Chapter 4
Intrusive Igneous Rocks

Classification and Distribution

The intrusive igneous rocks of the district comprise major intrusions of granodiorite and granite, and minor intrusions of porphyritic microgranite, feldsparphyric rhyolite, quartzphyric rhyolite and mafic dykes. Compositional classification is based on Le Maitre (1989) (Figure 7). The major intrusions are divided into medium-, fine- to medium-, and fine-grained lithologies. On the basis of geochemical and mineralogical studies, the granites may be further divided into separate plutons or intrusive units. These plutons form the country rock to swarms of rhyolite dykes that dominate the geology in north Lantau Island and Ma Wan. Significant textural variation is present within both major and minor intrusions.

Major Intrusions

Granodiorite

Porphyritic fine-grained granodiorite has been encountered only in offshore boreholes east of Ma Wan. The granodiorite is thought to be the oldest intrusive body of the district although it has not yet been dated. The granodiorite forms a sheet-like intrusion known as the Tai Po Granodiorite and is compositionally and mineralogically similar to the coarse ash tuffs of the Yim Tin Tsai Formation. Euhedral to

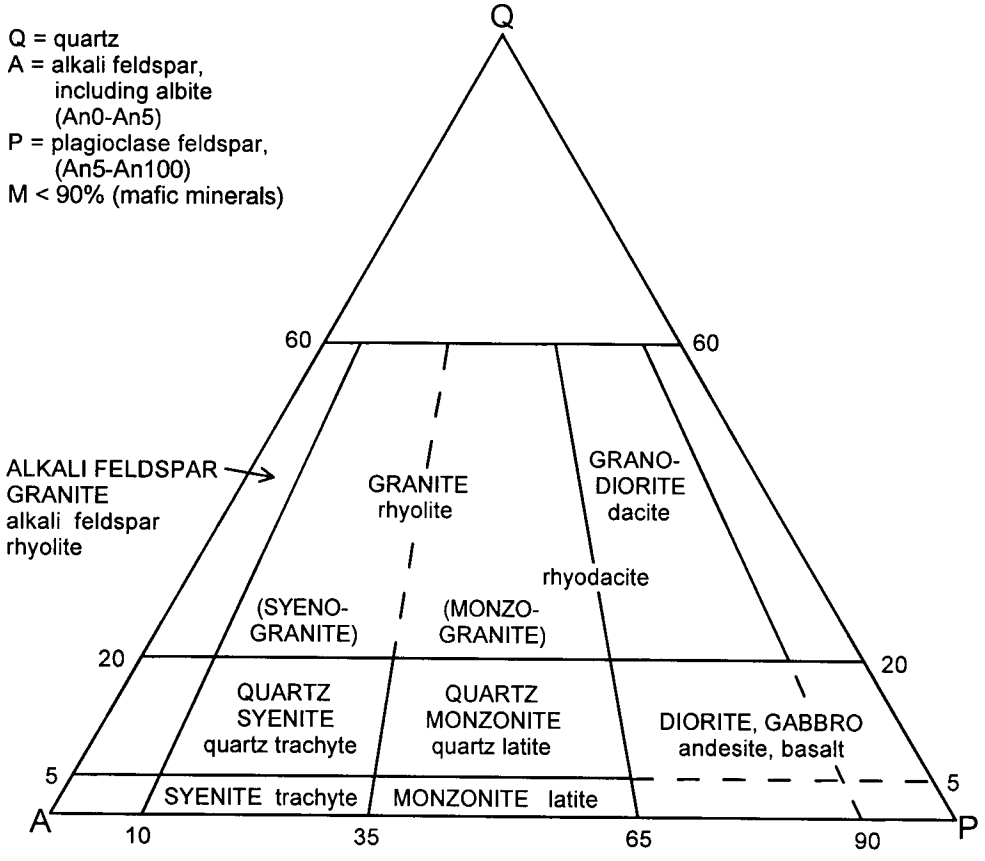

Figure 7 - Generalized Classification and Nomenclature of Selected Major and Minor Intrusive Rocks (after Le Maitre, 1989)

