Chapter 5
Intrusive Igneous Rocks

Classification and Distribution

The intrusive igneous rocks of the district comprise major intrusions of granite and quartz monzonite, and minor intrusions of porphyritic microgranite, feldsparphyric rhyolite, quartzphyric rhyolite, aplite, quartz veins and mafic dykes. Compositional classification is based on Le Maitre (1989) (Figure 7). The major intrusions are divided into medium-grained, fine- to medium-grained, 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 host rock to a swarm of rhyolite dykes (Lantau Dyke Swarm) that dominates the geology in northeastern Lantau Island. Abundant textural variation is present within both major and minor intrusions.

Major Intrusions

Granite

Two main varieties of granite are present in the district: megacrystic fine- to medium-grained and medium-grained granite belonging to the Lantau Granite, and fine-grained granite belonging to the Chek Lap Kok Granite (Sewell *et al.,* 2000). The Lantau Granite crops out intermittently across the northern part of the district between Pak Mong and Sha Lo Wan, whereas the Chek Lap Kok Granite crops out principally along the coast west of Tin Sam. U–Pb dating of zircon crystals has returned ages of 161.5 ± 0.2 Ma for the Lantau Granite, and 160.4 ± 0.3 Ma for the Chek Lap Kok Granite (Davis *et al.,* 1997). Both granites predate emplacement of the Lantau Dyke Swarm.

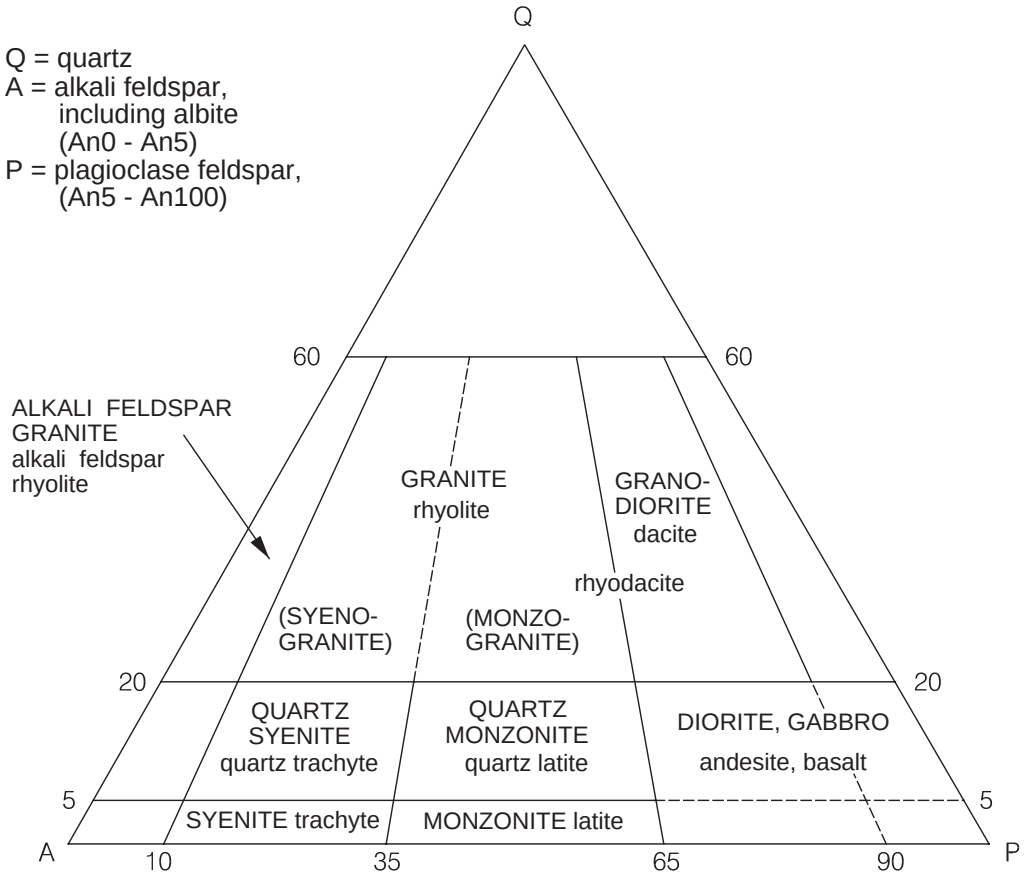

Figure 7 - Generalized Classification and Nomenclature of Selected Major and Minor Intrusive Rocks (after Le Maitre, 1989)

