in the Alishan Mountains. Only the portion upstream from the Cengwun Reservoir belongs to the scenic area, and forms a longitudinal valley with steep slopes and a rushing current.

A common characteristic of rivers in the scenic area is huge changes in flow volume. During the dry season, rivers may be nearly dry and flow sluggishly at less than 10 CMS (cubic meters per second). During the wet season, flow volumes are generally stable, though water levels can rise rapidly when there is heavy rain upstream. During summer, tourists love to have fun in the cool rivers, but should take note of whether there has been rain in the mountain areas. During typhoons and heavy rains, there may be flash floods with maximum flow volumes reaching over 1000 CMS. Care should be taken in outdoor activities in nearby areas during these times.

(2) Fluvial Landforms

There are many rivers, valleys, canyons, cliffs, and waterfalls in the



【穿入曲流圖】
Incised Meander



【劇場河階圖】
Amphitheater terrace

▶ 塑造地表的要素

Elements Forming the Land Surface

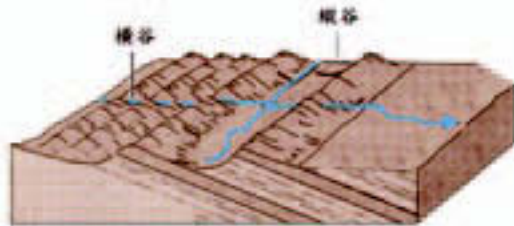
每個地區都有各自的地形特徵，到底哪些因素決定地表的形態和地表的變化呢？簡單的說，就是構成地形之岩石或沈積物的特性、施加在地形上的外來作用力和地形演育的時間長短，有時地形本身的形態也會影響地形後續的發展。

Every area has its own geomorphic characteristics. What then are the essential elements determining the morphology and the transformations of the land surface? In essence, they are the characteristics of the rocks or sediments in the geological formation, the external geomorphic forces acting on them, and the length of time the landforms undergo development. Sometimes, the morphology itself will also affect subsequent development.

岩石的強弱和地層的排列，以及地形的形態特徵（如邊坡的陡緩steepness）會決定地形抵抗外力的能力，地形本身的抗力和外來作用力之間的相互抗衡，則決定地形是發生改變或維持不變。施加在地形上的作用可能來自地球內部或者外部，前者如火山或地震，後者如風化和崩壞作用，以及河水、海水、風力、冰河的作用。

The strength of the rock, the arrangement of the strata, and the morphological characteristics (such as steepness) will determine a landform's resistance to external forces. The balance between the landform's resistance and the external forces will determine whether the landform undergoes any change. The forces affecting a landform can come from within the Earth or above it. The former can include volcanic action or earthquakes, while the latter might be weathering or slope failure. Likewise, rivers, seas, winds, and glaciers can also affect the landform.

Scenic Area. Based on the direction in which river channels and mountains run, river valleys can be divided into longitudinal valleys and transverse valleys. When a river runs parallel with the mountains, it is called a longitudinal valley; the Cengwun River found upstream of Cengwun Reservoir is one example. When a river runs directly or almost directly across the direction of the mountains, it is called a transverse valley, such as the portion of the Cingshuei River that passes through the Scenic Area. Because rock strata often run in the same direction as the mountain ranges, a river cutting across the mountains and strata does not lead to development of well-formed valleys, and a canyon may result.



【縱谷與橫谷圖】

Longitudinal and transverse valley

Rivers flow across strata of varying hardness as they pass through transverse valleys. When they cut through soft rocks, the riverbed is mostly smooth and even; when they pass over harder rock, waterfalls and rapids are formed. The results of the different degrees of erosion are quite evident. Furthermore, when the land moves upward, the river cuts down faster. Since the flow volumes of a river and its tributaries differ, the effects of erosion also differ, often times resulting in huge differences in height between the main channel and its tributaries. Waterfalls, such as the Leiyin waterfalls (Scenic Site 23), often form in such locations. These are the primary reasons why there are waterfalls aplenty in the Scenic Area or on the island.

