土木工程拓展署
土力工程處
Geotechnical Engineering Office
Civil Engineering and
Development Department

香港的地景
HONG KONG LANDSCAPES

地質與地景 3
GEOLOGY AND LANDSCAPE 3

前言

教育局於2005年公布，三年新高中學制將於2009年9月在中四級實施。地理科是其中一個重點的選修科目。

新高中地理科課程是根據2005年教育局出版的一份文件和課程發展議會《高中課程指引》(2007)的建議而制訂。在此課程中，地理被視為一門學科讓學生可以從空間的角度了解自身所處的地球。

土木工程拓展署轄下的土力工程處應教育局的請求，在天然災害及地球科學兩個新高中地理科課程內容上製備了一份「教學支援教材套」。其中有關香港岩石及礦物的資料亦適用於部份化學科的課程。

「教學支援教材套」包括了14本小書冊、4張海報、3片光碟及其他一些補充資料。此教材套在香港的斜坡安全、山泥傾瀉、地質及地貌等課題上提供了合適及最新的資料並同時符合新高中地理科課程的水平。

土力工程處的「香港地質調查組」負責編寫有關香港地質及地貌方面的內容，而「斜坡安全部」則負責香港斜坡安全及山泥傾瀉的部份，「斜坡安全部」的同事亦負責整個項目的策劃與安排。我謹向各位參與這項工作的同事致謝。

我相信這教材套對各位負責新高中地理科目的老師在擬備教材時能提供合適的參考。此教材套亦給予有興趣於這些課題的廣大讀者一些有用的資料。

陳健碩
土木工程拓展署
土力工程處處長
2008年12月

Foreword

In 2005, the Education Bureau (EDB) announced that a three-year New Senior Secondary (NSS) curriculum would be implemented at Secondary 4 in September 2009. Geography is one of the elective subjects under the NSS curriculum.

The NSS curriculum has been developed on the basis of the recommendations made by an EDB document in 2005 and a Senior Secondary Curriculum Guide of 2007. Within the curriculum, geography is seen as a key educational discipline that provides students with a spatial understanding of the Earth on which we live and work.

At the request of the EDB, the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department have prepared support teaching materials for the NSS Geography curriculum under the topics of Natural Hazards and Earth Science. The materials written on rocks, minerals and ores in Hong Kong are also suitable for part of the Chemistry curriculum.

The "Teaching Support Materials Kit" consists of 14 booklets, 4 posters, 3 CDs and other supplementary information sheets. This teaching kit contains pertinent and up-to-date information on slope safety, landslides, geology and geomorphology in Hong Kong, written at a level that is suitable for the NSS Geography curriculum.

Hong Kong Geological Survey of GEO have compiled the teaching materials that describe the geology and geomorphology of Hong Kong. The Slope Safety Division of GEO have prepared the teaching materials on Hong Kong slope safety and landslides. Colleagues in the Slope Safety Division are also responsible for the overall planning and coordination of this project. Their contributions are gratefully acknowledged.

I am confident that, for years to come, secondary school geography teachers will find the kit invaluable for preparing their classroom teaching materials. The contents will also be of interest to the more general readers who may wish to learn more about these topics.

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引言
Introduction

我們的地球是一個由大氣圈、水文圈、生物圈及岩石圈四個主要部份組成的動力體系。這四個部份在漫長的地球歷史中，持續互相影響。地質學為一門研究岩石圈的科學，並且包含岩石圈與其他三個部份相互作用的研究。

地形學是指對地貌的性質及成因的研究，特別是在大氣圈及水文圈中的風化及侵蝕過程。這些過程不斷改變地球表面形狀**(地質與地景之一)**，並且產生岩石循環中的沉積物。地形是岩石圈、大氣圈及水文圈互動產生的結果**(地質與地景之二)**。香港的天然地景是基於地質及地貌作用而形成，並多見於香港的郊野公園**(地質與地景之三)**。人為活動例如填海及築建水塘等，都改變了天然的地貌。

Our Earth is a dynamic system that comprises four main components: the atmosphere, the hydrosphere, the biosphere and the geosphere. These four components have been continuously interacting throughout the Earth's long history. Geology is the science that studies the geosphere, and encompasses the interactions between the geosphere and the other three components.

Geomorphology is the study of the nature and origin of landforms, particularly of the formative processes of weathering and erosion that occur in the atmosphere and hydrosphere. These processes continually shape the Earth's surface **(Geology and Landscape 1)**, and generate the sediments in the Rock Cycle. Landforms are the result of the interactions among the geosphere, atmosphere and hydrosphere **(Geology and Landscape 2)**. The natural landscapes of Hong Kong, displayed in many of the Country Parks, are determined by the underlying geology and geomorphological processes **(Geology and Landscape 3)**. Human activities, such as reclamation and the construction of reservoirs, have considerably modified the original landscapes.

內容
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地質學與香港的郊野公園

香港的土地面積約有四成受「郊野公園條例」管轄，使廣大面積的天然地貌免受市區化壓力的影響，得以為下一代保存(圖1)。這些地方包括大多數的山地、風景綿長的海岸線，以及大部分的離島。令這些地方成為研究地質學及地形學的理想戶外實驗室。

進出及置身於郊野公園並不受限制，但是，在郊野公園內嚴禁損壞露頭岩石進行採集岩石樣本或尋找化石。研究工作應該僅限於觀察、描述、量度、描繪及攝影，此舉方能讓無法替代的地質特色得以保持完好無缺，留待未來世世代代的學生及訪客觀賞。

