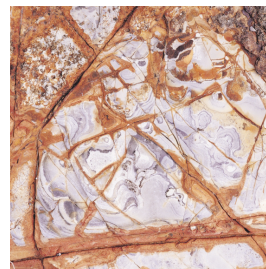
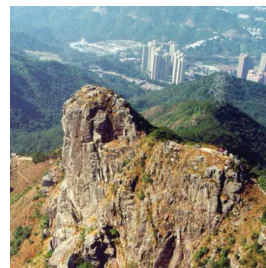


岩石循環與岩石鑑定 THE ROCK CYCLE AND ROCK IDENTIFICATION

岩石與礦物
ROCKS AND MINERALS

2



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.

Raymond K S Chan
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December 2008

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。

礦物和岩石是岩石圈的重要成分。雖然礦物種類超過三千種，但只有少數為常見組成岩石的礦物，例如石英、長石、雲母、角閃石、輝石、橄欖石及方解石(岩石與礦物之一)。岩石可視乎其形成的模式，劃分為火成、沉積及變質岩三大類(岩石與礦物之一)。過去地質年代期間，岩石逐漸從一種類變成另一類，這過程稱為岩石循環(岩石與礦物之二)。從仔細查驗岩石的岩理、成分及內部結構等特徵，可判斷該岩石的來源，這就是識別岩石的基礎(岩石與礦物之二)。在香港出現的岩石種類繁多，顯示區內複雜的地質情況(岩石與礦物之三)。

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.

Minerals and rocks are essential components of the geosphere. Although there are over 3,000 species of minerals, only a few of them, such as quartz, feldspar, mica, amphibole, pyroxene, olivine and calcite, occur commonly as rock-forming minerals (**Rocks and Minerals 1**). Rocks are classified into three main types, igneous, sedimentary and metamorphic, depending upon their mode of formation (**Rocks and Minerals 1**). Over geological time, rocks are gradually transformed from one type to another in what is termed the Rock Cycle (**Rocks and Minerals 2**). The origin of any particular rock can be determined by careful examination of its texture, composition, and internal structure, features that form the basis of rock identification and classification (**Rocks and Minerals 2**). The large variety of rock types present in Hong Kong reflects the complexity of the geology of the region (**Rocks and Minerals 3**).

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岩石循環與岩石鑑定

THE ROCK CYCLE AND ROCK IDENTIFICATION

岩石循環

岩石循環(圖1)是一個概念模型,用以闡釋火成岩、沉積岩和變質岩這三種主要岩石如何受地質活動影響,變成另一種岩石。而板塊運動正是推動岩石循環的原動力。

有關構造活動,見板塊運動之一。
有關岩石的造岩過程,見岩石與礦物之一。

要了解岩石循環,首先要明白造岩的過程:

▶ 位於地球深處的熔岩稱為岩漿,岩漿冷卻後結晶,形成**火成岩**,包括位於地殼深處的侵入性火成岩和地球表面的噴出性火成岩。火成岩造岩的過程包括岩漿形成、冷卻及結晶。

▶ 因構造活動而露出地球表面的岩石遭受風化及侵蝕,剝落的碎塊移至低窪的盆地沉積下來,經過埋藏、壓縮及凝固過程後,形成**沉積岩**。沉積岩的造岩過程包括風化、侵蝕、堆積、埋藏及岩化作用。

有關風化及侵蝕過程,見地質與地景之一。

▶ 岩石遇到高溫與壓力,以及含有礦物質的熱溶液的情況下,其岩理及/或礦物成分便會產生變化,形成**變質岩**。變質岩造岩的過程涉及因受熱力、壓力或熱溶液影響,而產生岩理和礦物成分的變化。

岩石循環可從這三種岩石中的任何一種開始,無須經歷由火成岩變為沉積岩、再轉為變質岩,然後重新變回火成岩的整個過程。例如火成岩可直接化身為變質岩,而途中無須到達地球表面,也不用先演變為沉積岩。同樣地,任何類型的岩石亦可轉變為同類的新岩石。