▶ 河流作用和主要河流地形

河水是刻畫陸地非常重要的一種力量，地表上無數的溪谷大多是河流長期侵蝕的結果。河水流動時，尤其是豪雨洪水時，不論河水直接侵蝕的或山坡崩塌下來的物質，河流都會將它們繼續往下游搬運，直到河流無法搬不動時，便發生堆積。

河流在上游地區以侵蝕作用比較顯著，產生的地形以河谷（比較窄而深的稱峽谷）、瀑布、壺穴等為主。在中、下游地區堆以積作用比較顯著，通常河水流速減低、流量減少或河道突然變寬時，就容易出現堆積現象，所產生的地形有沖積扇、氾濫平原、三角洲和河道中的沙洲等。

河道不論在山區或平原上常常都是彎曲的，稱為曲流。如果河流可以相當自由的向兩側擺動，稱為自由曲流，通常出現在下游平原地區。在中上游河段，深切而彎曲的河道好像穿鑿在山地之中，稱為穿入曲流（景點31）。本島因為地殼抬升作用顯著，也特別有利於河階或扇階這類地形的發育。當原來位於曲流凸岸的河床被相對抬升，取其近似半圓的形狀，特別稱為劇場河階（景點30）。如果是原來的沖積扇被相對抬高，就稱為扇階（景點35）。

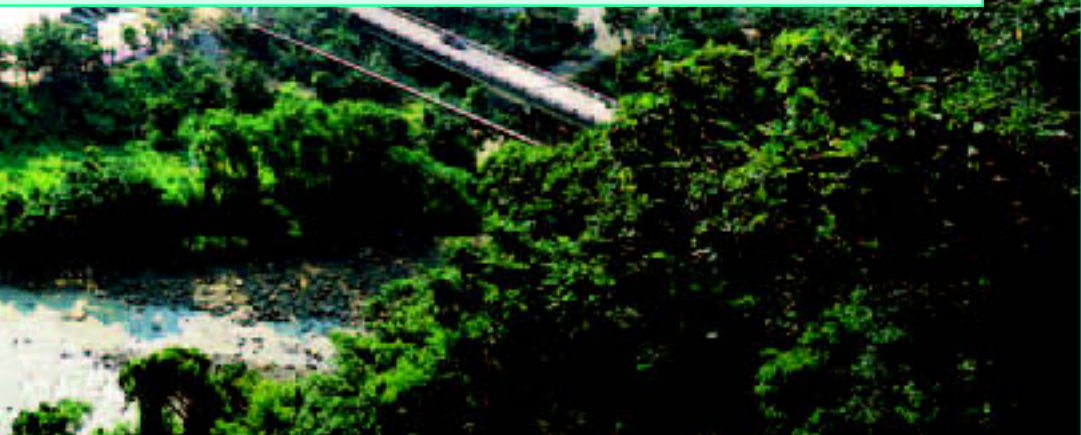


Fluvial Processes and Related Landforms

The river is an essential force in shaping the land. Most river valleys on the land surface are the result of long periods of fluvial erosion. When a river flows, in particular during heavy rains and floods, it carries eroded materials or remnants of collapsed mountains downstream. These materials begin to accumulate when the stream no longer has the force to move them.

Water erosion, most evident in upstream areas, produces river valleys (called canyons when they are narrower and deeper), waterfalls, and potholes. Deposition is more evident in the mid- and downstream areas, where the flow slows down, flow volume decreases, or the channel widens. The accumulation of sediments produces alluvial fans, floodplains, deltas, and sand bars.

River channels often curve, whether in mountain areas or plains; these curves are called meanders. If a stream can move freely within its channel, it is called free meander, which is often found in the plains downstream. Incised meanders, on the other hand, are deep, curving channels that seem to cut through the mountain in the mid- and upstream portion of the channel. Taiwan's rising crust facilitates the development of river and fan terraces. If the riverbed along the convex bank of a meander is raised, the semi-circular formation is called an amphitheater terrace. If an alluvial fan is raised, it is called fan terrace.



