AGS (HK)
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GROUND INVESTIGATION GUIDELINES – 05.0 - GEOLOGY FOR ENGINEERING PROJECTS

Why is geology important to a project?

At the beginning of any project a thorough geological investigation of the available geological knowledge is essential for the project's successful completion. The extent of the geological investigation will depend upon the nature of the engineering project and the complexity of the expected ground conditions. Without such an investigation unforeseen ground conditions become a distinct possibility, delays will become frequent, and costs will escalate.

A geological model is progressively developed throughout the project and is intended to identify uncertainties in the ground conditions and potential geological hazards. The initial geological model is based on a desk study and may also involve fieldwork, aerial photograph interpretation and geophysical, geomorphological, and hydrogeological surveys. It is essential that the engineer is familiar with all aspects of the geological model and its limitations. The accuracy and reliability of the ground and design models are dependent on a sound geological model.

So the clear message is to make sure that:

- the geological model is as good as is reasonably possible at the start of the project using all available information
- the ground investigation is planned to evaluate any geological uncertainties or hazards revealed in the desk study
- the geological model is reviewed and amended as additional information is made available throughout the project

What do you need to know?

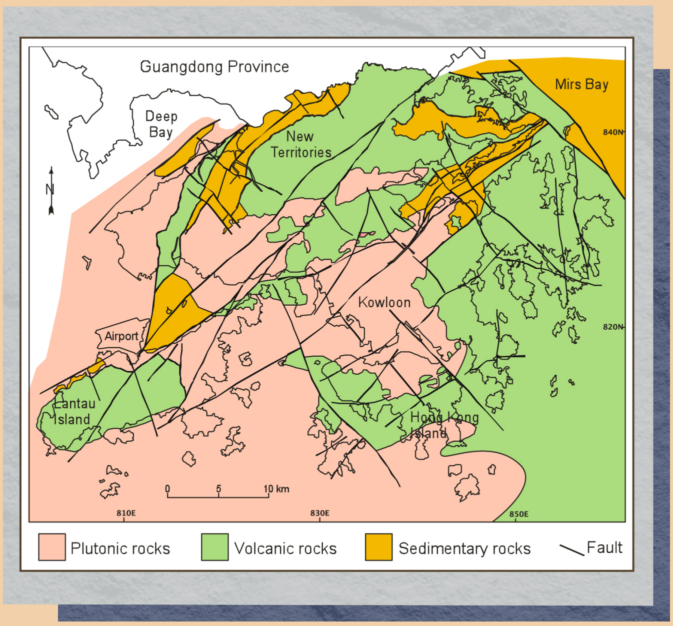
The engineer does not need to be a geologist, but it is essential that an understanding of the geological features that could affect the successful completion of a project are clearly understood. The engineer should be able to assess when expert advice is required and be sufficiently knowledgeable to appreciate and question the geological model. The geologist will assess the evolution of the rocks and soils in order to provide the best analysis of the distribution and nature of the rock, soil and geological structures, but one must recognize that a complete knowledge of the ground conditions prior to the construction phase of the project is rarely achievable.

What is the distribution of rocks and soils in Hong Kong?

The Hong Kong Geological Survey (CEDD) has published a complete series of 1:20,000-scale geological maps of Hong Kong that show the distribution of various rock types, superficial deposits and faults. More detailed maps are available in development areas. These maps, read in conjunction with the geological memoirs, provide an analysis of the geology at the time of publication - they are under continual revision. Always take note of the scale of the maps and remember they are not site specific and may need modification as your ground investigation results come in.

What are the key geological features?

Every rock type, discontinuity, weathering profile and superficial deposit has a set of characteristics that could affect a project. All geological features must be thoroughly assessed in relation to the consequence they may have on the planning, design and successful execution of the project.