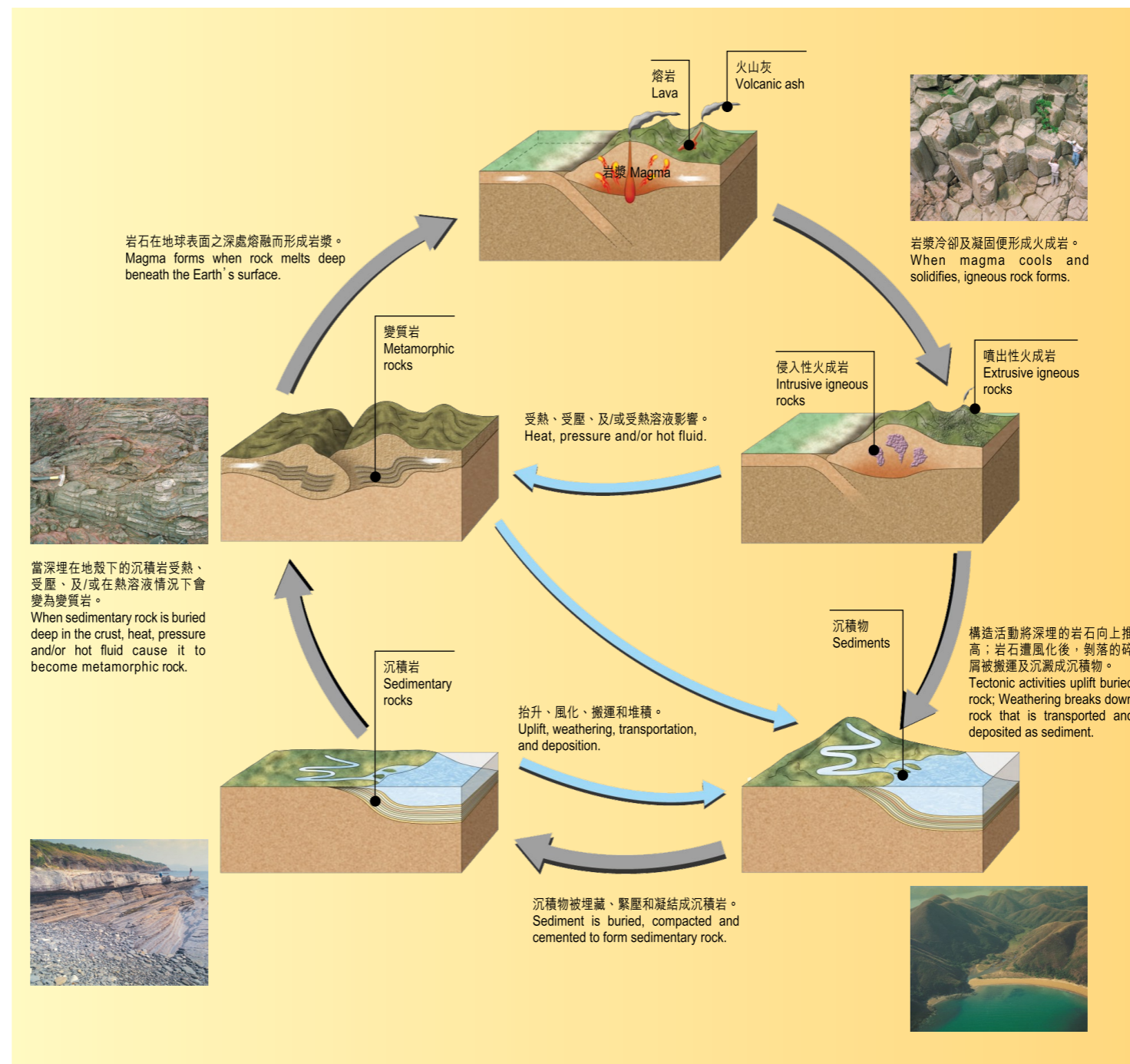


圖1. 岩石循環。
Figure 1. The Rock Cycle.