subhedral phenocrysts of alkali feldspar and concentrically zoned plagioclase are set in a fine-grained matrix of quartz, alkali feldspar, plagioclase, biotite and minor amphibole (Plate 4). Accessory minerals in the matrix include zircon, apatite, and allanite. Chlorite and epidote are ubiquitous alteration products of the mafic minerals. The granodiorite is similar in many respects to rocks described as dacite in the Tsuen Wan district (Langford et al, 1989).

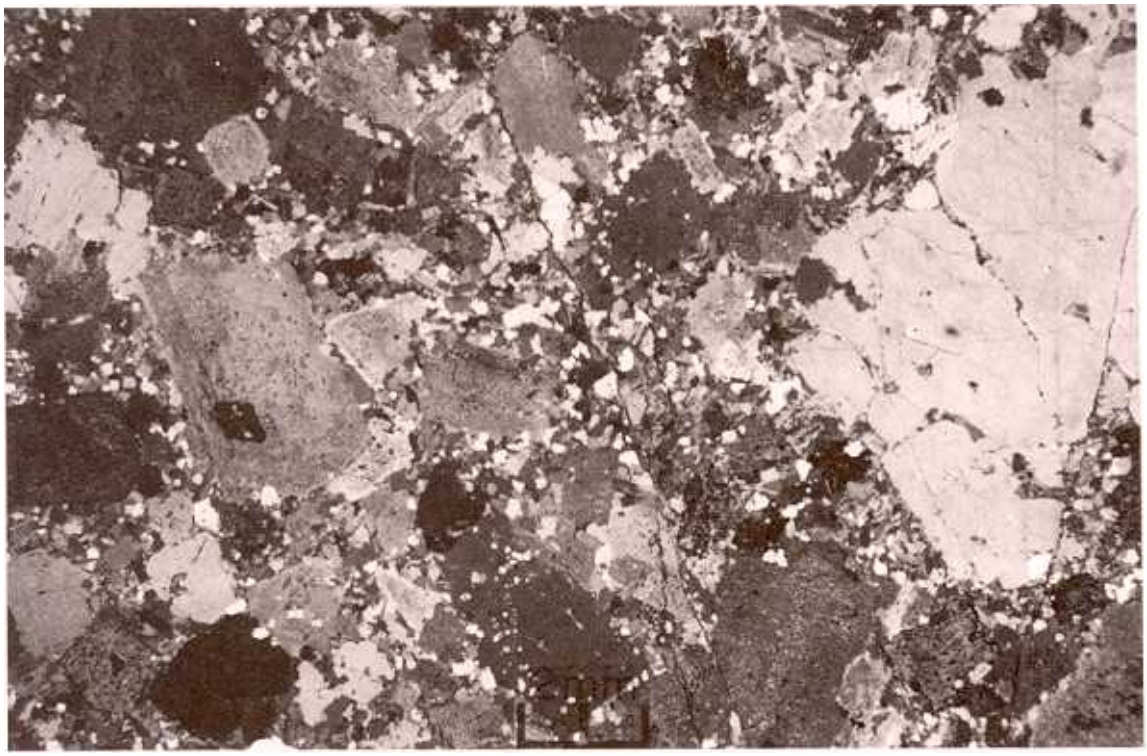

Plate 4 - Thin Section of Porphyritic Fine-grained Granodiorite from a Borehole West of Ma Wan (24395 23831); XPL

Granite

Two varieties of medium-grained granite are present in the district, megacrystic and non-megacrystic, and these are thought to represent separate plutons. The non-megacrystic granite crops out on Ma Wan and on Lantau Island north of Penny's Bay, and is termed the Ma Wan Granite pluton. The megacrystic granite crops out south of Penny's Bay and is termed the Lantau Granite pluton. Both granites predate emplacement of the Lantau dyke swarm.