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. Non-porphyritic fine- to medium-grained lithologies are also present (Plates 3 and 4). Accessory minerals include concentrically zoned allanite, apatite, titanite, zircon, rare fluorite, and Fe-Ti 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. Unzoned to weakly zoned plagioclase is generally euhedral and composed mostly of oligoclase and albite. The cores are often weakly sericitized. Anhedral quartz (30 – 35%) shows undulose extinction showing that it is typically strained. Yellowish brown to green biotite usually comprises between 2 – 10% of the mode and is sometimes accompanied by subordinate greenish brown amphibole (3 – 5%).

Plate 3 - Fine- to Medium-grained Lantau Granite from a Borehole South of Ha Law Wan (1131 1716)

Chek Lap Kok Granite

The Chek Lap Kok Granite (Sewell *et al.,* 2000) forms a subcircular pluton centred on the airport at Chek Lap Kok. Prior to construction of the airport, the unit was exposed on the western half of the island Chek Lap Kok and on Lam Chau (Langford *et al.,* 1995). Exposures are now confined to the area between Tin Sam and Hau Hok Wan on the northern coast of Lantau Island. The type locality is designated as Hau Hok Wan.

On the former island of Chek Lap Kok, the Chek Lap Kok Granite was seen (Langford *et al.,* 1995) to intrude porphyritic fine- to medium-grained Lantau Granite. This relationship is still exposed on the northern coast of Lantau Island at Hau Hok Wan indicating that the Chek Lap Kok Granite post-dates emplacement of the Lantau Granite. The U–Pb age-dating results are consistent with the observed field relationships.

The Chek Lap Kok Granite consists of an equigranular, fine-grained, leucocratic monzogranite (Plate 5). Euhedral to anhedral alkali feldspar is composed principally of mesoperthite. Subordinate euhedral to subhedral albite is unzoned and anhedral quartz is weakly strained. Interstitial late stage muscovite is commonly present along with trace amounts of euhedral fluorite. Biotite, zircon, and Fe-Ti oxide may be present in trace amounts.

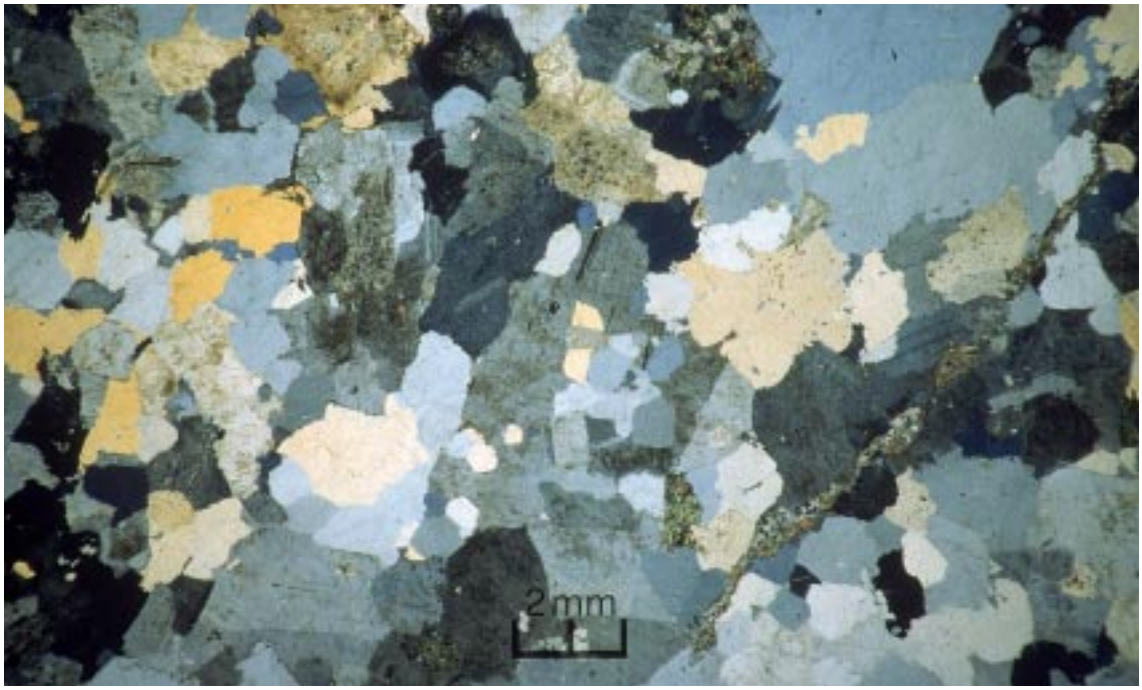

Plate 4 - Thin Section of Fine- to Medium-grained Lantau Granite from Pak Sha Tsui, Tung Chung (HK9236, 1131 1698); XPL

Quartz Monzonite

Small intrusions of quartz monzonite crop out at the faulted contact between the Lantau Volcanic Group and other rocks south of Sha Lo Wan and Hau Hok Wan.

