

Chapter 4

Metamorphic and Igneous Rocks

Metamorphic Rocks

The alteration of the rocks of the district by both regional and thermal metamorphism has been a long and complex process. The regional effects are dominant in the San Tin Group and are here classified as the greenschist facies. The metamorphic mineral assemblages are represented by epidote, chlorite and actinolite. Chlorite, muscovite, biotite and chloritoid are typical in the pelitic rocks. Regional metamorphism began in the Palaeozoic basement (Bennett, 1984c; Chan, 1987), but the main phase to affect the district occurred after the deposition of the Upper Jurassic/Lower Cretaceous Repulse Bay Volcanic Group.

Thermal metamorphism affects sedimentary rocks and tuffs close to igneous intrusive contacts, with the formation of garnet and tremolite as accessory minerals. Many rocks have a hornfelsed or spotted texture which result from the introduction of biotite and pyrite.

Metasomatism or chemical alteration caused by fluids and gases emanating from the cooling pluton body, has affected marble overlying granite and granodiorite to the northeast of Yuen Long and near Tin Shui Wai (Plates 13 & 14).

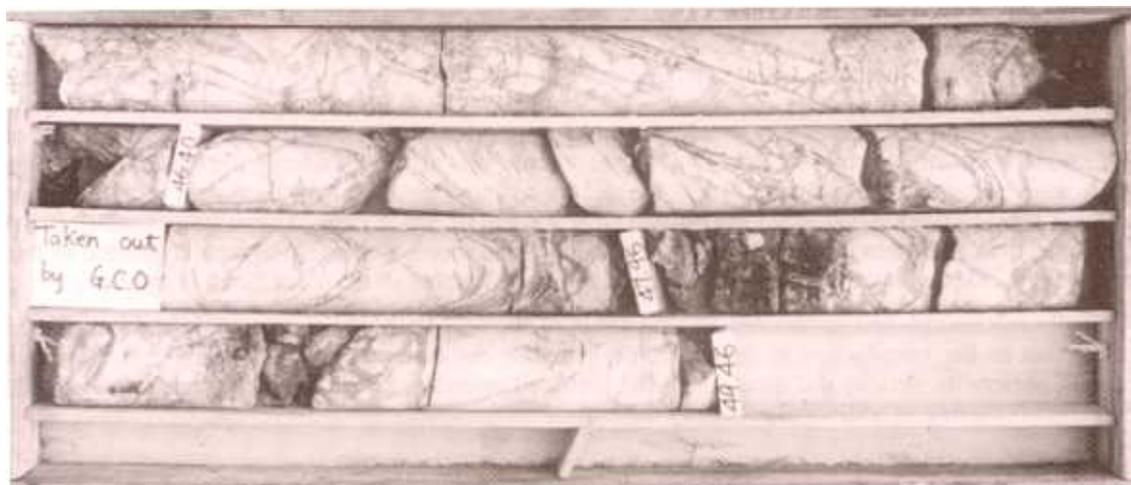


Plate 13 - Veined and Fractured Marble Closely Overlying Granodiorite; BGS9, 45.25-49.46m

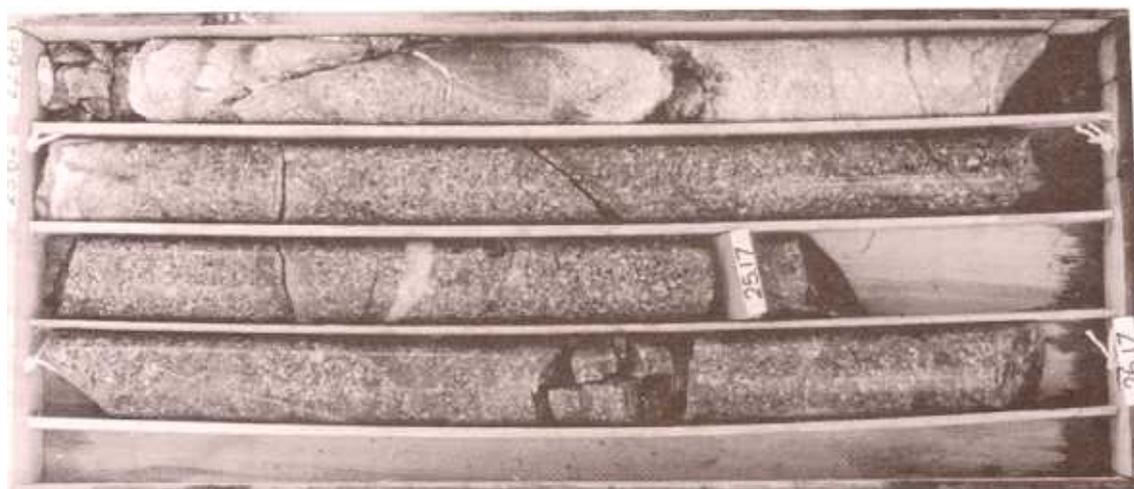


Plate 14 - Granodiorite Showing Stained Joints; BGS6, 22.66-26.17 m

Regional Metamorphism

Regional metamorphism was caused by the overthrusting of the Palaeozoic basement on to Mesozoic volcanics (Langford *et al*, 1989), and its effects extend from Tuen Mun northeast into Shenzhen. The 2 km wide zone of Carboniferous rocks near Mai Po [240 400], sandwiched between the Tsing Shan granite pluton to the northwest and the volcanic rocks to the southeast, shows many features of regional metamorphism. A 600 m wide belt of olive green phyllites border the granite, and are interbedded and interlaminated with pale grey metasiltstone and metasandstone. The siltstones are calcareous in places and commonly exhibit injection of quartz and calcite veins; secondary pyrite is particularly common. The rocks are highly chloritized, and kaolinite occupies many joints and microfractures. Some of the sandstone beds show boudinage structures. In thin section, cryptocrystalline quartz and muscovite show preferred orientation, with some quartz grains showing elongation in the plane of schistosity.