成呈橢圓或圓形的凹穴，稱為壺穴。這種小地形經常成群出現，也常見到相鄰兩個壺穴因為岩壁被磨穿而相連，形成有趣的形狀，例如石夢谷和仙人堀（景點16、18）。

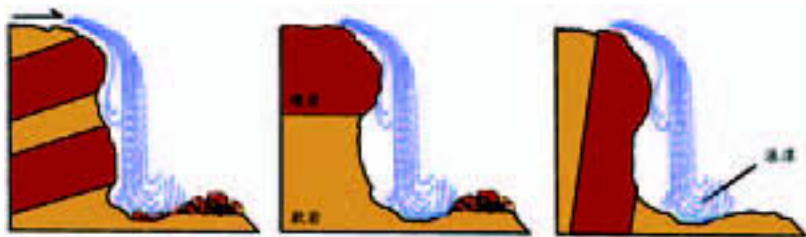


【壺穴圖】
Formation of potholes

本區境內大多是位在河流的上游段，上游河谷的谷床通常較為狹窄，河階地形不甚發達，還有一些是支流扇階。由於這類地形是山區少見的平坦地，大多已被開發為聚落用地或農地。另外值得介紹的是八掌溪在觸口以下發展的沖積扇階。八掌溪在觸口流出在此形成廣大的沖積扇（景點35）。此扇自東向西低降，後來因河流下切，而相對抬高形成扇階。

（三）風化與崩壞地形

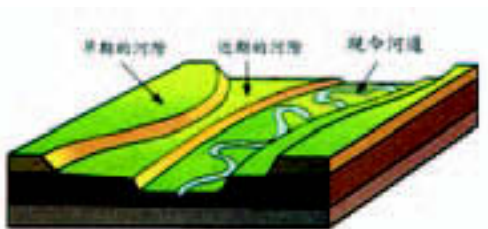
在許多改變地表形態的外力作用中，風化作用和崩壞與各種侵蝕作用最大的不同是，風化作用最靜態卻又無所不在。只要接觸到空氣或水分，岩石就會逐漸碎裂、疏鬆或體質弱化，只是不同的岩石性質風化效果的差異很大，而風化產物也較容易被其他的作用侵蝕搬運帶走。像本區多處大石壁，因為岩質堅硬，所以風化效果有限，而少量的風化產物也很容易被流水沖刷帶走，所以壁面總是看來光潔而無碎石堆積其上。



【硬岩瀑布與支流懸谷瀑布】
Waterfalls

Rivers flow especially rapidly in the upstream areas, carrying loose stones that carve out the riverbed and form elliptical or rounded holes in hard rock that are called potholes. These small landforms are often found in clusters, and two neighboring potholes may also be connected when the wall separating them has been eroded away. This can result in interesting shapes, such as those found in the Shihmong Valley and the Sianrenjyue (Scenic Sites 16, 18).

The Scenic Area is situated mostly in the headwater areas of rivers. The valley floors in these upstream areas are usually narrower, and river terraces are not well developed, though tributaries may form fan terraces.



【河階圖】
River terraces

Since flat areas such as fan terraces are rare in mountainous areas, they have mostly been developed for settlements or farming. One worthy of note is the alluvial fan terrace of the Bajhang River that formed below Chukou. There, the Bajhang River flows out of Chukou and forms a large alluvial fan (Scenic Site 35) descending from east to west. Since the river later continued to downcut, the land forming the fan terrace is relatively higher.

