Chapter 3
Sedimentary and Volcanic Rocks

Palaeozoic Rocks of the San Tin Group

Classification and Distribution

The sedimentary rocks of this Palaeozoic basin (the San Tin Group) occupy a northeasterly, curving, faulted, irregular belt at least 25 km long and up to a maximum of 4 km in width. This fault-bounded basin extends northwards into Shenzhen and Guangdong, and south through Tuen Mun. Bennett (1984c) outlined the basic structure of the area as a narrow graben between the Castle Peak and the Sung Kong granites, and noted the presence of metasedimentary rocks of the Repulse Bay Formation and the Lok Ma Chau Formation.

The San Tin Group is divided into two formations; a lower, largely calcareous Yuen Long Formation, and an upper, mostly arenaceous/argillaceous Lok Ma Chau Formation (Langford *et al*, 1989)(Figure 5).

Yuen Long Formation

The Yuen Long Formation was named by Lee (1985) to distinguish the *concealed marbles and limestones* of the Yuen Long area from the better known clastic rocks belonging to the established and exposed Lok Ma Chau Formation (Bennett, 1984b). The distinctive carbonate lithologies were originally recognised by Ha *et al* (1981), who suggested that they probably belonged to the Carboniferous Period. General support for a Carboniferous age was provided by the strike of the rocks which could be traced northeastwards into Shenzhen, where unpublished 1:50 000 geological mapping of the Shenzhen Special Economic Zone apparently showed similar lithologies classified as Lower Carboniferous (Visean) (Lai & Mui, 1985).

The Yuen Long Formation is overlain by the Lok Ma Chau Formation. The boundary between the two formations is in places gradational but in others sharp and probably unconformable. The presence of beds of marble intercalated with the lowest metasiltstones in some boreholes is interpreted by Langford *et al* (1989) to be a gradual passage from a dominantly calcareous sequence to one of largely clastic material. The boundary is invariably difficult to interpret at depths down to -100 mPD, because of the karstification of the marble. A poorly recovered borehole core of marble with silt-filled cavities may closely resemble that of a weathered interbedded metasiltstone and marble, or a tuff-breccia with clasts of marble. In the Long Ping Estate area of Yuen Long, metasiltstones of the Mai Po Member rest on the dark grey marble of the Long Ping Member. This boundary would appear therefore to be an important unconformity.

Micropalaeontological evidence (Langford *et al*, 1989) confirmed the rocks of the formation to be of Carboniferous age. Most of the samples were obtained from graphite schists interbedded with siltstones of the Mai Po Member. They range from Tournaisian (Lower Carboniferous) to Namurian-Westphalian ages (Upper Carboniferous). Further samples from the San Tin Group analysed during this project yielded Visean miospores (Appendix 4).

A gravity survey was undertaken in an attempt to identify areas of positive anomaly corresponding to the marble subcrop around Yuen Long Town. Eight closures of a positive gravity anomaly overlie or closely correspond to known areas of marble beneath superficial deposits. Particularly good correspondence occurs in the main marble area in southeast Yuen Long at localities [208 337], [209 303] and [216 339]. A borehole near the first locality confirmed marble to a depth of 430 m without proving the base. Smaller areas of subcrop [214 358], such as those north of Yuen Long bordering the Industrial Estate, those northwest of the town around the Long Ping Estate at [205 346], [206 343] and [206 340], and near the Lung Bin Temporary Housing Area [198 337], are sufficiently large to highlight density differences between the marble and the surrounding rocks.