Lantau Granite

The Lantau Granite is typically megacrystic medium-grained with large megacrysts of pink alkali feldspar set in a granular matrix of quartz, plagioclase, alkali feldspar, amphibole and aggregates of biotite (Plate 5). Non-porphyritic fine- to medium-grained lithologies are not common. Accessory minerals include concentrically zoned allanite, apatite, titanite, zircon, rare fluorite, and Fe-oxide. Euhedral to subhedral K-feldspar megacrysts (5-15 mm) are dominantly composed of perthitic orthoclase with subordinate microcline. Two generations of plagioclase crystals (25-30%) are commonly present: strongly concentrically zoned species and relatively unzoned species. The strongly zoned plagioclase grains are euhedral (2-5 mm) to subhedral with andesine-rich cores and oligoclase to albite-rich rims. The cores of these crystals are commonly altered to sericite and sharp boundaries often exist between successive growth phases. In some rocks, residual cores of extensively altered anhedral alkali feldspar are mantled by concentrically zoned plagioclase reminiscent of rapakivi texture. Unzoned to weakly zoned plagioclase is generally euhedral and composed mostly of oligoclase and albite. The cores are often weakly sercitized. Anhedral quartz (30-35%) is typically strained showing undulose extinction. Yellow-brown to green biotite usually comprises between 2-10% of the mode and is sometimes accompanied by subordinate greenish brown amphibole (3-5%).

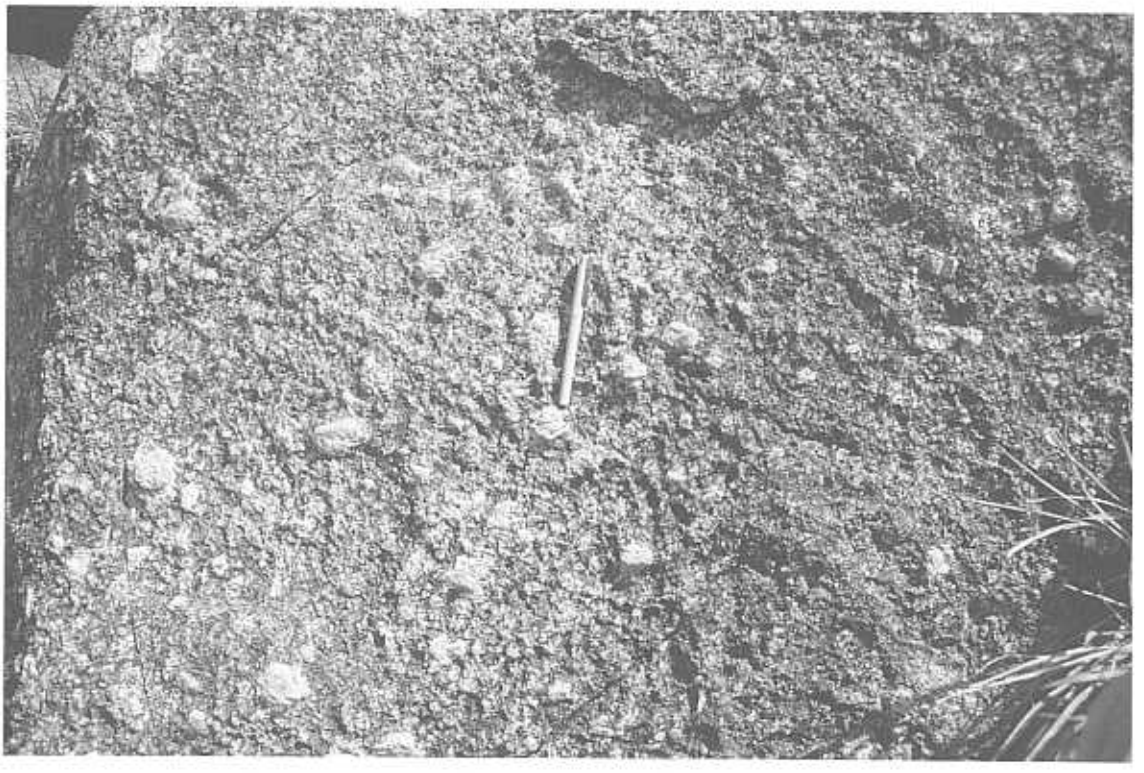

Plate 5 - Megacrystic Lantau Granite Exposed at Sz Pak Wan (21900 19070)