(3) Weathering and Mass-movement Related Landforms

Among the external forces that shape land surfaces, including mass

若一處地層是由抵抗風化能力不同的岩石所構成，長期下來經常造成硬岩處突出、軟岩處凹入的形態，就稱為差別風化。本區頗負盛名的奇特地景燕子崖、蝙蝠洞（景點28、29）都是差別風化的產物。若一地除了風化作用，還有流水同時進行侵蝕，而且作用更為顯著，則可以差別侵蝕稱之，本區很多瀑布流經薄層的砂頁岩互層，瀑面岩壁經常是凹凸有致就是一例。

臺灣島因為板塊運動活躍、地層破碎、地勢起伏大、風化侵蝕作用旺盛等環境特性，崩壞作用（山坡崩塌）是最自然不過的現象，本區也不例外。一般人對崩塌的印象大多把它看成是破壞的力量，大者山崩地裂、屋倒塌斷，小者落石砸車傷人，很少從地景欣賞的角度來看它所造成的地

▶ 風化作用

Weathering Processes

地表的岩石與空氣（尤其是氧氣和濕氣）、水分接觸或因生物活動等影響，而使其發生崩解或分解的現象，稱為風化作用。一般將風化作用分為物理風化和化學風化兩大類，前者主要指造成岩石崩解碎裂的作用；後者則指造成岩石成分改變而使體質弱化的作用。通常高溫高濕的環境較有利於各種化學風化作用的進行，低溫乾燥或暴露岩壁的山區則較有利於物理風化作用的進行。

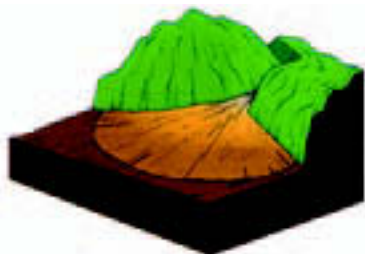
Rock on land surfaces disintegrates or decomposes in a process called weathering, due to exposure to air (especially its oxygen and moisture) and water, as well as the activities of living organisms. Generally, weathering is classified as either physical or chemical. Physical weathering refers to the splitting and disintegration of rock, while chemical weathering refers to the weakening of rock structure due to changes in composition. Typically, high temperatures and very humid environments facilitate various types of chemical weathering, whereas low temperatures, a dry environment, or exposed cliffs in mountain areas contribute to physical weathering.

movement and erosion, weathering is unique because it is both gradual and ubiquitous. When rocks are exposed to air or water, they gradually disintegrate, loosen up, or weaken. Different rocks, however, exhibit very different weathering effects, and the products of weathering are like-

wise easily eroded and carried away by other forces. Since many of the rock walls in the Scenic Area are hard, weathering is limited, and the small amounts of weathering products are easily carried away by flowing water. For this reason, the surface of rock walls here are generally clean and smooth and free of accumulations of loose rock.

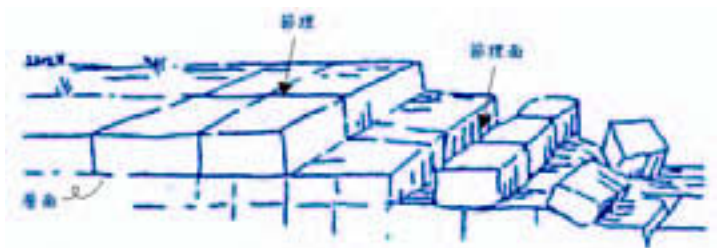
If the strata of a particular area are composed of rocks with different degrees of resistance to weathering, a phenomenon known as differential weathering will leave the harder rock protruding and softer rock indented after a long period of weathering. The famous Swallow Cliffs and Bat Caves in the Scenic Area are products of differential weathering. If an area experiences weathering and water erosion at the same time, and the effects of the latter are more pronounced, it can be called differential erosion. One example of this is the many waterfalls in the Scenic Area which flow over thin interbedded layers of sandstone and shale, resulting in an uneven rock wall.