The Rock Cycle

The Rock Cycle (Figure 1) is a conceptual model that explains how geological processes acting on any one of the three main rock types — igneous, sedimentary and metamorphic — can change one rock type to another over geological time. Plate tectonics is the driving force of the Rock Cycle.

See Plate Tectonics 1 for further discussion of tectonic processes.
The rock-forming processes are introduced in Rocks and Minerals 1.

In order to understand the Rock Cycle, it is important to understand the rock-forming processes.

▶ Molten rock deep within the Earth is termed magma. When magma cools and crystallizes it forms **igneous rock**, either deep inside the Earth's crust (intrusive igneous rocks) or at the Earth's surface (extrusive igneous rocks). Igneous rock-forming processes involve melting, cooling and crystallization.

▶ When tectonic activity exposes rocks at the Earth's surface, they are subject to weathering and erosion. The resulting sediments are transported and deposited in a basin, where they are buried, compacted and cemented to form **sedimentary rock**. The sedimentary rock-forming processes involve weathering, erosion, deposition, burial and lithification.

See Geology and Landscape 1 for further discussion of weathering and erosion processes.

▶ When rocks are subject to high temperatures and pressures, and to hot, mineral-rich fluids, their textures and/or mineral compositions are changed to form **metamorphic rock**. The metamorphic rock-forming processes involve changes to rock textures and mineral compositions under different temperature, pressure or hot fluid conditions.

The Rock Cycle can begin with any one of the three rock types. It is important to understand that a rock does not necessarily pass all the way through the Rock Cycle from igneous, to sedimentary, to metamorphic, and back to igneous rock again. For example, an igneous rock can become a metamorphic rock without reaching the Earth's surface, and without first becoming a sedimentary rock. Also, any type of rock can become a new rock of the same type.

岩石鑑定介紹

岩石根據形成的模式分為三大主要類別，即火成岩、沉積岩和變質岩。在大多數情況下，岩石的形成過程不可能直接觀察得到。因此，要判斷岩石的類型，就必須從其獨有的特徵來識別，而岩石的岩理及礦物成分是推斷岩石類型的兩個可靠線索。

有關造岩過程，見岩石與礦物之一。

- ▶ **岩理**是指岩石結構內礦物或粒子的大小及形狀，和它們在岩石內的排列形態。
- ▶ **成分**是指岩石的組成成分，包括晶體、礦物、其他岩石碎片及/或化石；同時亦指岩石的化學成分。岩石的顏色為判斷岩石成分提供重要指示。

香港常見岩石的鑑定

鑑定和識別岩石的類型，許多時是一項需要技巧的工作，要求擁有廣博的地質知識及豐富經驗。然而，本章將提供一些辨認香港常見岩石的實用指引。

侵入性火成岩的特徵

▶ 花崗岩

- 花崗岩主要成分是長石和石英礦物，其次是角閃石及雲母。
- 花崗岩以深成岩體、岩牆或岩床形態出現(圖2)。
- 個別礦物一般可憑肉眼觀察(圖3及圖4)。
- 花崗岩內的礦物呈晶體狀，並顯現出互鎖的岩理(圖3及圖4)。
- 未受風化的花崗岩一般呈淡粉紅色或淡灰色。