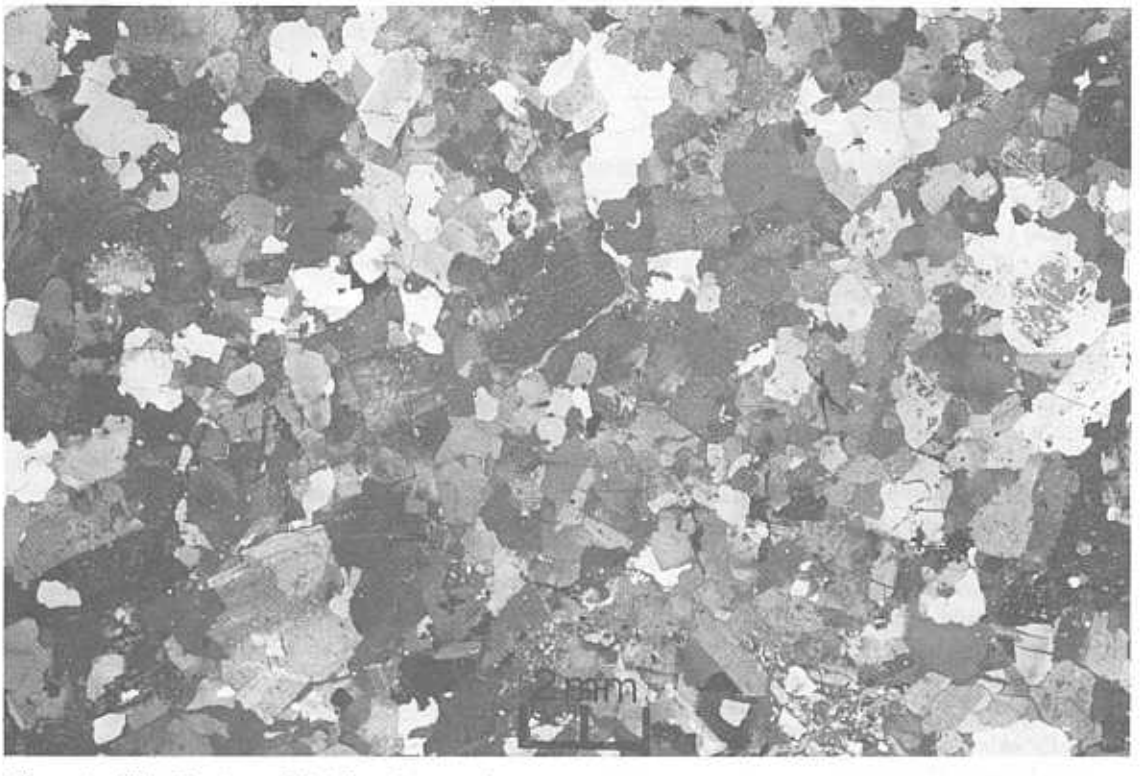

Plate 6 - Thin Section of Ma Wan Granite from a Borehole at Ma Wan (24503 23045)