The environmental characteristics that favor tectonic plate activity, the disintegration of strata, rugged terrain, and weathering and erosion



【沖積扇圖】

Alluvial fan



【岩石沿裂面崩解示意圖】
Rocks disintegrate along the fractures

形。本區常見的崩壞地形有：由陡坡墜落或翻滾而下的巨大岩塊～落石塊（也有戲稱飛來石），如頂湖巨石（景點40），山坡崩塌後遺留下來的凹地～山崩窪，堆積在陡峭山坡下部的碎石堆～落石堆。還有因為崩塌物質堵塞河谷而積河水成湖～山崩湖（又稱堰塞湖），位在本區北界的清水溪河段，在集集地震時因為北坡嚴重的地滑，阻塞河道形成草嶺潭（景點22）。

土石流常沿著小溪溝發生，因為侵蝕搬運力量太強大，會顯著的刷深加寬河道，也常在溪口堆積形成土石（流）扇（景點8、9、10）。在豐山村的一個土石流的景點，可以讓遊客深刻的體認大自然的威力。其實遊客對於崩塌不必過度驚惶，如果了解它們絕大多數是由豪大雨催生，只要在颱風期多注意氣象報導，或出發前詢問本處，夏季午後雷陣雨時遠離溪流或陡崖，就可避免危險。

（四）相關連的地景

就如同本章一開始所強調，地景是所有要素共同作用的結果。沒有風化、崩壞、侵蝕哪來的搬運、堆積！沒有上游山區邊坡的風化、崩塌與溪流的切割，山谷怎麼形成？河裡的土沙石礫從那裡來？又怎麼會有沖積扇、三角洲等河流堆積地形？其實連海邊沙灘的沙粒很大一部份也是來自上游的山區呢。

make mass movement (the collapse of mountain slopes) a very natural phenomenon throughout Taiwan, and the Scenic Area is no exception. People generally view mass movement as a destructive force, which on a larger scale caves in mountains, collapses houses, and destroys roads, and on a smaller scale, brings falling rocks that damage cars and injure people. Very rarely do people view the resultant geological formations from an appreciative perspective. Some of the mass movements seen in the Scenic Area include large hillside depressions resulting from slope collapse called the scars; the talus, piles of loose rocks accumulated below a steep mountain slope; and large boulders that have fallen or are rolling down the slopes (wittily referred to as "fly-bys"), such as the Dinghu Rock. There is also a barrier lake, the Caoling Lake, which has formed because a portion of the Cingshuei River (at the northern boundary of the Scenic Area) is blocked by a massive landslide on the northern slope of the river during the Chichi earthquake.

Debris flows usually occur along small river ravines. Since the flows have a powerful erosive and propulsive force, they visibly slice into the river channel and widen it, and often will form debris-flow fans at the mouth of the river. Several scenic spots featuring debris flows in Fongshan Village demonstrate nature's might. Tourists need not be overly worried about debris flows, however, if they understand that most debris flows are caused by heavy rains. Tourists can avoid danger by paying attention to weather reports during typhoon season, inquiring at the Scenic Area service center, or distancing themselves from rivers or precipices during thunderstorms in summer afternoons.



所有地形作用都是同時運作，只是其他環境因子的配合（如地層狀況）會凸顯出某些作用的成果。例如在軟硬岩層交替的地方，差別風化侵蝕的效果才會顯現出來。又如壺穴，雖然常被解釋為河流磨蝕作用的產物，但其實河床岩石的特性、風化作用和流水水力的衝擊也都十分重要。

許多地形之間都是有關連的，如本區多懸崖峭壁與多瀑布這兩種狀況也是關係密切。除了發展在順向坡的大石壁，本區還有更多的峭壁是因為持續崩場所形成的陡坡，最常見於河流的源頭，或者河谷的邊坡。河流的快速下切，造成山地與谷床很大的高度落差，河流向兩岸侵蝕，則常造成谷壁邊坡不穩，而容易導致崩塌。但是在後退過程中能一直維持陡坡則和地層的特性也很有關。