大欖郊野公園 — 花崗岩地區、風化及斷層

大欖郊野公園提供了極佳的機會，以研究由斷層控制的主要山谷、花崗岩的風化特色(包括突岩、巨礫、抗風化的石英岩脈)、蝕溝受嚴重侵蝕的後果、及控制侵蝕作用的植林。

大欖郊野公園蘊藏着侏羅紀年代的大欖花崗岩，屬中至幼粒花崗岩。不同粒體大小的花崗岩構成截然不同的地貌，有渾圓的被侵蝕的山丘地形，也有嶙峋的突岩群和巨礫區域。

東北-西南走向的大欖斷層橫跨了大欖郊野公園，深層風化及選擇性的侵蝕沿着此大型斷層出現，形成一個筆直峽谷，包含今天的大欖水塘(圖2)。

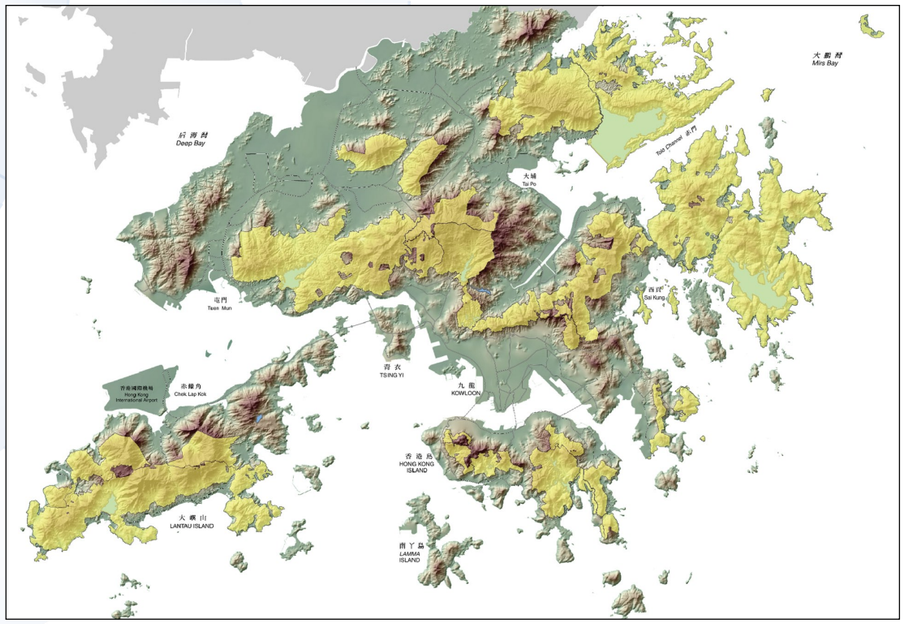

圖1. 香港的郊野公園(圖中黃色部份)。
Figure 1. The Hong Kong Country Parks (shaded in yellow).

Geology and the Hong Kong Country Parks

About 40% of the land area of Hong Kong is designated under the Country Parks Ordinance (Figure 1), which protects large areas of the natural landscape from the pressures of urbanisation, and preserves them for posterity. These areas encompass most of the wild upland regions, extensive sections of scenic coastline, and large segments of the outlying islands, making them ideal outdoor laboratories for geological and geomorphological studies.

Access to, and within, the Country Parks is unrestricted. However, it should be emphasised that the damaging of rock outcrops, for collecting rock samples or searching for fossils, is prohibited. Studies should be carried out purely by observation, description, measurement, sketching and photographing. In this way, irreplaceable geological features will be left intact and undamaged for future generations of students and visitors to observe.

Tai Lam Country Park – Granitic Terrain, Weathering & Faults

The Tai Lam Country Park presents an excellent opportunity to examine a major fault-controlled valley, features of granite weathering including tors, boulders, resistant quartz veins, the effects of severe gully erosion, and erosion-control planting.

The Tai Lam Country Park is underlain by the Jurassic Tai Lam Granite, a medium- to fine-grained porphyritic granite, which has given rise to contrasting landscapes of rounded and eroded hills, and rocky tors with boulder fields.

The Country Park is traversed by the northeast to southwest trending Tai Lam Fault. Deep weathering and preferential erosion along this extensive, linear fault trace has resulted in the straight master valley that today contains the Tai Lam Reservoir (Figure 2).

圖2. 沿大欖斷層侵蝕而成的筆直河谷。
Figure 2. Linear valley eroded along the Tai Lam Fault.

位於大欖郊野公園中央的花崗岩經過深層風化，以及後期多次受開墾者砍伐樹木，使該地區受到嚴重的侵蝕而形成「劣地」的地貌，其中有遭深度侵蝕的蝕溝，及沙泥暴露的山頂(圖3)。

在1980年代控制侵蝕措施實行之前，區內活躍的侵蝕溝道形成複雜形態活現在山頭。當中包括在山頂區樹枝狀的細溝，這些細溝山坡下方匯集並進入深窄的蝕溝。大多數情況，蝕溝多從源頭開始被侵蝕，以致源頭變成非常陡峭的斜坡。細溝的支流進入蝕溝的地方，實際上是瀑布。

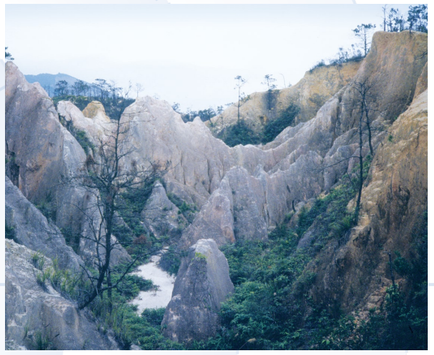

圖3. 大欖郊野公園中的蝕溝。
Figure 3. Erosion gullies in the Tai Lam Country Park.