Bedrock geology of the onshore and offshore areas of Hong Kong

Plutonic rocks (granite)

- Confined within circular and elliptical bodies
- Generally homogeneous and very strong across large rock masses
- Close to granite contacts the spacing of joints, grain size, and alteration may differ from the main rock mass

Volcanic rocks (tuff)

- Tuff composition can vary both vertically (in layers) and laterally (in lenses)
- Generally strong to extremely strong
- Interbedded with sandstone and mudstone in places

Dyke rocks (basalt, rhyolite)

- Intruded long pre-existing fractures
- Dykes vary from less than 1 m to over 100 m in width
- Generally very strong

Sedimentary rocks (sandstone, mudstone, limestone)

- Commonly occur in planar layers but may also form lenticular bodies
- Highly variable geotechnical properties
- Strength largely dependent upon the inter-grain cement material

Metamorphic rocks

- Occurs as narrow halos around igneous intrusions or across regional tectonic zones
- Change in mineralogy from original rock type
- Formation of weak cleavage and schistosity planes

Superficial deposits

Alluvium

- Lenticular sand and silt deposits define courses of old river channels
- Alluvial deposits have a wide range of compressibilities
- Sand, gravel and desiccated layers strongly influence ground water flow patterns

Colluvium

- Composed of poorly sorted mixture of soil and rock fragments
- Formed by mass wasting processes on hillsides
- Recent colluvium is commonly loose with high permeability

Marine Deposits

- Composed dominantly of very soft to soft clayey silt and sand
- Highly compressible and can result in large settlements across reclamations
- Act as an impermeable blanket to the alluvial sands below

Discontinuities

Faults

- Planar displacement zones in rock with significant lateral and vertical continuity
- Fault material is weak unless replaced by secondary minerals (e.g. quartz)
- Fault can act as either an aquiclude or aquifer

Foliation

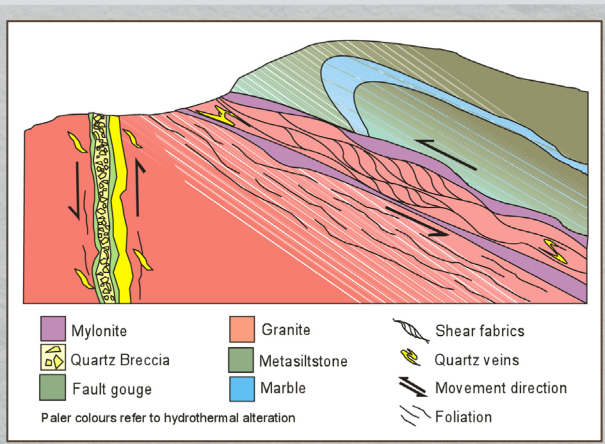
- Penetrative very closely spaced, planar discontinuites
- Define multiple planes of weakness in a rock
- Foliated rocks can be extremely fissile and friable

Joints

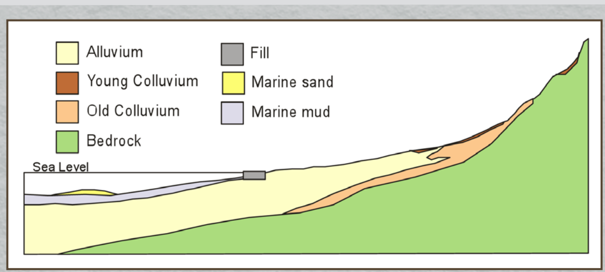
- Planar fractures in a rock with no displacement
- Joints can be filled with low strength material.
- Occur in distinctive sets with different orientations and spacings

Hydrothermal alteration

- Generally close to granite contacts or in fault zones
- Silicification greatly increases the strength of the rock and anneals fault zones
- Chloritization may lessen the strength of the rock and can reduce the friction angle of joints