Not all areas of known marble subcrop correlate with zones of positive anomaly (Collar *et al*, 1990). For example, north of Wang Chau no positive anomaly exists, but the marble is probably less than 10 m thick in a small thrust-slice which is incapable of contributing towards the typical anomaly. Evidence of lineaments is present in several areas of Yuen Long, in particular the sharp southeastern edge to the main marble subcrop. This lineament corresponds to a thrust fault seen at outcrop to the northeast of the

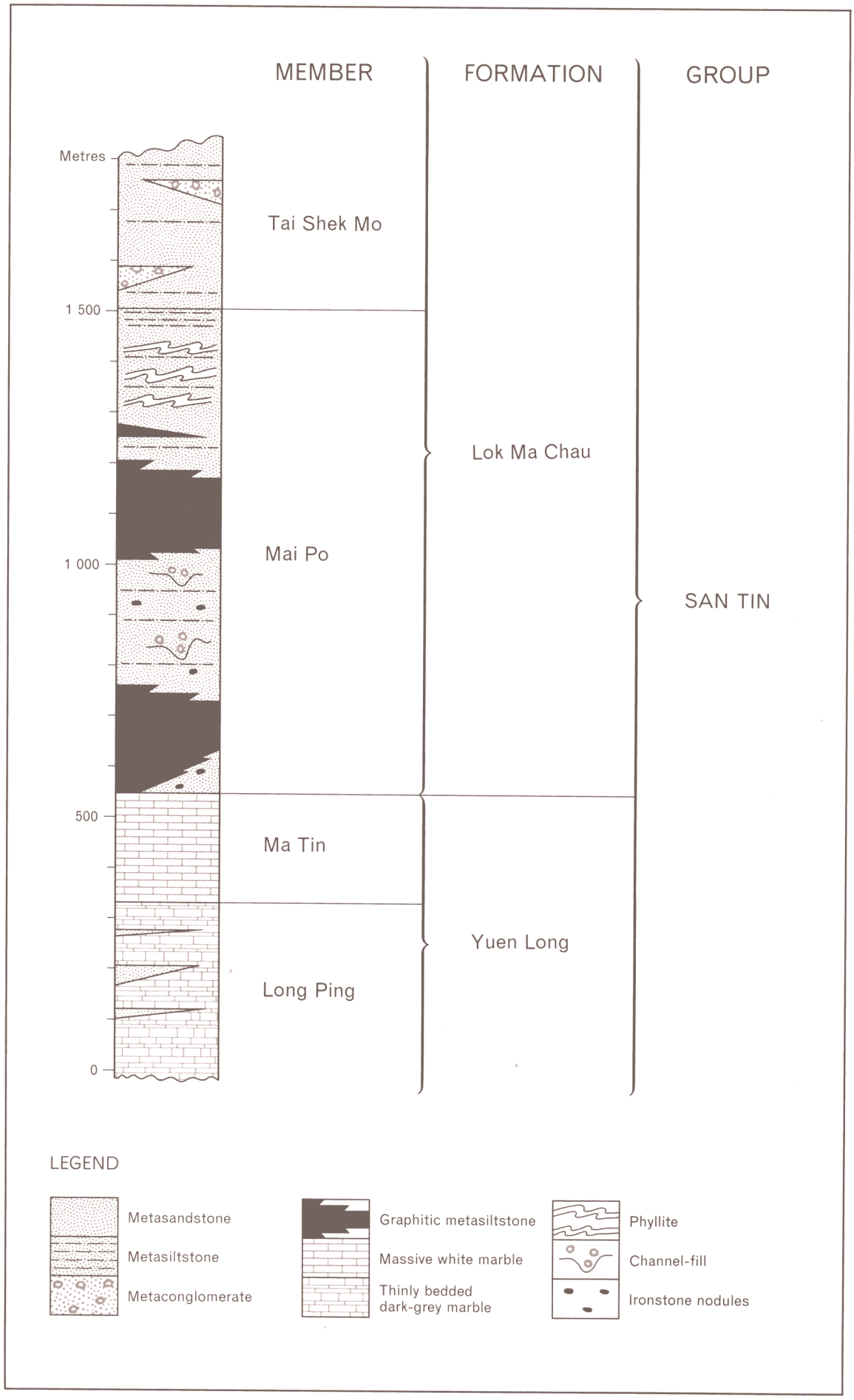

Figure 5 - Generalised Section of the San Tin Group

district [242 387] near Mai Po. The deeply weathered volcanics on the downthrust eastern side contrast markedly in density with the massive white marble of the Yuen Long Formation to the west. A similar boundary on the west of this subcrop indicates the steeply dipping edge of the marble overlain by Mai Po siltstones. Some indication of the dislocation of this margin by cross-faulting is also given by the changes in direction of the anomaly.