儘管近年來區內大部分地方都已植林以控制破壞性侵蝕，但是蝕溝仍然保存在地貌之上。

行經這處的群山，會發現地面覆蓋著一層含沙、粉砂及黏土組成的土壤。這些物質為花崗岩受風化後的殘餘物，其中有從長石分解而成的粉砂/黏土，以及直接從石英演變得來的沙。由於這些土壤脆弱且易於流失，因此如沒有天然植物作保護層，土地將極易被侵蝕。

穿過山峰及山坡，會發覺具抗風化及抗侵蝕的石英脈，像一幅矮短石牆。這些岩脈的顯現是因周圍較軟、受風化後的花崗岩經侵蝕後被移離。

在大欖郊野公園的其他範圍，花崗岩的突岩，屹立於山峰上、岔線盡頭及山谷兩旁，或是形成山旁的小懸崖。在南邊，可見巨礫覆蓋山峰及山旁，而巨礫的溪澗則圍繞山谷(圖4)。

西貢郊野公園 — 火山岩範圍及海岸營力

西貢郊野公園的東南部提供了一個理想機會，以研究在遠古時代於火山盆地內形成，迷人的含柱狀節理的岩石。

西貢郊野公園的東南部蘊藏白堊紀時代的糧船灣組的火山岩層。

糧船灣組別具特色、含柱狀節理的岩石，於大型的西貢破火山口內形成。西貢破火山口是個龐大的火山盆地，是當原來的火山中心倒塌後剩下的低火山口邊緣。

來自破火山口西北面的證據顯示，西貢破火山口的直徑最少達20千米。然而，從前南方及東方的破火山口邊緣的位置，相信已處於今天的海底。

The granite in the central areas of the Country Park is deeply weathered and, following several periods of deforestation by successive waves of settlers, the area has been severely eroded to create a 'badlands' landscape of deep erosion gullies and exposed sandy soils on the hill summits (Figure 3).

Prior to the implementation of erosion control measures in the 1980s, an intricate pattern of active erosion channels scarred the hills in this area. These comprised dendritic networks of small rills on the summit areas, which converge downslope to enter deep and narrow gullies. Headward erosion of the gullies has, in most cases, resulted in a very steep scarp at the head of the gullies. Tributary rills enter the gully at this point over what is, in effect, a waterfall.

Over recent years, trees have been planted over much of the area to control the damaging erosion, although the gullies are still preserved in the landscape.

Traverses of the hills will reveal a surface covered with a sandy, silty, slightly clayey soil. This material is the residue of granite weathering, comprising silt/clay derived from decomposition of the feldspars and sand derived directly from the quartz. The soil is crumbly and easily displaced, hence is very susceptible to erosion if not clothed with a protective cover of natural vegetation.

Traversing the summits and slopes, like low stone walls, are weathering- and erosion-resistant veins of white quartz. These veins have been exposed as the softer surrounding weathered granite was removed by erosion.

In other areas of the Country Park, granitic bedrock is exposed as blocky tors on hill summits, spur ends or valley sides, or as small cliffs on hillsides. Towards the southern margins, boulder fields mantle the summits and hillsides, and boulder streams choke the valleys (Figure 4).

圖4. 巨礫散落在新界西部的山丘上。
Figure 4. Boulder strewn hills of the western New Territories.

Sai Kung Country Park – Volcanic Terrain and Coastal Processes

The southeastern part of the Sai Kung Country Park presents an excellent opportunity to examine fascinating columnar-jointed volcanic rocks that formed in an ancient volcanic depression.

The southeastern part of the Sai Kung Country Park is underlain by volcanic rocks of the Cretaceous High Island Formation.

The distinctive columnar jointed rocks of this Formation were formed in a large caldera, the Sai Kung Caldera, a large, low-rimmed volcanic depression that survived after the original volcanic centre had collapsed.

含柱狀節理的岩石屬凝灰岩，原來是一層既厚又炙熱的火山灰堆積覆蓋於破火山口盆地上。火山灰緩緩冷卻，並隨着冷卻而收縮，形成與冷卻面垂直的冷縮節理(冷卻面是指位於灰層的底部、破火山口的地面，及灰層上部的大氣圈)。

基於上述情況，冷縮節理呈現出緊密互扣的六角形網絡(圖5)，而六角形是幾何學上最穩固的堆疊圖案。

圖5. 糧船灣組的柱狀節理。
Figure 5. Columnar jointing in the High Island Formation.

大部分的石柱都是垂直或近乎垂直，然而，從近距離觀察岩石的表面，會在某些地方發現石柱傾斜，或成淺S形的彎曲(圖6)。在冷卻過程期間，火山灰經歷塑性階段。區內持續發生的火山活動，引發地震或破火山口地面下陷，導致火山灰層以緩慢的蠕動在火山盆地沉積下來，而其石柱彎曲的形狀一般顯示向東南方的蠕動。

觀察亦發現深色岩石條帶傾向地穿過石柱(圖6)。這是岩牆，是玄武岩質岩漿從隙縫(節理或斷層)迂迴地侵入石柱而成，岩漿侵入是當火山灰已凝結成堅硬的凝灰岩之後發生。這顯示在火山活動後的時期，岩漿湧上穿過已存在的岩石。

圖6. 岩牆侵入於具柱狀節理的岩石中。
Figure 6. A dyke intruded in the columnar jointed rocks.

放眼海上，可看到柱狀凝灰岩在離岸的島嶼展現，它們以突出的陡峭懸崖屹立於海中。毗鄰的石柱令懸崖顯示條紋狀圖形。

在果洲群島至糧船灣一帶出現的石柱發展得尤為完善。

海浪侵蝕導致部份石柱崩塌，在懸崖面留下筆直的槽溝。如只有石柱的下部崩塌，上部會保持懸垂。在其他地方，石柱的上段則沿傾斜裂縫崩塌，造成多面傾向海邊的斜坡。

在部份地方，較脆弱及抗侵蝕力較弱的岩石被侵蝕，導致石柱集體倒塌，並形成海蝕洞。較罕見的是海蝕洞在狹窄的岬角兩邊較弱的地方同時被侵蝕，最終連結合一起形成海蝕拱。

Evidence from the surviving fragments of the northwestern section of the caldera indicates that the Sai Kung Caldera was at least 20 kilometres in diameter. However, the locations of the former southern and eastern caldera rims lie somewhere out under the sea today.