Ma Wan Granite

The Ma Wan Granite is typically equigranular and fine- to medium-grained in texture but may sometimes display inequigranular texture. Fine-grained granite generally intrudes the fine- to medium-grained lithologies forming the roof of the pluton. Dykes of fine-grained granite also intrude the Lantau Granite farther south. In thin section, the hypidiomorphic granular texture is composed of euhedral to subhedral zoned plagioclase, anhedral quartz and subhedral perthitic orthoclase with interstitial pools of zoned microcline commonly with cloudy cores (Plate 6). Quartz is weakly strained showing undulose extinction and plagioclase may display bent twin lamellae. Biotite is the chief mafic mineral and is commonly altered to chlorite. Accessory minerals include zircon, fluorite, and rare allanite. Many samples show evidence of alteration and veining. The granite may be confused with Lantau Granite because of a similar degree of deformation. However, microcline is more abundant in the Ma Wan Granite and feldspar megacrysts are not common. Zoning in the plagioclase is not as strongly developed as in the Lantau Granite. Fine-grained lithologies have similar mineral compositions and abundances to the fine- to medium-grained granites, and may display granophyric texture.

Minor Intrusions

With the exception of mafic dykes, the minor intrusions of the district are divided on the textural basis into feldsparphyric rhyolite, porphyritic microgranite, and quartzphyric rhyolite. The felsic dykes are present as a dense swarm of strongly ENE-WSW-oriented multiple intrusions cutting granite and tuff country rock. Several phases of dyke injection have been identified. Composite intrusions, featuring a felsic phase injected into a more mafic one, are found in the northern part of Lantau Island and Ma Wan. In general, the multiple dykes are thought to predate the composite dykes.

Plate 7 - Alkali Feldspar Megacrysts in Rhyodacite Porphyry from Wo Shueng Au (17390 15670)

Feldsparphyric Rhyolite

Based on contact relationships and bulk rock compositions, at least two generations of feldsparphyric rhyolite dykes have been recognised (Figure 5). The older dykes are relatively broad intrusions (>5 m thick) and dominantly rhyodacitic in composition (rhyodacite porphyry). In some of the larger dykes (>10 m), there is commonly a complete gradation from strongly feldsparphyric textures at the margins to porphyritic microgranite textures in the cores. The younger dykes are chilled against the older dykes, narrower (<5 m thick) and dominantly rhyolitic in composition (rhyolite porphyry).

Rhyodacite Porphyry

Rhyodacite porphyry dykes form the bulk of the minor intrusions and are generally concentrated in central and southern parts of the district (Plate 7). They generally have large megacrysts (5-20 mm) of alkali feldspar, bipyramidal quartz and plagioclase, and crystal aggregates of biotite, set in a cryptocrystalline groundmass containing zoned allanite, zircon and magnetite. The groundmass represents a devitrified matrix produced as a result of chilling of the felsic magma against country rock. Slightly less rapid cooling is probably responsible for development of porphyritic microgranite in the cores of the dykes.

Porphyritic Microgranite

Porphyritic microgranite is a textural variant of feldsparphyric rhyolite and is compositionally equivalent to rhyodacite porphyry. Porphyritic microgranite dykes are characterised by granophyric texture in the groundmass. South of Penny's Bay, porphyritic microgranite dykes commonly host large xenoliths of granite country rock. They also appear to grade upward into rhyodacite prophyry dykes. A textural boundary between porphyritic microgranite and rhyodacite porphyry can be traced around the hillside between Discovery Bay in the east and Tai Ho Wan in the west. In the vicinity of Lo Fu Tau, the change in texture is accompanied by a change in pattern of jointing. Sheet jointing is a feature in porphyritic microgranite exposed on the lower hill slopes around Lo Fu Tau (Plate 8) whereas columnar jointing occurs in overlying rhyodacite porphyry lithologies.