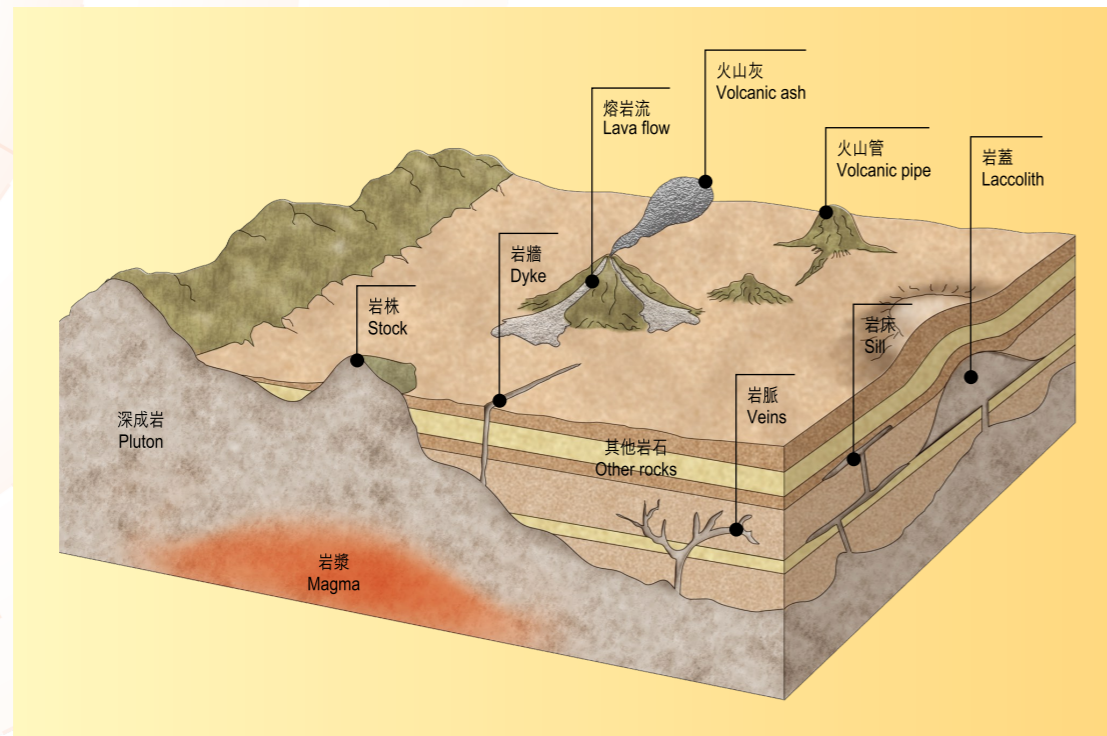


圖 2. 各種火成岩的形態。
Figure 2. Various forms of igneous rock.

Introduction to Rock Identification

Rocks are classified into three main types, igneous, sedimentary and metamorphic, according to their mode of formation. In most cases, it is not possible to directly observe how rocks are formed. Therefore, it is necessary to rely on the distinctive features of a rock to infer its origin. Texture and mineral composition are two important characteristics that may help to confirm the origin of a rock.

See Rocks and Minerals 1 for details of rock-forming processes.

- ▶ **Texture** refers to the sizes and shapes of the component minerals or grains, and to their collective arrangement in a rock.
- ▶ **Composition** refers to the crystals, mineral grains, fragments of other rocks, and/or fossils, that make up a rock. It also refers to the chemical constituents of a rock. The colour of a rock may also provide an important guide to its composition.

Identification of Common Rocks in Hong Kong

In many cases, the identification and classification of rocks is a skilled task that requires a broad understanding of geology and considerable experience. Nevertheless, this section will provide some useful guidelines for identifying the common rock types in Hong Kong.

Characteristics of Intrusive Igneous Rocks

▶ Granitic Rocks

- Granitic rocks contain predominantly feldspar and quartz minerals, with subordinate amphiboles, and micas.
- Granitic rocks occur as plutons, dykes or sills (Figure 2).
- Individual minerals, can generally be identified with the naked eye (Figures 3 & 4).
- Minerals are crystalline and show an interlocking texture (Figures 3 & 4).
- Unweathered granite is commonly pinkish grey or light grey in colour.