The columnar jointed rocks are tuffs, which originally accumulated as a very thick blanket of extremely hot volcanic ash on the floor of the caldera. The ash cooled slowly, gradually contracting and developing vertical joints that formed at right angles to the bounding surfaces (*i.e.* the floor of the caldera at the base of the ash layer, and the atmosphere at the top of the ash layer).

From above, the cooling joints display a tightly interlocking hexagonal network (Figure 5). Hexagons are the most efficient geometrical 'stacking' pattern.

Most of the columns are vertical, or subvertical. However, close observation along the rock faces will reveal that, at certain locations, the columns are inclined or have a shallow S-curve (Figure 6). During the cooling process, the ash body would have passed through a plastic state. Continued volcanic activity in the region would have periodically produced earth tremors or local subsidence of the caldera floor, causing the ash layer to settle into the depression by a process of slow creep. The shape of the flexures generally indicate that creep was towards the southeast.

Observations will also reveal that there are bands of a darker rock that traverse the columns obliquely (Figure 6). These features are dykes, discordant (*i.e.* not following the main structures) intrusions of basaltic magma that would have penetrated an oblique crack (joint or fault) across the columns, long after they had cooled to form hard tuffs. They indicate that in subsequent periods of volcanic activity, magma was forced up towards the surface through the pre-existing rocks.

Looking out to sea, the columnar-jointed tuffs can be seen displayed along the offshore islands, where they form very distinctive vertical cliffs that rise abruptly out of the sea. The adjacent columns give the cliffs a striated appearance.

The columns are also particularly well-developed on the Ninepin Group of islands to the south of the High Island area.

Erosion by the waves has resulted in the collapse of some columns, leaving vertical slots in the cliff faces. Where only the lower part of a column has collapsed, the slots are topped by overhangs. In other places, collapse of the upper sections of columns along inclined fractures has produced polygonal facets that slope towards the sea.

In some places, erosion along weaker, less erosion-resistant, zones has resulted in concentrated areas of column collapse, and the formation of sea caves. More rarely, caves developing along weaker zones from opposite sides of a narrow promontory or headland have merged to create sea arches through the cliffs.

八仙嶺郊野公園 — 沉積岩及結構

八仙嶺郊野公園呈現一個研究大型陡崖及相關的水系、瀑布及近期的天然山坡山泥傾瀉的理想機會。

八仙嶺郊野公園主要蘊藏白堊紀時代的八仙嶺組岩層，在此岩層之下是侏羅紀時代大帽山組的火山岩。

白堊紀八仙嶺組的岩石主要為紅褐色厚層礫岩，灰紅色的砂岩，以及紫紅色的粉砂岩。這些岩石本來沉積於兩大主要地質環境。礫岩和含卵石的砂岩積聚於河道，而席狀砂岩是在一個半乾旱的環境以片流形式沉積。

這些岩石向北傾斜約20°至25°，形成香港唯一的大型陡崖(圖7)。陡崖上的山脊形成顯著的山峰，由西面的黃巒(639米高)伸延至東面的觀音峒(304米高)。

圖7. 八仙嶺的陡崖。
Figure 7. The Pat Sin Leng escarpment.

基於陡崖的不對稱形狀，在陡崖南方的山坡上是陡傾而短直的河道，只在降雨時有水流，這些河道稱為季節性或短暫性河流。相反，北面山坡上的溪澗隨較平坦的斜坡向下流，其河道較長，因而發展成典型的樹枝狀支流，全年川流不息。這些河道稱為永久性或常流河。結果，位於八仙嶺陡崖以南的村落只能從山上獲取極少量的供水，但在較平坦的斜坡的山腳則可獲恆常的供水。

靠近陡崖的中央，純陽峰山頂之東(588米高)，山脊被山谷分隔，是現時的糧船灣水塘的位置。接近新娘潭的山谷源頭有由八仙嶺組岩層組成、景色優美的瀑布。

這瀑布顯示出多項典型瀑布發展的特質，包括堅硬抗侵蝕的石牆，清晰的裂點、在瀑布底部的掏槽、近圓型的瀑潭，受掏蝕的河床岩石及壺穴。

多個近期的天然山坡山泥傾瀉可在南方較陡峭的山坡發現，大部分是較淺而短的滑坡。

市區地形

因人類活動而改變的地形

過去數千年來，天然過程不斷地侵蝕及塑造大地。近期的人類活動改變土地面貌的速度，遠比天然過程快。香港原來的地形大部份已因人類活動而改變，主要為供應額外的建築用地、建築物料及可靠的水源。香港可建樓宇的平地有限，亦沒有湖泊、

Pat Sin Leng Country Park – Sedimentary Rocks and Structures

The Pat Sin Leng Country Park presents an excellent opportunity to examine a large escarpment, the associated drainage patterns, a waterfall, and recent natural terrain landslides.

The Pat Sin Leng Country Park is predominantly underlain by Cretaceous rocks of the Pat Sin Leng Formation, which are in turn underlain by volcanic rocks of the Jurassic Tai Mo Shan Formation.

The Cretaceous rocks are reddish-brown, thickly bedded conglomerates, greyish red sandstones, and reddish purple siltstones that were originally laid down as beds in two main geological settings. Conglomerates and pebbly sandstones were deposited in river channels, and the overlying sheet-like sandstones were deposited by sheet floods in a semi-arid environment.