A number of boreholes (for example, BGS 26, 27, 28) in the Mai Po area proved graphitic siltstone and mylonitic graphite schist, up to 100 m in thickness, which were in lens-like form at several different horizons. Exposures of mylonitic graphite schist were also noted near Mai Po [2450 3915] in temporary excavations for new road construction. Thin sections showed a predominance of quartz with ribbon-like graphite interlaminated with the quartz grains. Two preferred orientations were displayed, suggesting two phases of metamorphism. A biotite schist was recorded at 154 m in BGS 11, which in thin section showed phenocrysts of biotite in a groundmass of quartz, with muscovite and pyrite both having preferred orientation.

The pure white marble of the Ma Tin Member has undergone complete recrystallisation with a mosaic of equigranular calcite crystals usually dominating thin sections. In a thin section of a fragment of marble core from 97 m in BGS 8 biotite is abundant and shows a preferred orientation.

Thermal Metamorphism

In the Ma Tin Road Borehole, garnet is recognisable as pink patches within the marble cores above and below a thin dyke intruded at depths between 362.75 m and 363.40 m. In an adjoining site close to the Ma Tin Road Borehole, garnet was present in core from a ground investigation borehole at a depth of 93.20 m. The close proximity of dykes within the marble was again considered the cause of this high temperature metamorphic inclusion. Tremolite occurs as large areas of white crystals with a fibrous radiating habit in the Ma Tin Road Borehole core at a depth of about 92 m. Tremolite is usually found as a contact metamorphic mineral in impure crystalline limestones, and its stratigraphic position in this borehole coincides with the top boundary of the Long Ping Member of the Yuen Long Formation.

Thermally metamorphosed sandstones and siltstones of the Mai Po Member commonly show a spotted texture due to the introduction of metamorphic minerals, the commonest of which is pyrite. In thin sections, muscovite, sericite and quartz showing preferred orientation form the groundmass, with biotite and garnet occurring as additional accessory minerals.

Metasomatism

In borehole BGS 9, some 50 m of marble overlies granodiorite. In hand specimen this marble is mostly white to pink in colour, and is strongly fractured and veined. Dark brown silty clay fills some of the fractures in the epikarst zone, whilst others comprise open boxwork structures. The clays are weathered concentrations of ferruginous and manganese minerals. In thin section a specimen of marble from a depth of 65 m showed an irregular mosaic of calcite crystals, some displaying pressure solution effects along their margins. Cleavage traces are in places curved, whilst others are fractured in an en-echelon structure in response to regional stress. The mineralised veins are opaque and indeterminate.

Intrusive Igneous Rocks

The minor intrusions of the district have been described in detail by Langford *et al* (1989). Only one exposure of a dyke at surface was seen during this project, but numerous examples were intersected at depth by the BGS borehole series.

By far the commonest dyke rock encountered was quartzphyric rhyolite. In BGS 14 such a dyke was proved some 7 m thick at -98.93 mPD. It trends northeastwards and cuts both the Yuen Long and the Lok Ma Chau formations. Feldsparphyric rhyolite dykes are older than the quartzphyric variety and have been recorded in the Ma Tin Road Borehole and in boreholes at the Light Rail Transit depot in Yuen Long.

An andesite dyke was intersected in ground investigation boreholes [1965 3312] to the southwest of Yuen Long. Examples of basalt dykes trending both northeastwards and northwestwards have been

recorded from the Light Rail Transit depot in Yuen Long, and in sites adjacent to Ma Tin Road in the south of the town. The basalt dykes form the youngest intrusions of the district and are considered to be of Tertiary age (Langford *et al*, 1989).

Granitoid Rocks and Heat Generation

Metagranodiorite has been found in many boreholes in the district. The rock is commonly foliated and forms irregular intrusive bodies, some of which have dyke-like form. Some 15 m of metagranodiorite were proved at the bottom of BGS 14 adjacent to Deep Bay. BGS 6, 9, 10, 14, 16, 39 and 41 all proved granodiorite at various depths, showing that much of the district is underlain by granitoid rocks.

The granites surrounding the Yuen Long district are well exposed and have been described by Langford *et al* (1989). Further provings have been made during the present survey, for example, BGS 33 and 36 penetrated the northeasterly extension of the Castle Peak (Tsing Shan) granite pluton.

Recent research in Europe has investigated granite bodies heated by radioactive decay as potential sources of energy. The presence of radioactive elements within the Hong Kong granites is implied by the concentrations of radon gas found in a recent preliminary survey by the Environmental Protection Department (Lee, 1989) and by fairly high levels of the trace elements uranium and thorium. The presence of two deep boreholes of over 400 m depth in the Yuen Long district provided an opportunity to measure the temperature at depth. In the Ma Tin Road Borehole a temperature of 36°C was recorded at a depth of 366 m, suggesting a 1°C rise for every 30 m depth.