Long Ping Member

The lowest known Carboniferous strata comprise the Long Ping Member (Frost, 1989a). The areas of subcrop are made up of small fault-slices to the southeast and north of Yuen Long (Figure 4). The strata consist of a thick sequence of grey to dark grey, finely crystalline marble, probably exceeding 300 m in thickness. The internal structure is complex, showing many convoluted, disturbed and disrupted bedding planes and laminae. The member is considered to have originated as an alternating and interbedded sequence of thin limestones, calcareous mudstones and siltstones which have been metamorphosed both regionally and thermally. The sediments are typical of a basinal carbonate environment influenced by rapid sedimentation and a nearby supply of terrigenous material. The detrital content, mostly fine silt, pyrite and mica, imparts the dark colour to the rock. The extent of the subsequent tectonic history and metamorphism is shown by the disruption of the once uniform and even bedding. Calcite and quartz veins are common. Insoluble residues making up 8% by weight of the rock are common but up to 33% has been recorded. Minerals identified from the residues by X-ray diffraction include chlorite, talc, amphibole, pyrite, mica, quartz, feldspar and haematite. Strata of the Long Ping Member are well represented in borehole cores in BGS 2, 17, 23, 38, and the deep Ma Tin Road Borehole (Plate 7).

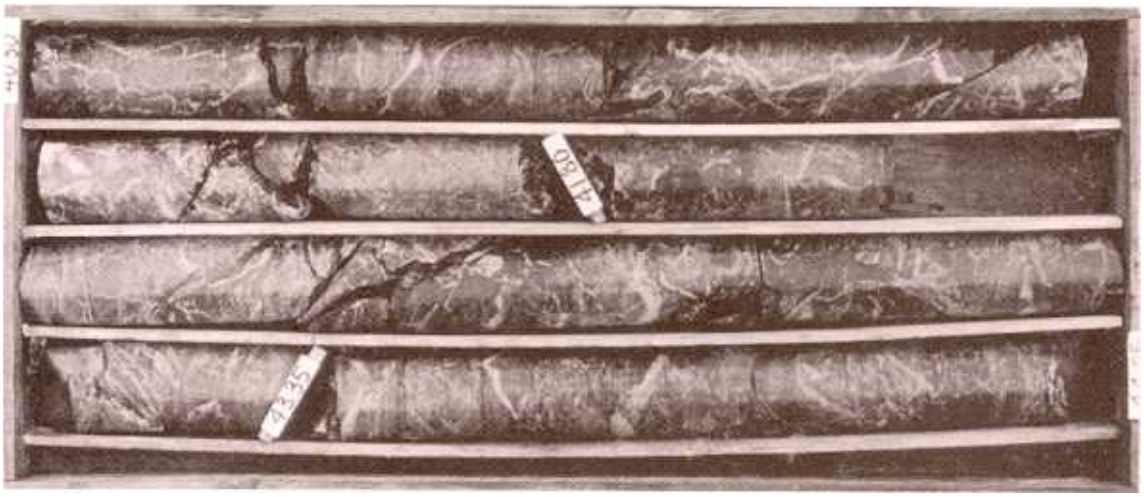

Plate 7 - Marble From the Long Ping Member, Yuen Long Formation; BGS2

Local changes in the supply of terrigenous material are reflected in variations of lithology. Sporadic siliceous rocks (originally sandstones), dolomites (associated with periods of partial shallowing of the basin), and graphitic metasiltstones (carbonaceous siltstones) have also been recorded. As the basin began to fill with Carboniferous sediments, a gradual change occurred to a more shelf-like model of sedimentation in which strata of the Ma Tin Member were deposited.