Tong Fuk Quartz Monzonite

The Tong Fuk Quartz Monzonite crops out in a series of discontinuous stocks along the faulted contact between the Lantau Volcanic Group and other rocks. Major outcrops occur at Sha Lo Wan on the western side of Lantau Island and at Tong Fuk on the eastern side of Lantau Island (Plate 6). Smaller outcrops are found at Fan Lau and Pui O.

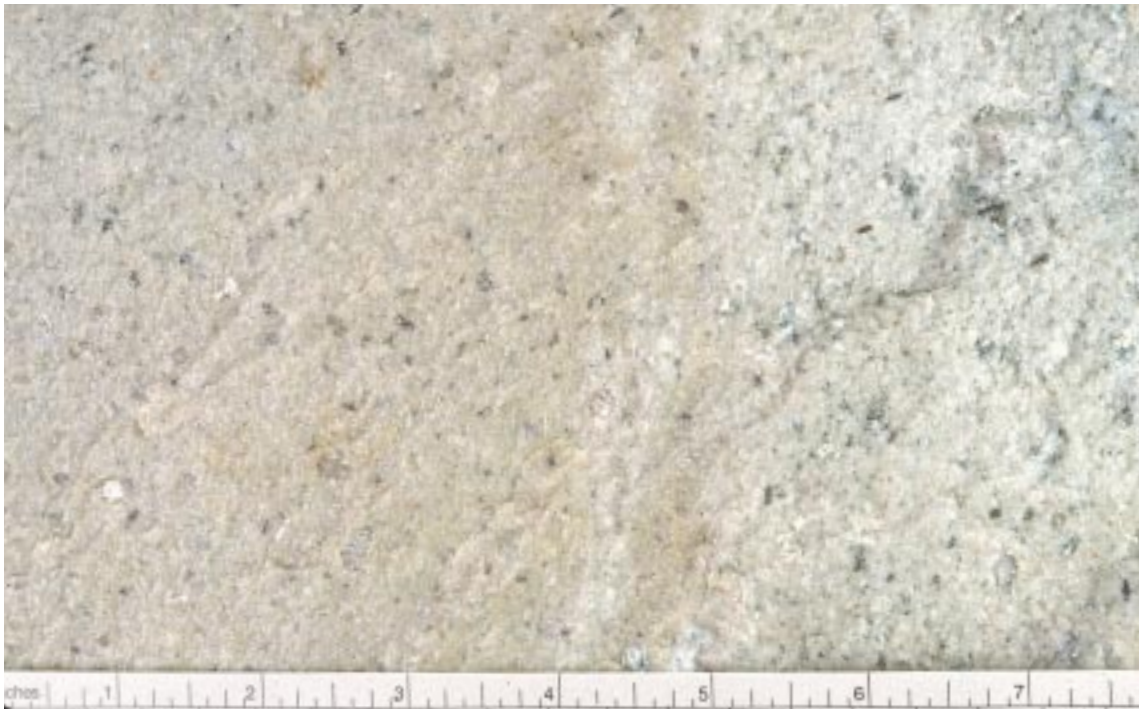

Plate 5 - Fine-grained Chek Lap Kok Granite from Tin Sam (HK9252, 0945 1709)

Plate 6 - Fine-grained, Porphyritic Tong Fuk Quartz Monzonite from Sha Lo Wan (HK10067, 0812 1633)

The Tong Fuk Quartz Monzonite is typically fine-grained and porphyritic, with roughly equal abundances of alkali feldspar and plagioclase phenocrysts, although alkali feldspar usually predominates. Rounded mafic enclaves composed mostly of quartz microdiorite, are common. In the Sha Lo Wan area, the quartz monzonite locally may vary to porphyritic fine-grained granite, but it is distinguished by the presence of scattered alkali feldspar phenocrysts with prominent twinning. In places, the quartz monzonite has been highly weathered to a reddish brown soil.