對本區軟硬互層交替的沉積岩而言，當地層傾斜角度小或接近水平時，或者傾斜角度較大的逆向坡位置，或地層中夾有抵抗侵蝕能力高的厚層砂岩時，都很有利於陡坡的維持，也就有利於懸崖峭壁的出現。如果有河流流經這類懸崖，就常形成瀑布。不過因為要有夠大的集水區，河流才會終年有水，所以很多在接近山脊的懸崖上的溝澗，只有在豪雨時才有水流，而出現臨時的瀑布。

(4) Relationship between Scenic Sites

As emphasized at the beginning of this chapter, the appearance of the landscape is produced by a combination of factors. Without weathering, mass movement, and erosion, there would be no matter to transport or accumulate, and how could valleys form without the weathering of slopes, mass movement, or the downcutting of rivers in the mountain areas upstream? Where would the soil, sand, and gravel in the rivers come from? How could there be alluvial fans and deltas? In fact, a large portion of the sand on beaches likewise comes from mountain areas upstream.

All processes affecting landforms occur simultaneously, but the combined effect with other environmental factors (such as the condition of a stratum) can amplify certain results; for instance, differential weathering is evident in areas with interbedded layers of hard and soft rock. In addition, although potholes are usually explained as product of abrasion in rivers, the characteristic of rocks in the riverbed, weathering effects, and the strength of the river's flow are also important determining factors.

Many landforms are related; for



▶ 崩壞作用

Mass Movement

崩壞作用是指地表或接近地表的土壤、岩石等因重力作用而沿山坡向下崩落移動的現象，有非常多類型，包括快速的岩塊墜落和土石流到極緩慢的潛移。土石流是泥砂礫（以礫為主）等未固結的物質與水混合的一種流體，因為含有較多的水分，移動速度快，又因常挾帶巨石，所經之處無堅不摧，只有在流出谷口或在河道加寬、變緩之處，才會停下來。

Mass movement refers to the downward sliding of soil and rocks on or near the land surface along mountain slope because of gravity. There are many kinds of mass movement, including the rapid rockfall and debris flow, as well as the very slow creep. Debris flow is a flowing mixture of loose matters and water, such as mud, sand, and gravel (primarily gravel). Since it is composed mostly of water, it flows at a faster rate and is formidable due to the large rocks it carries. Debris flow stops only when the stream slows down at the mouth of the valley or when river channel widens.

在台灣，颱風豪雨和大地震是造成崩塌最主要的自然外力，因建屋或開路不當開挖所造成的崩塌也顯著增多。但受到同樣外力的干擾時，有些山坡特別容易崩塌，有些則否，這就和山坡本身的特性很有關係。

In Taiwan, typhoons, heavy rains, and severe earthquakes are the natural forces that cause mass movement. Incidents of mass movement due to improper excavation for house and road construction are also increasing in number. But when subjected to similar external forces, mass movement readily occurs in some mountains but not in others, depending on the characteristic of the particular mountain slope.

instance, many precipices and waterfalls in the Scenic Area are closely related. In addition to large rock wall formations in dip slopes, the Scenic Area has even more precipices formed by continuous mass movements, which are most frequently seen at the headlands of a river or the slopes of a river valley. The rapid downcutting of the river produces large differences in elevation between the mountain area and the valley floor. Erosion along the banks of a river makes valley walls unstable and vulnerable to collapse. The maintenance of steep slopes even as the valley walls recede from the river is related to the characteristics of the local strata.

Given the sedimentary rocks with interbedded hard and soft layers in the Scenic Area, it is easy to maintain slopes when the slope of a stratum is mild nearly horizontal, as well as in escarpments with a steep inclines, or when the stratum includes thick layers of sandstone with higher resistance to erosion. These factors contribute to the formation of precipices, and rivers flowing across such precipices often form waterfalls. Because a large catchment area is required to maintain a year-round flow, channels above precipices near high mountain ridges only have flowing water during heavy rains, when waterfalls are sometimes temporarily created.