The rocks dip towards the north at about 20° to 25° to form the only large escarpment in Hong Kong (Figure 7). The crest of the escarpment forms a prominent ridge that extends from Wong Leng (639 metres high) in the west to Kwun Yam Tung (304 metres high) in the east.

Because of the asymmetrical shape of the escarpment, streams on the southern scarp slope have steep, linear, and very short courses, and only flow following rainfall. These are termed seasonal or ephemeral streams. In contrast, streams on the gentler northward sloping dip slope have longer courses, so they have developed a typical dendritic pattern, and flow almost all year. They are termed permanent or perennial streams. Consequently, villages on the southern side of the Pat Sin Leng escarpment receive very little water supply from the hills above them, whereas villages located on, or near the foot of, the dip slope tap into an almost permanent water supply.

Towards the centre of the escarpment, to the east of the summit of Shun Yeung Fun (588 metres high), the ridge is breached by a valley that is now occupied by the waters of the Plover Cove Reservoir. Near the head of the valley at Bride's Pool is a very scenic waterfall that plunges over a rock shelf composed of the Pat Sin Leng Formation.

This waterfall displays many classical features of waterfall development including a hard, resistant rock band, a well-defined knick point, undercutting at the base of the fall, an almost circular plunge pool, scouring of the rock that forms the bed of the stream, and deep potholes.

Several recent landslide scars can be seen on the steeper southern scarp slope, most of which are shallow, short runout features.

The Urban Landscape

Modifications of the Landscape by Human Activity

Natural processes have steadily eroded and shaped the land over thousands of years. More recently, human activities have changed the surface of the earth at rates far faster than those of natural processes. The original, pre-settlement, landscape of Hong Kong has been considerably modified by human activity, largely in order to supply additional building land, building materials, and reliable water supplies. Hong Kong has limited flat land for building, and no lakes, large rivers, or major aquifers to provide drinking water. Consequently,

河流或大型儲水地方提供飲用水。因此，須進行填海及土地平整來創造平地；亦須開採石礦以提供建材及混凝土物料；以及建築水壩及水塘來解決儲水問題。此等活動聯結一起，對香港的陸上地形、海岸線的形狀及水系形態造成深遠的影響。這不僅在市區發生，亦包括在新界區的村莊。

沿岸填海

香港首個填海建議於1855年提出，為堅尼地城的西區海傍計劃。該計劃最終於1868年展開，並於1873年完成，為海旁增加了50公頃(0.2平方公里)的土地。

第二個填海計劃於1890年2月動工，並在1904年完成，共動用了350萬噸物料創造出65公頃(0.3平方公里)的新土地。

在接續下來的幾年間，填海速度迅速加快。由1868年至1967年間，共填平了10平方公里土地；由1967年至1991年間，另增加了30.5平方公里的額外土地；而1991年至1995年間，進一步加添19平方公里的新填海土地。總計填海得來的新增土地，合共超過60平方公里(圖8)。

香港大部份的新市鎮，包括天水圍、馬鞍山、將軍澳、沙田、屯門、荃灣及東涌，都涵蓋廣大的填海土地。

同時，香港多個著名發展項目均建於填海土地上，有前啟德機場、新赤鱲角機場(12.5平方公里)(圖9)，以及九龍半島及港島中區的龐大面積，其中包括：西九龍填海區(3.3平方公里)和迪士尼項目(2平方公里)。

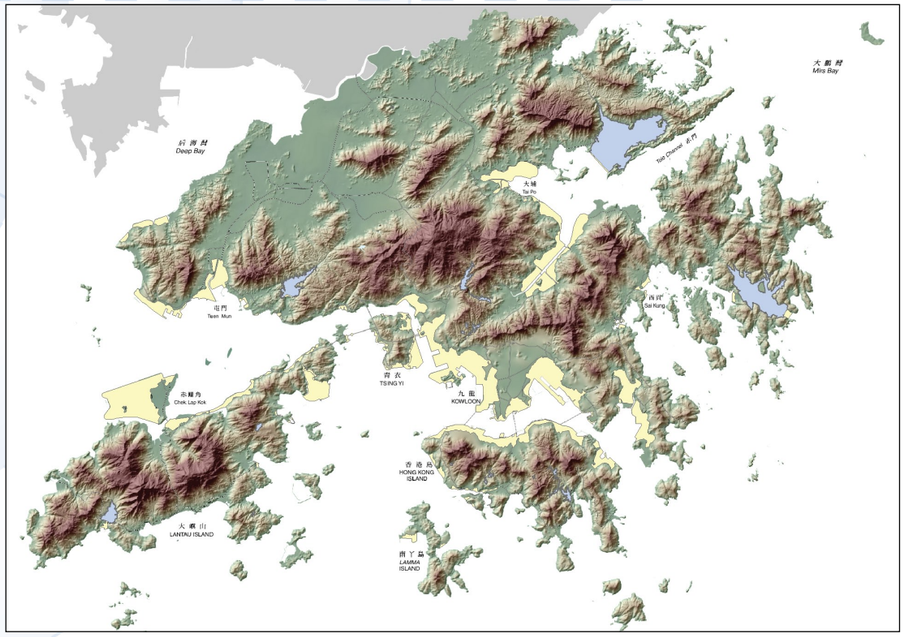

圖8. 香港的填海地區(圖中黃色部份)。
Figure 8. Reclamations in Hong Kong (shaded in yellow).

flat land has been created by coastal reclamation and site formation, quarrying has provided building materials and concrete aggregates, and water has been stored by building dams and impounding reservoirs. Together, these activities have had a profound effect on the onshore topography, the shape of the coastline, and the drainage pattern of Hong Kong, not only in the urban areas, but also in many of the New Territories villages.