Ma Tin Member

The main area of mapped subcrop of the Ma Tin Member is limited to the urban area of Yuen Long, with small faulted lenses to the west near Ping Shan and in the area of Tin Shui Wai (Figure 4a); total thickness is about 300 m. Typical core of the Ma Tin Member is present in boreholes BGS 3, 4, 5, 9, 12, 22, 24 and in the type area of the deep borehole at Ma Tin Road. The latter is retained within the Hong Kong Geological Survey archives (Plate 8).

The Ma Tin Member comprises massively bedded, white, crystalline marble. Subsidence of the basin floor kept pace with the sedimentation, as shown by the considerable thickness of carbonates which formed. However, the supply of silt was cut off for most of this period and the purity of the original limestones must have been very high. The chemical composition of the marble (Langford *et al*, 1989) comprises over 99% calcium carbonate. Minerals identified from the insoluble residues, which make up about 1% of the rock, include mica and smectite with minor occurrences of quartz and chlorite (Appendix 5). The petrography (Yuen, 1990) showed crystalline calcite ranging between 0.1 and

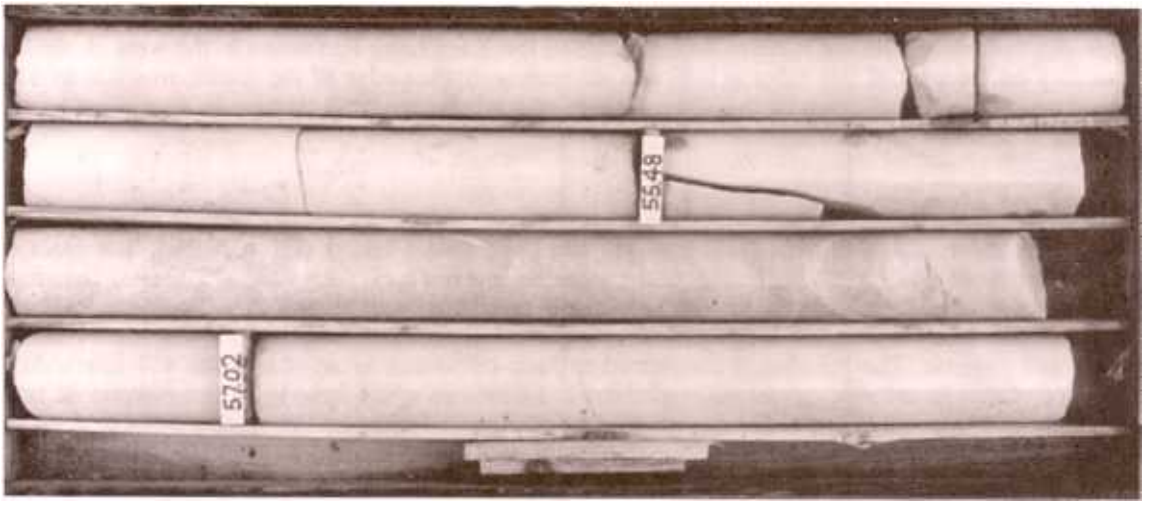

Plate 8 - Marble From the Ma Tin Member, Yuen Long Formation; BGS3

0.5 mm. Accessory minerals include dolomite, tremolite, epidote, wollastonite, quartz, chlorite, sericite, sphene, garnet and pyrite. The grade of metamorphism is therefore locally high. Secondary silicification occurs in places towards the top of the marble rockhead. Fossil remains in the original limestone have been destroyed by the recrystallisation, and despite the application of the latest techniques of cathode luminescence, no trace of fossil *ghosts* were detected. An attempt to date the marble using the variations in the uranium/lead isotope ratios was unsuccessful.