In thin section, euhedral to subhedral alkali feldspar phenocrysts (1 – 7 mm) display well-developed Carlsbad twins and are weakly zoned. Plagioclase phenocrysts are strongly zoned with sericitized andesine cores and albite rims. The matrix is generally granular and fine- to very fine-grained and comprises quartz and alkali feldspar, with subordinate plagioclase. The mafic minerals consist of greenish brown biotite and rare brown amphibole. Biotite is commonly altered to chlorite. Accessory minerals include zircon, fluorite, titanite, apatite, allanite, epidote, and Fe-Ti oxide.

A sample of quartz monzonite from Tong Fuk has yielded a U–Pb single zircon age of 140.4 ± 0.3 Ma.

Minor Intrusions

With the exception of mafic dykes, the minor intrusions of the district are divided on the basis of texture into feldsparphyric rhyolite, porphyritic microgranite, and quartzphyric rhyolite. The felsic dykes are present as a dense swarm of strongly eastnortheast–westsouthwest-oriented multiple intrusions cutting granitic and volcanic rocks. The dykes were intruded in at least three pulses and show evidence for compositional zoning (Li *et al.,* 2000). Composite intrusions, featuring a felsic phase injected into a more mafic one, are sometimes observed. None of the dykes in the district have been dated. However, rhyolite dykes to the northeast of the district have returned ages of 146 Ma which suggests that the age of emplacement is synchronous with that of the Lantau Volcanic Group.

Feldsparphyric Rhyolite

Feldsparphyric rhyolite is the general term given to dykes ranging in composition from rhyodacite to high-silica rhyolite which contain abundant feldspar (±quartz) phenocrysts (<1 mm – 10 mm) or megacrysts (10 – 25 mm) (Li *et al.,* 2000). Within a single dyke, textures may vary from coarsely feldsparphyric on the margins to finely feldsparphyric in the cores (Li *et al., op. cit.*). In compositionally zoned dykes, the margins are

usually composed of aphyric basaltic andesite to andesite. These compositions grade rapidly through feldsparphyric rhyolite to aphyric rhyolite in the cores of the dykes. Sometimes there is evidence for abrupt changes in composition which reflect separate pulses of magma intrusion within a single dyke (Li *et al., op. cit.*).

Fresh, feldsparphyric rhyolite has a distinctive dark grey appearance with white and grey phenocrysts. The phenocrysts are made up of slightly pinkish grey euhedral alkali feldspar, with subordinate euhedral to subhedral white plagioclase, dark grey bipyramidal quartz, aggregates of biotite, and rare crystals of hornblende. With a slight degree of weathering, the groundmass turns to greyish green, or greyish purple, and ultimately to orangish brown in intensely weathered rocks.

In thin section, the groundmass is dark grey, very fine-grained to cryptocrystalline and aphanitic, with occasional granophyric intergrowths of quartz and feldspar, and biotite. Accessory minerals include zoned allanite, zircon and Fe-Ti oxide.

Along with the granite, these blocks have been intruded by composite feldsparphyric rhyolite to porphyritic microgranite dykes of the Lantau Dyke Swarm.

Porphyritic Microgranite

Porphyritic microgranite is the term given to a textural variant of feldsparphyric rhyolite in which individual crystals in the groundmass are less than 2 mm diameter on average, but are still visible to the unaided eye. The rock is compositionally similar to feldsparphyric rhyolite and contains phenocrysts of feldspar (±quartz) up to about 25 mm in size. Porphyritic microgranite dykes are characterised by the presence of granophyric texture in the groundmass. The cores of these dykes may be either finely feldsparphyric or aphyric and indistinguishable from normal fine-grained granite.

Porphyritic microgranite dykes trend eastnortheast and have mainly been mapped to the east of Tung Chung Wan between Tin Sam and Tung Hing. They vary from 2 to 30 m wide and intrude fine-grained granite (Chek Lap Kok Granite). The porphyritic microgranite dykes were probably intruded broadly at the same time as the feldsparphyric rhyolite (*c.*146 Ma) although slight differences in the age of emplacement are displayed by signs of chilling along some dyke to dyke contacts.