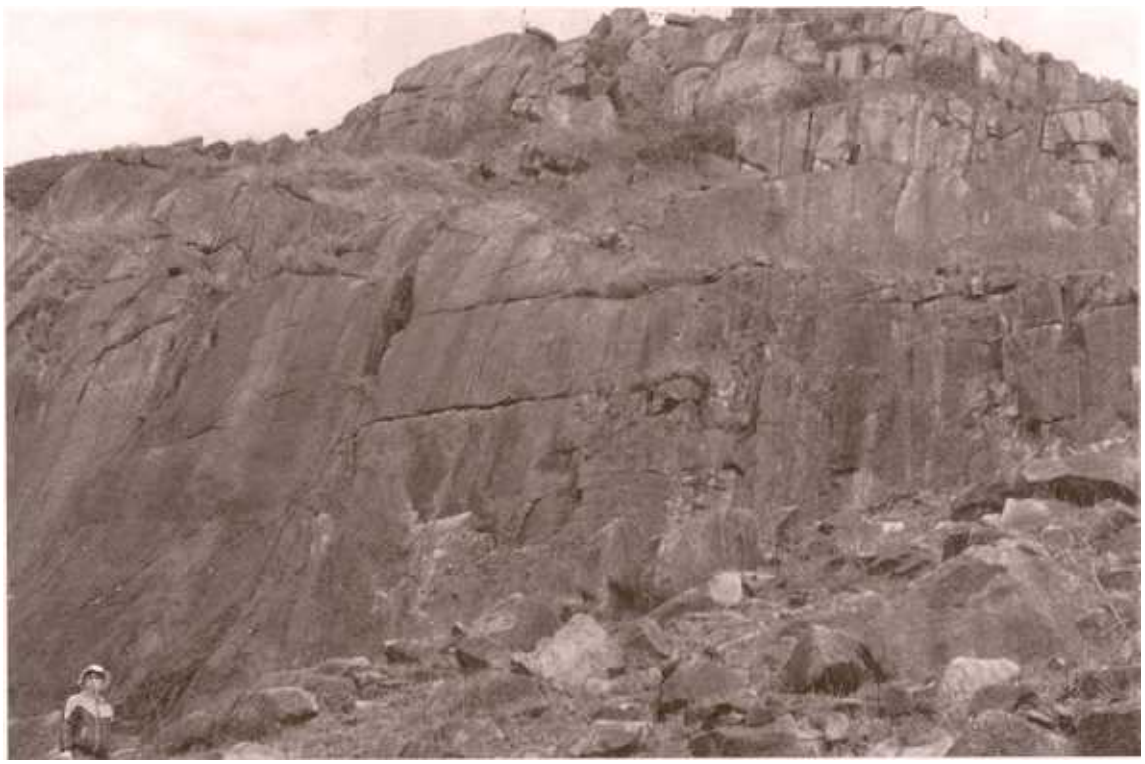

Plate 8 - Sheet Jointing in Porphyritic Microgranite Exposed on the Southwestern Slopes of Lo Fu Tau 17000 17645)

Plate 9 - Contact between Rhyolite Porphyry and Porphyritic Microgranite Showing Development of an Aphanitic Chilled Margin in the Younger Dyke (17925 20150)