Lok Ma Chau Formation

This formation was named and defined by Williams (1943). A Permian age was attributed to these rocks by Heim (1929), but Brock *et al* (1936) in the first geological map of Hong Kong implied a Cretaceous age. Later, Allen & Stephens (1971) placed the formation in the Jurassic Period. Lai (1977) was the first to suggest that the strata were of Carboniferous age, using comparisons with rocks in Shenzhen. Lai & Mui (1985), after further fieldwork in the northwest New Territories and examination of many new boreholes, compiled a more detailed stratigraphy of the formation and calculated a total thickness exceeding 1 000 m. They correlated the formation with strata containing Carboniferous macrofossils in Shenzhen and Guangzhou (Nan, 1979). Again by inference the Lok Ma Chau Formation was taken to be of Lower Carboniferous age. No equivalent representative of the Upper Carboniferous Hatian Series of Guangzhou and Shenzhen was recognised.

The Lok Ma Chau Formation underlies a large proportion of the low-lying ground between Tuen Mun and Mai Po, and has been divided into an upper Tai Shek Mo Member and a lower Mai Po Member (Langford *et al*, 1989).

Mai Po Member

This member is some 1 000 m thick and comprises metamorphosed argillaceous limestones, mudstones, siltstones, sandstones and thin conglomeratic beds. Towards the base of the succession, the siltstones and mudstones are carbonaceous with ferruginous concretions, and have been converted into graphitic metasiltstones and graphite mylonitic schists. Red and yellow staining of the sandstone is also common where associated with the carbonaceous mudstones. Washouts and channel-fills are sedimentary structures sporadically seen in temporary exposures. Parts of the succession are repetitive, but no evidence of cyclical sedimentation has been noted. On a microscopic scale, interlamination of coarse and fine quartz is present. The complex structure and metamorphism may mask any cyclic pattern. The heavy mineral suites of sandstones are dominated by zircons, with apatite and rutile locally common (Appendix 6). Most samples contained epidote and garnet of secondary (metamorphic) origin.

The Mai Po sediments are typical of a deltaic environment in which sedimentation was fairly rapid and continuous. Local changes in geography and topography caused the frequent variations in lithology. These variations are well displayed in cores from the numerous boreholes, for example in BGS 4, 5, 7, 11, 14, 18, 19, 20, 21, 23, 27, 28, 29, 42, 43, 46 and the deep borehole at Deep Bay. Cores from BGS 27 & 28 exhibited good examples of the graphitic metasiltstone and graphite schist (Plates 9 & 10; Appendix 7).