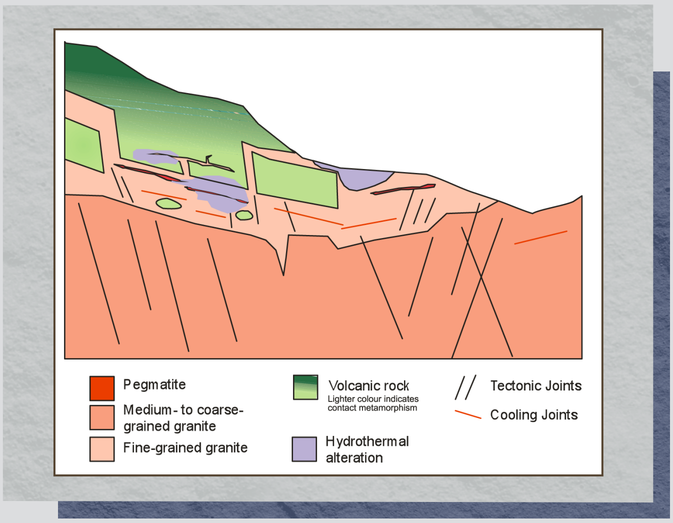
Cross-section of typical fault zones



Land and offshore superficial deposits of Hong Kong

Contacts

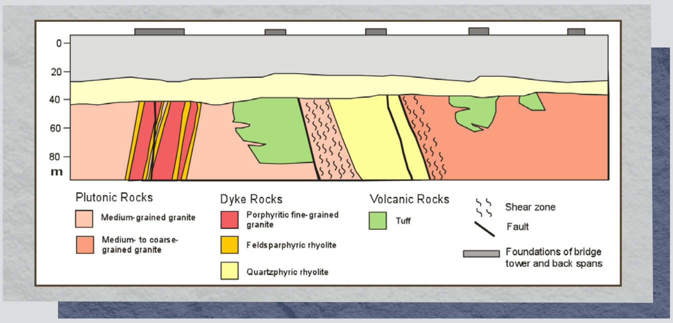
The contacts between rock types are commonly a cause for concern in many ground engineering projects. Contacts vary from intrusive, sedimentary, metamorphic to tectonic. The strength, permeability, excavatability or friction angles of materials may change abruptly or gradationally across a contact. It is therefore essential to define the form and characteristics of any contact. For example, granite contacts can vary greatly in orientation over short distances and can be locally associated with intense hydrothermal alteration, contact metamorphism, brecciation, faulting, jointing, veining and changes in grain size, all of which may have significant engineering consequences. Sedimentary rocks may vary both vertically and laterally, and interbedding of different rock types is common. Fault contacts can result in abrupt changes of the strength of materials and hydrogeological regimes, both within a fault zone (e.g. between breccias, fault gouge) or different rock types across a fault. All contacts must, therefore, be investigated during ground investigations, in order to enhance the reliability of the geological model.



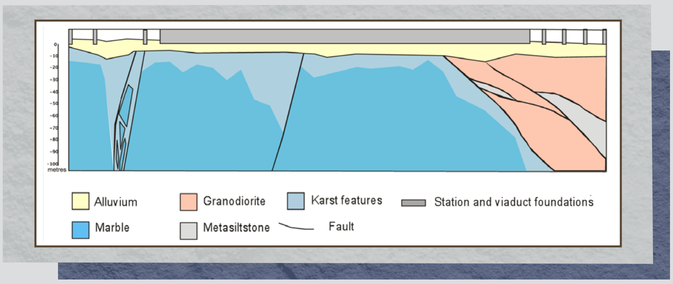
Schematic cross-section through the intrusive contact of a granite body and overlying volcanic rocks

Cross-Sections

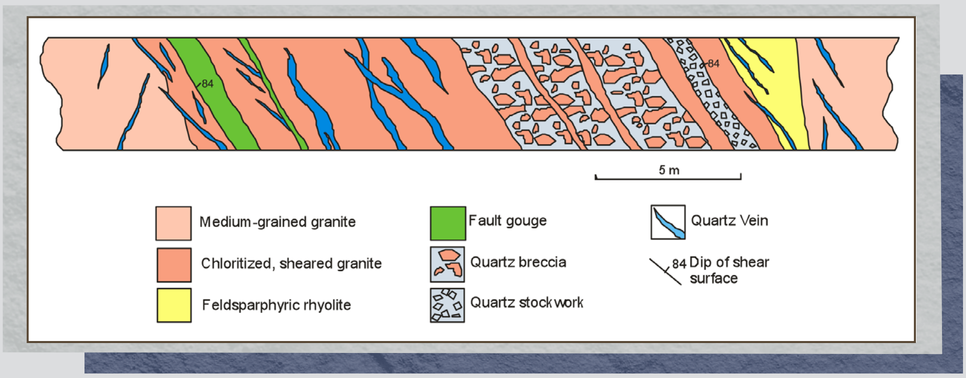
Geological models for infrastructure projects, such as dams, retaining walls and building foundations all require geological cross-sections to be constructed. These are mainly generated from geological maps of the project area and ground investigation data (borehole and trial pit logs). However, it is essential that other data is taken into account, for example published regional geological maps, aerial photographs, geophysical surveys and also data from nearby projects. The cross-sections must not contravene geological principles and should be consistent with the evolutionary history of the rocks and superficial deposits of the area. Cross-sections highlight where there is uncertainty in the geological model and indicate where any additional ground investigation may be required. Always review and update cross-sections as more data become available throughout the life of the project.