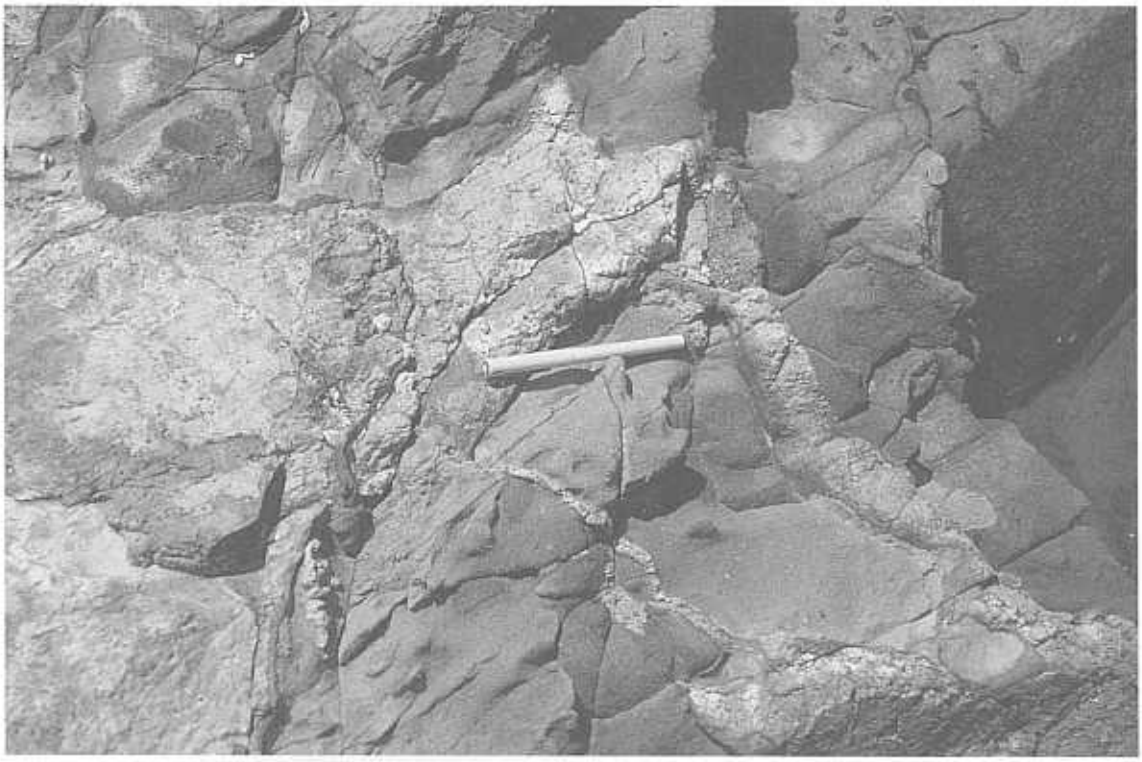

Plate 10 - Composite Dyke Exposed on Ma Wan Showing Injection of Felsic Magma into Partly-cooled Mafic Magma (24685 22865)

Rhyolite Porphyry

These rhyolite dykes are typically strongly feldsparphyric throughout although the largest dykes may possess quartzphyric cores. Rhyolite porphyry dykes commonly intrude older rhyodacite porphyry and porphyritic microgranite dykes (Plate 9), and appear to penetrate to a higher structural level cutting the volcanic rocks in central and northern parts of the district. They are characterised by euhedral alkali feldspar megacrysts, plagioclase and bipyramidal quartz set in a devitrified cryptocrystalline matrix.

Quartzphyric Rhyolite

Quartzphyric rhyolite dykes are mostly found in central and northern parts of the district in the vicinity of Tsing Chau Tsai peninsula and Ma Wan. They largely post-date emplacement of the feldsparphyric rhyolite and porphyritic microgranite dykes and may form composite intrusions featuring dacitic margins and rhyolitic cores (Plate 10). The quartzphyric rhyolite dykes commonly have flow-banded margins and grade inward into fine-grained granite. Quartz phenocrysts are typically bipyramidal.

Mafic Dykes

Mafic dykes are mostly of basaltic andesite composition but range from basalt to andesite. On Ma Wan and at Tsing Chau Tsai, melanocratic enclaves within quartzphyric rhyolite dykes are dacitic in composition and similar to the melanocratic margins of composite dykes. Whereas these dacitic dykes are relatively narrow (<2 m) and subparallel to the margins of quartzphyric rhyolite dykes, mafic dykes are thicker and generally have more varied orientations (Plate 11). The basaltic rocks typically are very fine-grained and aphyric with a groundmass composed of augite, biotite and magnetite. Potassium-rich mafic dykes have amphibole instead of augite as the chief mafic mineral. The mafic dykes, in general, are considered to be the youngest intrusions of the district (Tertiary) although some are clearly coeval with late stage felsic dykes (Plate 10).

Plate 11 - Basalt Dyke Cutting Feldsparphyric Rhyolite at Sz Pak Tsui (21435 19015)