Coastal Reclamations

The first proposal for land reclamation in Hong Kong was made in 1855 for the Western Praya Scheme in the area of Kennedy Town. The scheme eventually began in 1868 and was completed in 1873, adding 50 acres (0.2km^2) to the waterfront.

A second reclamation scheme commenced in February 1890 and was completed in 1904, using about 3.5 million tons of material to create 65 acres (0.3km^2) of new land.

Over the succeeding years, the rate of reclamation increased almost exponentially. Between 1868 and 1967 a total of 10.0km^2 had been reclaimed, between 1967 and 1991 an additional 30.5km^2, and between 1991 and 1995 a further 19.0km^2 were reclaimed. In total, more than 60km^2 of land have been formed by reclamation (Figure 8).

Most of the New Towns in Hong Kong, including Tin Shui Wai, Ma On Shan, Tseung Kwan O, Sha Tin, Tuen Mun, Tsuen Wan, and Tung Chung, comprise large areas of coastal reclamation.

Also, many of the notable developments in Hong Kong are located on reclaimed land, including the former Kai Tak Airport, the new Chek Lap Kok Airport (12.5km^2) (Figure 9), large areas of the Kowloon peninsula and Central District on Hong Kong Island, including the West Kowloon Reclamation (3.3km^2), as well as the Disneyland complex (2.0km^2).

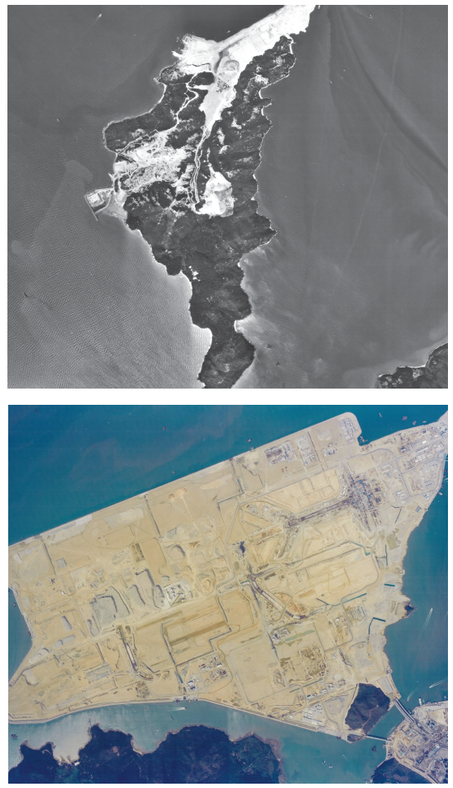

圖9. 填海前和填海後的赤鱲角。
Figure 9. Chek Lap Kok before and after the airport reclamation.

Today, reclaimed land makes up about 6% of the onshore area of Hong Kong, development land that now supports housing for about 20% of the population.

今天，香港約有百分之六的土地面積來自填海，足以應付約百分之二十的人口興建住屋。

首項填海工程以傾倒公共廢物進行，包括建築及家居廢料。方法是先興建堤壆，然後將城市廢物棄積於潟湖中。這辦法進展緩慢，需多年時間始能完成。

多個早期的填海工程採用海沙作材料，項目包括啟德擴建(1929,1931及1956-1959)、銅鑼灣避風塘、維多利亞公園及屯門新市鎮的填海工程。

許多大型填海工程，則從山邊挖取風化岩石作為填海物料。這方法的優點是較使用棄置公共廢物的方法快捷。同時，開挖而得的新土地可用於建屋發展。

然而，選用風化岩石的缺點是由於風化岩石的粒狀大小不規則，並含有體積較大碎石，加上含黏土成份阻礙排水。同時，挖掘、爆破工程及重型車輛運載物料，都會為市區帶來環境滋擾。

於1980年代海沙為首選的填土材料，率先應用於兩個重大項目。葵涌貨櫃六號碼頭於1986年至1989年間興建，共耗用了860萬立方米海沙；而天水圍新市鎮於1986年至1988年間興建，共用了2,400萬立方米海沙。這方法的優點是快速，對環境造成的滋擾減至最低，而且填土的排水及整固迅速。

主要土地形成

除進行填海工程外，亦可透過平整山頂或將斜坡切割成平台，以增加發展土地。採用這方法以獲得土地的例子眾多，包括不同規模由興建小型村屋以至發展大型屋苑。

隨著九龍半島的發展逐漸北移，多個大型屋苑(例如慈雲山及竹園)是將九龍山腳削開作發展用途。同樣地，在香港島的主要項目，如康怡花園，也涉及切割香港島的山坡。近期在佐敦谷土地平整工程包括遷走大量岩石(圖10)。

圖10. 佐敦谷土地平整工程。
Figure 10. The Jordan Valley site formation.

多個工程如將軍澳新市鎮發展計劃，同時涉及大型土地平整及填海。岩石大規模地從山旁移走，形成一個環繞海灣的平台，而大部分挖出來的岩石，則作填海之用。

The first reclamations were carried out using material provided by public dumping, including construction and household waste. Bunds were built, and city waste was deposited in the lagoons. This method was slow, taking many years to complete.

Several early reclamations were carried out using sand from offshore sources. These included the Kai Tak extensions (1929, 1931 and 1956-1959), the Causeway Bay Typhoon Shelter, Victoria Park, and Tuen Mun New Town.

Many large reclamations were carried out using weathered rock obtained by cutting back into hillsides. This method had the advantages of being faster than public dumping, and also created new land for housing developments in the "Borrow Areas".