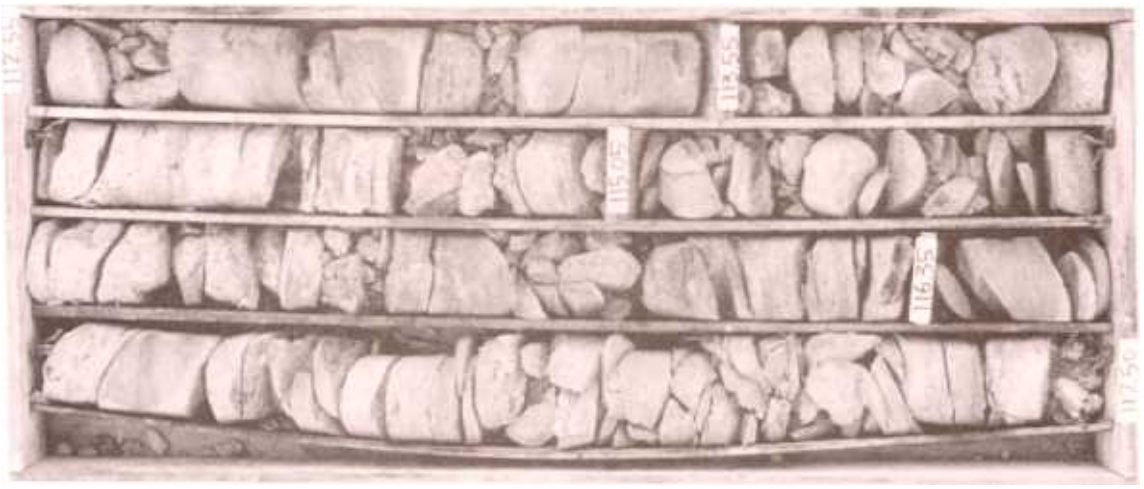

Plate 9 - Metasiltstone and Metasandstone of the Mai Po Member, Lok Ma Chau Formation; BGS11,112.55-117.50 m

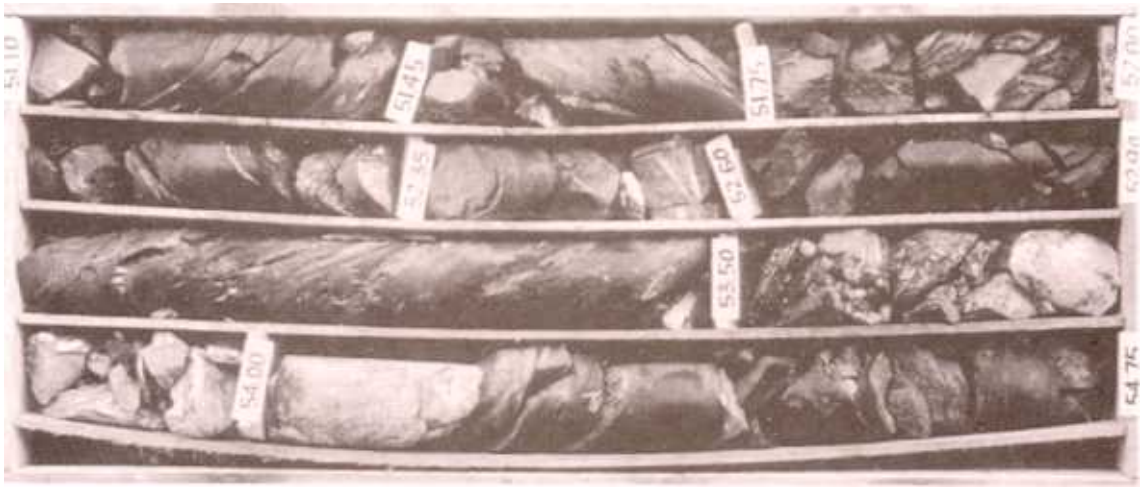

Plate 10 - Graphite Schist of the Mai Po Member, Lok Ma Chau Formation, with Prominent White Quartz Veins; BGS27, 51.10-54.75 m

Tai Shek Mo Member

This Member forms the arenaceous top to the Carboniferous succession in the northwest New Territories and is exposed on the high ground northeast of Lok Ma Chau. The dominant lithology is a yellowish white medium- to fine-grained metasandstone, interbedded with metasiltstone near the base and containing several metaconglomerate horizons within the lower half of the sequence. The thickness of the Tai Shek Mo Member is calculated to be over 300 m (Langford *et al*, 1989).

Mesozoic Sedimentary and Volcanic Rocks

The Tolo Channel Formation was originally defined by Brock & Schofield (1926) with the type section in Tolo Channel. The discovery by Yuen (1989) of an ammonite (Arietites sp) in sandstone at an outcrop south of Yuen Long [2112 3035] showed that this area contains Lower Jurassic strata. The sandstone mapped near Tai Tong, 2 km south of Yuen Long, is now therefore classified as belonging to the Tolo Channel Formation.

The first detailed lithostratigraphy of the Mesozoic volcanic rocks was presented by Addison (1986), who established the Repulse Bay Volcanic Group. The basal formation in the Tuen Mun district (Tsing Shan Formation) contains interbedded sedimentary rocks which were first recognised and mapped on the 1:20 000 geological map Sheet 5 (Tsing Shan) (Langford *et al*, 1989).