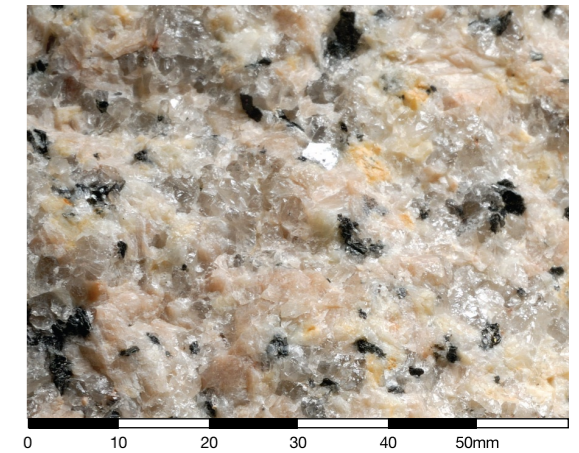


圖 3. 等粒花崗岩，即其晶體大小大致相同。
Figure 3. Equigranular granite, i.e. mineral grains are of approximately the same size.

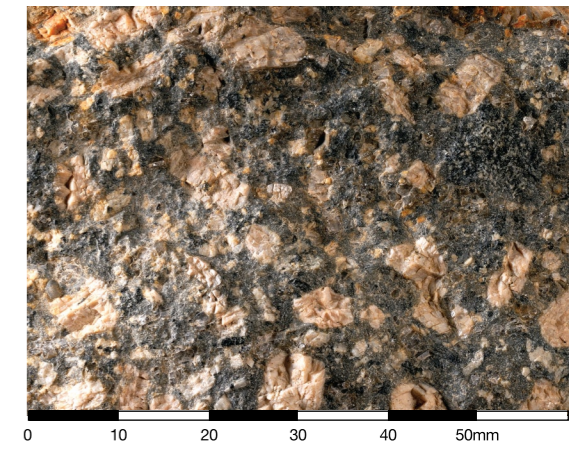


圖 4. 不等粒的花崗岩，含有晶體較大的長石(斑晶)。
Figure 4. Inequigranular granite, containing large crystals (phenocrysts) of feldspar in a matrix of smaller crystals.

噴出性火成岩的特徵

▶ 熔岩

- 熔岩中的個別礦物顆粒一般都非常細小，難以憑肉眼辨認。
- 熔岩的幼細基質內可能含體積較大的晶體(斑晶)。
- 岩石可呈流動構造。

▶ 凝灰岩

- 凝灰岩(圖5)成分包括礦物、玻璃、浮石及/或已存在岩石的碎塊。
- 凝灰岩根據不同碎塊的相對成分分類。
- 碎片一般呈棱角狀及破碎。
- 未被風化的凝灰岩通常呈深灰色。
- 岩石可呈條紋斑狀(圖6)、熔結構造等特徵。
- 部分凝灰岩顯現柱狀節理。



圖5. 粗火山灰晶屑凝灰岩，主要含有晶體碎屑。
Figure 5. Coarse ash crystal tuff, containing mainly crystal fragments.

沉積岩的特徵

▶ 碎屑沉積岩(粉砂岩、砂岩及礫岩)

- 碎屑沉積岩由已存在的岩石，經風化侵蝕而出的岩石及礦物顆粒結集而成(圖7及圖8)。
- 個別顆粒由石英或方解石礦物組成的膠結物凝結而成。
- 碎屑沉積岩可能含有化石。
- 沉積層理可能出現，是岩石中排列有序的顆粒，因其結構及成分改變而劃定。
- 顏色的變化反映岩石的成份、沉積環境、及/或遭受風化的狀況。



圖6. 條紋斑狀凝灰岩(熔結凝灰岩)，含有在其形成時被壓扁的浮石碎塊(火焰石)及玻璃碎片。
Figure 6. Eutaxitic tuff (welded tuff), containing pumice fragments (fiamme) and glass shards that are flattened during its formation.

Characteristics of Extrusive Igneous Rocks

▶ Lava

- Individual mineral grains in lava are generally too small to be identified with the naked eye.
- Lava may contain some larger crystals (phenocrysts) within the fine-grained groundmass.
- Lava may display a flow fabric.