However, there were several disadvantages to using weathered rock. The placed fill required a long period to settle because of the irregular particle sizes, which included large rock fragments, and the material drained slowly because of the clay content. Importantly, severe environmental disturbance was created in city areas during excavation and blasting, and by heavy vehicles transporting material to the coastline.

Offshore sand became the preferred fill option in the 1980s, pioneered by two important projects. Container Terminal 6 was constructed between 1986 and 1989 using about 8.6Mm^3 of marine dredged sand, and the Tin Shui Wai New Town was constructed between 1986 and 1988 using about 24.0Mm^3 of sand. This method had the advantages of being rapid, creating minimal environmental disturbance onshore, and the placed fill drained and consolidated rapidly.

Major Site Formations

In addition to reclaiming land from the sea, development land is also created by levelling the tops of hills, by completely removing hills, and by cutting platforms back into steep hillsides. There are many examples of this kind of site formation, at all scales from the erection of small village houses to the construction of vast housing complexes.

As urban development on the Kowloon peninsula gradually spread northwards, several large housing sites, such as Tsz Wan Shan and Chuk Yuen, were developed by cutting back into the Kowloon Foothills. Similarly, major projects such as the Kornhill development involved cutting into the hills on Hong Kong Island. More recently, the Jordan Valley site formation included the removal of large quantities of rock (Figure 10).

Several projects, such as the the Tseung Kwan O New Town development, involved both major site formation and reclamation. Large-scale rock removal created housing platforms on the hillsides surrounding the bay, and much of the excavated rock was used as fill for extensive areas of coastal reclamation.

採石

採石業是一門重要行業，提供建築石材及混凝土的石料。然而，鑑於採石是一項急速的人為侵蝕作用，會急速地改變地貌。在製造侵蝕痕跡之餘，同時重新分佈大量以花崗岩為主的物料。

早於1966年前，香港有不少持有「許可證」的小型石礦場，主要從事生產的建築石材，而最後一家持「許可證」的石礦場於1974年關閉，以便讓予較大型的特許石礦場。

在1978年之前，所有經處理的石料皆來自香港的石礦場。其後石料開始進口。至1987年，約有百分之四十四的需求，是從深圳及珠海經濟特區的入口而來。此改變減輕了香港受土地有限及石礦場關閉的壓力影響。

1980年，由政府經營的兩家大石礦場及七家合約石礦場，其生產約1,500萬噸石料。到了1988年，數目已減至一間由政府經營及五家合約經營者。

隨著香港人口上升，整體石料需求亦同時增加。從1960年至1990年間，整體石料消耗顯著增加，由300萬噸增至1,800萬噸。撇除期間人口上升了五成，這代表了每年每人的平均增幅由0.75噸調整至3.4噸。

如以侵蝕率來解讀這些石料的開採數量，開採1,800萬噸花崗岩相等於移離以全港土地面積為基礎(1,105平方公里)的6.3毫米厚的岩層。

根據1989年訂定的計劃，香港目前餘下三個營業中的石礦場。它們正展開復修綠化工程，以配合未來發展。石澳(將於2009年完成)、安達臣道(將於2013年完成)及藍地(將於2015年完成)石礦場的復修工程，包括重整山坡的輪廓，以減少尖峭的山勢，令山坡變得渾圓；種植樹木及樹叢，以及控制侵蝕。類似的復修工程亦曾於南丫島進行，並已於2002年完成，該處形成一個面積共0.49平方公里的綠色地帶。

復修工程除了包括改善在石礦場的地景外，亦同時生產可供銷售的石料。安達臣道石礦場於2013年將可生產共5,000萬噸岩石(於2006年產量為260萬噸)、石澳石礦場將生產共2,300萬噸，而藍地石礦場將生產共650萬噸。

石礦場無論大小都是香港地景的特徵，並可於許多地區觀看得到，顯示出人類對「侵蝕作用」作出的貢獻。

Quarrying

Quarrying is an important activity, providing both dressed building stones and aggregates for concrete. However, quarrying, which is an accelerated form of artificial erosion, dramatically changes the appearance of the landscape, both by producing 'erosion scars' (quarries), and by redistributing and 'depositing' vast quantities of, largely granitic, material.

Prior to 1966, there were numerous small 'permit' quarries scattered around Hong Kong, largely producing dressed building stone. The last 'permit' quarry closed in 1974 in favour of larger, licensed quarries.

Until 1978, all processed stone was obtained from quarries in Hong Kong. Subsequently, importation of stone began, so that by 1987 about 44% of the demand was met by imports from the Shenzhen and Zhuhai Special Economic Zones. This change reduced the pressures on the limited land area of Hong Kong, and many quarries were closed.

In 1980, two large Government quarries and seven contract quarries were operating, which produced 15 million tonnes of aggregates. By 1988 the number was reduced to one Government quarry and five contract quarries.

As the population of Hong Kong grew, the demand for aggregates grew. There was a significant increase in the consumption of aggregates between 1960 and 1990, from 3 million tonnes to 18 million tonnes. Despite a 50% increase in population over the period, this represented an annual increase from 0.75 tonnes per head to 3.4 tonnes per head of population.

To express the removal of this amount of rock material in terms of erosion rates, the quarrying of 18 million tonnes of granite is equivalent to removing a layer 6.3mm thick from the whole land area of Hong Kong (1,105km^2).

Today, under a plan formulated in 1989, the three remaining operational quarries in Hong Kong are being rehabilitated to form green areas for future development. Shek O (completion in 2009), Anderson Road (completion in 2013) and Lam Tei (in 2015) quarries are being rehabilitated under contracts that involve major recontouring to soften the appearance of the angular quarry profile, tree and shrub planting, and erosion control. A similar rehabilitation contract at Lamma Quarry was completed in 2002 to form a green site of 0.49km^2.