Volcanic rocks have been proved only in a few of the boreholes drilled for the present project. These include 1, 8, 13, 15, and 21. The strata in these boreholes were originally classified as sedimentary in origin, but Darigo (1989) has shown that most comprise an interbedded sequence of volcaniclastic rocks

Plate 11 - Highly to Completely Weatherd Tuffaceous Siltstone with Clasts of Marble, Tin Shui Wai Member, Tuen Mun Formation; BGS8, 91.80-97.40 m

including tuff-breccia, fine to coarse ash andesitic tuff and tuffite, tuffaceous siltstone, lapilli tuff and andesitic conglomerate (Tin Shui Wai Member)(Plate 11).

The clasts within the Tin Shui Wai Member are angular to subrounded and are composed of white marble, quartzite, metasiltstone and andesitic tuff. In BGS 8 the succession originally considered to represent the transition zone between marble and siltstone is now interpreted as highly and completely weathered volcaniclastic rocks with clasts of marble. The largest clast, from a depth of 92.50 to 94.80 m, suggests a source of the marble close to the borehole. Conglomerates typical of those in BGS 15 near Tsim Bei Tsui were previously thought to be part of the Tai Shek Mo Member (Lok Ma Chau Formation) but are now classified as belonging to the Tin Shui Wai Member and are a sedimentary facies further removed from the volcanic source (Plate 12).

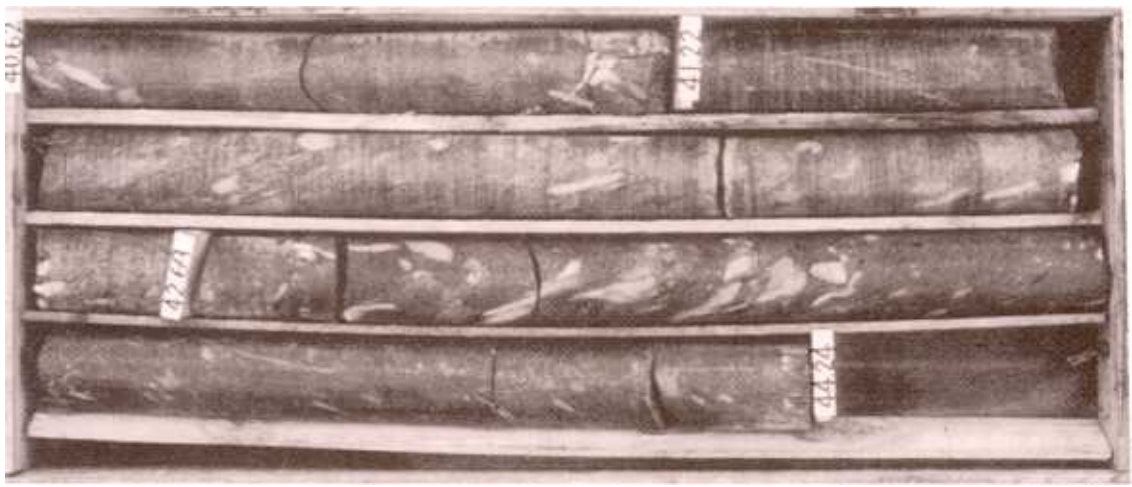

Plate 12 - Interbedded Tuffite and Marble-bearing Breccia, Tin Shui Wai Member, Tuen Mun Formation; BGS18, 40.62-44.24 m

The volcanic rocks of the district are the most deeply weathered of all the lithologies. They are weathered to depths of -140 mPD, and the marble breccia layers are probably the most susceptible. Exposures of weathered tuffs were noted near Mai Po [245 385] where road cuttings exposed sections adjacent to the thrust boundary with the Lok Ma Chau Formation. They comprised red, yellow and brown sandy silts intruded by thin quartz veins trending northeastwards.