Cross-section for bridge tower and highway foundations in faulted granite, composite dyke and volcanic rocks



Cross-section for station foundations in faulted marble and granodiorite.

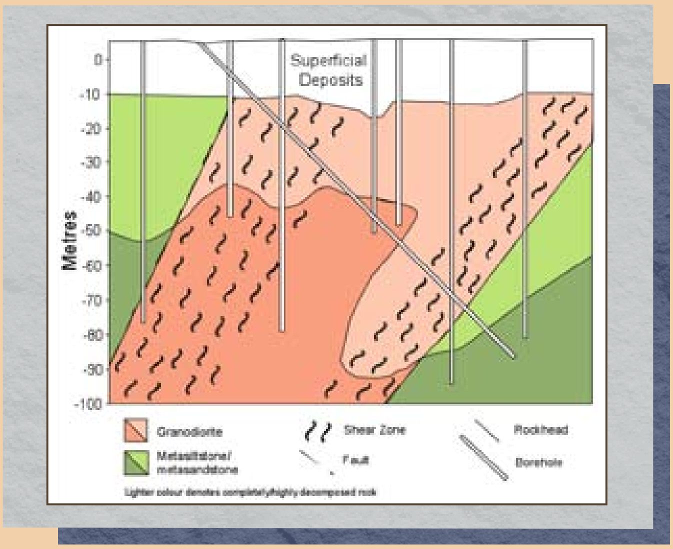


Intrusive, alteration and tectonic contacts in a tunnel through complex fault zone

Weathering

Weathering is the process of alteration and breakdown of rock and soil material at the Earth's surface by chemical decomposition and physical disintegration. Weathering occurs in place and the original texture of the rock is preserved except in the residual soil. Each rock type has different weathering characteristics that depend on the original mineral content, grain size, matrix composition and geological structures. Granite and volcanic rocks can be divided into six weathering grades, whereas the weathering of sedimentary rocks is less uniform. Calcareous rocks weather to form cavities and other karst features. Weathering is often preferentially enhanced along contacts and faults, for example in faulted limestone areas the karst can extend to over 100 m below ground surface. Weathering of granite and volcanic rocks causes:

- Reduction in material strength
- Formation of clay minerals which may be concentrated near rockhead
- Increased porosity and in places formation of soil pipes

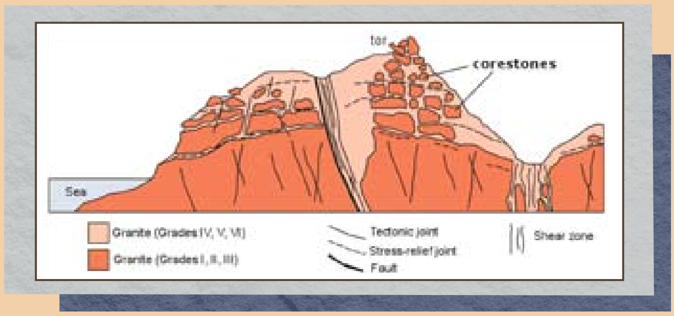


Cross-section of a development site showing deep depression in rockhead along shear zone

Rockhead

Rockhead is an idealized surface across which soil (Grade IV to VI) passes downwards into rock (Grade I to III). In places, this surface can be extremely sharp, but more commonly there is either a gradual transition between the two or there is an increased frequency of rock masses (corestones) within the soil profile. Rockhead is generally depressed across fault and shear zones or where the joint frequency is high. Although the average depth of rockhead in Hong Kong is less than 50 m below ground level, it can reach over 100 m within and close to fault zones.

Descriptive Term	Grade Symbol	Distinguishing Features in Granitic and Volcanic Rocks
Residual Soil	VI	No original rock texture preserved Crumbles by finger pressure
Completely Decomposed	V	Original rock texture preserved Crumbles by finger pressure Slakes in water Completely discoloured in comparison with fresh rock
Highly Decomposed	IV	Original rock texture preserved Breaks into smaller pieces by hand Does not slake in water Completely discoloured in comparison with fresh rock
Moderately Decomposed	III	Rock completely stained Cannot be broken into smaller pieces by hand Easily broken by geological hammer
Slighty Decomposed	II	Stained close to joints Not easily broken by geological hammer
Fresh	I	No staining Not easily broken by geological hammer



Cross-section of weathering features in granite. Note development of corestones and depth of rockhead is very variable

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