Quartzphyric Rhyolite

Quartzphyric rhyolite is the name given to rhyolite dykes in which large (up to 3 mm) bipyramidal quartz phenocrysts are more abundant than feldspar phenocrysts. Crystals in the groundmass are too fine-grained to be distinguished by the unaided eye, and flow banding may be discernible. The cores of quartzphyric rhyolite dykes may be almost aphyric. Very fresh examples of quartzphyric rhyolite may be dark grey to black, whereas with slight alteration, the colour is grey, purple or pink.

Quartzphyric rhyolite dykes within the district trend northeast and eastnortheast and are confined almost entirely to the former island of Chek Lap Kok where they intrude granite. A few quartzphyric rhyolite dykes have been mapped along the coast northeast of Tung Chung. The dykes are typically 3 to 5 m wide, but can be up to 30 m wide. The margins of the quartzphyric rhyolite dykes are commonly flow banded.

In thin section, the quartz phenocrysts are euhedral to subhedral with well-developed bipyramidal shapes, although occasionally they may be slightly embayed. Alkali feldspar is commonly microperthitic and plagioclase feldspar is mostly oligoclase. The fine- to very fine-grained groundmass contains accessory minerals of muscovite, biotite and Fe-Ti oxide. Granophyric texture is sometimes present.

Aplite

Sporadic northeast- and eastnortheast-trending dykes of aplite have been mapped along the coast between Sha Lo Wan and Hau Hok Wan. These dykes vary from 25 to 50 mm wide and intrude fine- to medium-grained Lantau Granite and Chek Lap Kok Granite. The aplite dykes are typically leucocratic and equigranular, and are thought to represent granitic fluid expelled along fractures at a late stage in the cooling history of the granitic magma.

Quartz Veins

Quartz veins are ubquitous in the northern part of the district where they are commonly seen intruding granitic rocks, rhyolite dykes, and volcanic rocks. The quartz veins vary from stringers a few millimetres wide to dykes up to 30 m wide. Ruxton (1958) divided the quartz veins into two types: 1) high temperature (pneumatolytic) type, typically of grey colour and medium-grained granular texture, found between granite and country rock, and in its immediate vicinity, interlacing in all directions at the contact zone, and 2) moderate to low temperature (hydrothermal) type composed dominantly of glassy or milky quartz, with minor feldspar, and found in more regular linear zones which cross cut the type 1 veins. The pneumatolytic veins (type 1) are composed of quartz and bleached biotite with minor quantities of feldspar, topaz, fluorite, molybdenite, chalcopyrite, arsenopyrite, wolframite, pyrite, and beryl. The concentrations of the metallic ores are sporadic. The hydrothermal veins have sharp boundaries with the country rock and appear to have exploited structural planes of weakness, such as shearing, jointing and fracturing. These veins often carry pegmatitic patches composed of pink orthoclase. The type 2 quartz veins strike eastsoutheast–westnorthwest and dip about 60º to the southsouthwest. Chalcopyrite is the dominant ore mineral in these veins, with minor amounts of pyrite, arsenopyrite, galena, and wolframite. Veins of magnetite ore also occur on the coast between Sha Lo Wan and Hok Hau Wan.

Numerous quartz veins have been mapped adjacent to the faulted contact between the Lantau Volcanic Group and other rocks in the western part of the district. These quartz veins contain zones of tungsten mineralisation. The thickest quartz vein is exposed on the western side of Hau Hok Wan.

Mafic Dykes

Mafic dykes, ranging from 50 mm up to 7 m wide and with variable orientations, are present mainly in the northern part of the district. They intrude granitic rocks and rhyolite dykes. They are mostly of basaltic andesite composition, but range from basalt to andesite. Several high-K varieties can be classified as lamprophyres. The mafic dykes are all strongly altered. Although none of these dykes has been radiometrically dated, they have similar composition to mafic dykes that occur in northeastern Lantau Island and which have returned Late Cretaceous ages (GEO, unpublished data).

In thin section, the rocks are typically very fine-grained and microporphyritic. The basaltic andesite dykes have sericitized plagioclase and pyroxene phenocrysts, sometimes showing the development of sub-ophitic texture. The groundmass of the basaltic andesite dykes contains abundant hornblende, with plagioclase, epidote, and Fe-Ti oxide (Plate 7). Lamprophyric dykes generally have abundant augite and/or hornblende in the groundmass, and are distinguished from the basaltic andesite dykes by the absence of plagioclase phenocrysts.

Plate 7 - Thin Section of a Mafic Dyke from Hau Hok Wan (HK9237, 1156 1727)