▶ Tuff

- Tuff (Figure 5) contains fragments of minerals, glass, pumice and/or pre-existing rocks.
- Tuff is classified on the basis of the relative components of the various fragments.
- The fragments are generally angular and broken.
- Tuff is commonly dark grey in colour when the rock is unweathered.
- The rock may show a welding structure (Figure 6).
- Some tuff is columnar-jointed.



圖7. 礫岩，含有被磨圓的岩石碎屑。
Figure 7. Conglomerate, containing rounded lithic clasts.

Characteristics of Sedimentary Rocks

▶ Clastic Sedimentary Rocks (Siltstone, Sandstone and Conglomerate)

- Clastic sedimentary rocks are composed of rock and mineral grains eroded from pre-existing rocks (Figures 7 & 8).
- Individual grains are held together by a cement that is commonly composed of quartz or calcite minerals.
- Clastic sedimentary rocks may contain fossils.
- Sedimentary bedding may be present, defined by variations in the texture and composition of the constituent grains that are systematically arranged in layers.
- Colour variations reflect composition, the depositional environment of the sediments and/or the texture and weathering state.

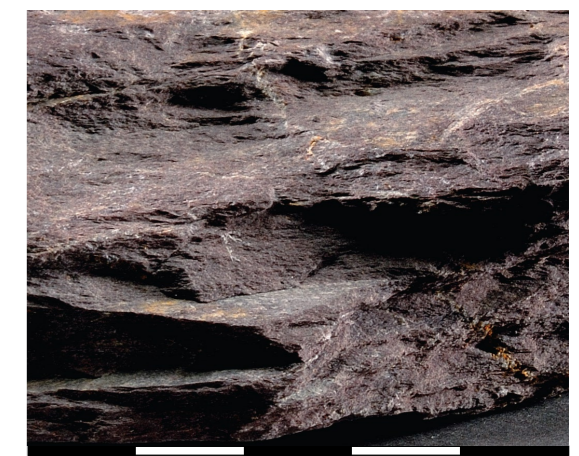


圖8. 粉砂岩，展示薄的沉積層。
Figure 8. Siltstone, showing thin sedimentary layers.

變質岩的特徵

▶ 片岩及千枚岩

- 岩石原有的礦物可能被新的變質礦物取代，如雲母（片狀礦物）及角閃石（稜柱狀礦物）。
- 呈現葉理，由片狀或稜柱狀的礦物排列而成（圖9）。
- 變質岩一般呈深淺色帶交替，層次分明，反映深色和淺色礦物的不同密集度。
- 由於岩石內含有雲母，一般呈絲質的光澤。

▶ 大理岩

- 大理岩（圖10）是由方解石礦物晶體形成。
- 純大理岩是白色或奶白色，但亦可能因內含雜質而變成淺灰或灰藍色。
- 大理岩跟稀鹽酸會有化學反應，產生氣泡（泡騰）。



- 大理岩很容易給小刀刮花。
- 礦物晶體互鎖。



圖9. 石墨片岩，展示變質葉理。
Figure 9. Graphite schist, showing metamorphic foliation.

Characteristics of Metamorphic Rocks

▶ Schist and Phyllite

- The minerals of the original rock may be replaced by new metamorphic minerals, such as micas (platy minerals) and amphibole (a prismatic mineral).
- The rocks show a foliation, which is defined by the alignment of platy or elongate prismatic minerals (Figure 9).
- The rocks commonly display alternating dark and light coloured bands that reflect the concentration of dark and light coloured minerals.
- The rocks generally display a silky or shiny appearance due to the presence of micas.

▶ Marble

- Marble is composed of crystalline calcite minerals (Figure 10).
- Pure marble is in white or creamy colour, but impure marble may be light grey to bluish grey.
- Marble reacts with dilute hydrochloric acid to produce gas bubbles (effervescence).



- The rock is easily scratched with a knife.
- The mineral grains are interlocking.



圖10. 大理岩，含有結晶的方解石礦物。
Figure 10. Marble, containing crystalline calcite minerals.

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