Rehabilitation contracts involve the landscaping of the quarries, and the production of saleable rock products. Thus, Anderson Road Quarry will produce 50 million tons of rock up to 2013 (2.6 million tons in 2006), Shek O Quarry will produce 23 million tons, and Lam Tei Quarry will produce 6.5 million tons.

Quarries, both large and small, are a feature of the Hong Kong landscape and can be identified at many localities, indicating the scale of the human contribution to 'erosion'.

水塘及引水道

香港的面積共1,105平方公里，其中約百分之三十三的土地是集水區，以引導雨水從山上流入15個原是山谷的水塘，以及船灣淡水湖及糧船灣的原是海洋的水塘(圖11)。

薄扶林水塘是首個原來是山谷的水塘，於1877年落成。其餘14個現存的山谷水塘於其後的八十八年接踵完成(圖12)。於1965年完成的下城門水塘是最後一個山谷水塘。十五個水塘的總儲水量為7,500萬立方米。

多個小型水塘，包括佐敦谷及黃泥涌水塘，已不再使用、被填平或已遷離。

船灣淡水湖及糧船灣水塘均以興建水壩來阻擋海水進入(圖13)。船灣淡水湖於1967年初步落成，當時的儲水量為1.7億立方米。其後，水壩於1973年加高，令儲水量提升至2.3億立方米。糧船灣水塘於1978年竣工，儲水量共2.81億立方米。

全港17個運作中的水塘總儲水量為5.86億立方米，足夠維持全港222天用水，即全年的百分之六十的用水。

環繞香港山旁建築的引水道網絡(圖11)，將山上或高地溪澗的天然水源，直接引到水塘。

這些引水道成功地引導天然溪流，經過隧道，分流至鄰近的集水區。香港的天然排水系統已被廣泛改造，包括在市區的下水道及市區外的引水道。

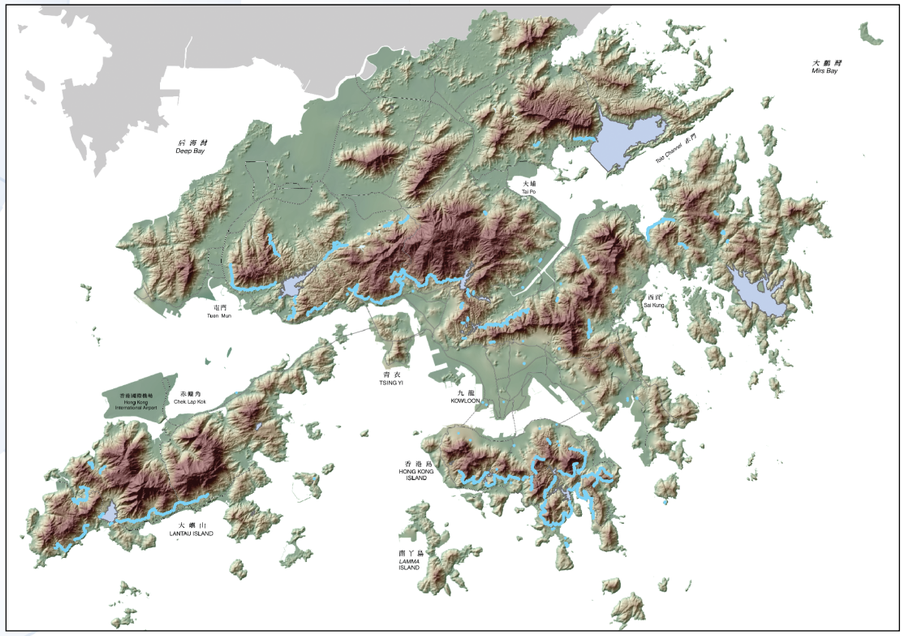

圖11. 香港的水塘及引水道(圖中藍色部份)。
Figure 11. Reservoirs and catchwaters in Hong Kong (shaded in blue).

Reservoirs and Catchwaters

About 33% of the 1,105 square kilometre area of Hong Kong has been developed as catchments to direct rainfall runoff from the hills into the fifteen 'old' valley reservoirs in Hong Kong, and to the Plover Cove and High Island 'marine' reservoirs (Figure 11).

Pok Fu Lam was the first valley reservoir, completed in 1877. Fourteen other (surviving) valley reservoirs were built in the following 88 years (Figure 12), the last being the Lower Shing Mun Reservoir, which was completed in 1965. The total capacity of these fifteen reservoirs is 75 million cubic metres.

圖12. 大潭水塘。
Figure 12. Tai Tam Reservoir.

Several smaller reservoirs, including Jordan Valley and Wong Nei Chong, have been de-commissioned and either filled-in or removed.

The Plover Cove and High Island (Figure 13) reservoirs were both built by damming marine inlets. Plover Cove was initially completed in 1967, with a capacity of 170 million cubic metres, but the dam was later raised by 1973 to increase the storage capacity to 230 million cubic metres. The High Island Reservoir, completed in 1978, has a storage capacity of 281 million cubic metres.

圖13. 萬宜水庫西霸。
Figure 13. The High Island West Dam.

The total storage capacity of Hong Kong's seventeen operational reservoirs is 586 million cubic metres, which is about 222 days supply for Hong Kong, or sufficient for 60% of the year.

A network of sub-contour channels (catchwaters) has been constructed around many of the hillsides of Hong Kong (Figure 11). They are designed to intercept the natural runoff from hillsides and upland streams, and to direct it into the reservoirs.

Catchwaters effectively behead the natural streams, and commonly transfer the runoff, via tunnels below the drainage divides, to adjacent watersheds. Thus, the natural drainage system in Hong Kong has been considerably modified, both in the urban areas where the former watercourses are culverted, and in many of the extra-urban areas where catchwaters redirect the runoff.

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