Chapter 3
Sedimentary and Volcanic Rocks

Palaeozoic Rocks of the San Tin Group

Classification and Distribution

Palaeozoic sedimentary rocks are only exposed on Tsz Kan Chau (Reef Island) to the north of Lantau Island. However, an extensive subcrop of sedimentary rocks has been proved by boreholes to the north of this island, just outside the district. These sedimentary strata are thought to form either a roof capping to granite intrusions or a screen between plutons.

The sedimentary rocks of the district have lithological similarities with the main outcrop of Carboniferous rocks in the northwest New Territories and are assigned to the San Tin Group (Langford *et al*, 1989). The San Tin Group comprises two formations; the older Yuen Long Formation (Lee, 1985) and the younger Lok Ma Chau Formation (Williams, 1943). Only the Lok Ma Chau Formation is exposed in the district although white marble of the Yuen Long Formation is known from a few boreholes located to the north of Tsz Kan Chau (NS1/14460, NS3/14460, T8/3/13951) just outside the district.

Lok Ma Chau Formation

Mai Po Member

The Lok Ma Chau Formation comprises two member units; the older Mai Po Member consisting of metamorphosed siltstone, fine-grained sandstone and carbonaceous siltstone and the younger Tai Shek Mo Member consisting of metamorphosed sandstone and conglomerate. The rocks exposed at Tsz Kan Chau are assigned to the Mai Po Member.

At the southeastern end of Tsz Kan Chau, the sedimentary rocks are composed of cream to brown, cross-bedded, pebbly coarse-grained sandstone to laminated fine-grained quartz sandstone, with sparse,

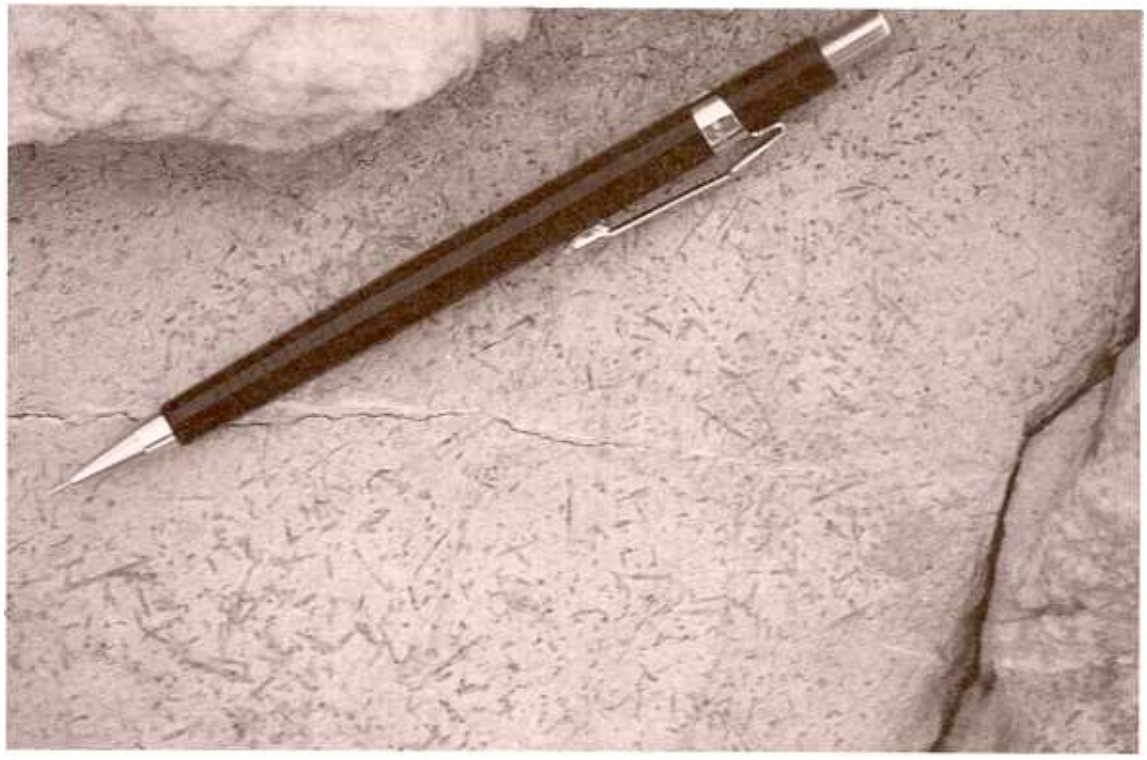

Plate 1 - Andalusite Crystals in Sandstone of the Lok Ma Chau Formation Exposed on Tsz Kan Chau (15880 20849)

intercalated beds (0.5 - 1 m) of dark grey to black, massive to poorly laminated graphitic siltstone. Andalusite crystals are well-formed in the sandstone beds (Plate 1) indicating that the succession has been contact metamorphosed. To the northwest, the sedimentary rocks grade upward into northwesterly-dipping (65-70°), cream to reddish brown, massive fine-grained quartz sandstone. The succession is believed stratigraphically to overlie marble of the Yuen Long Formation found in offshore boreholes to the north.

Depositional Environment

Sedimentary rocks of the Lok Ma Chau Formation are interpreted as having been deposited in a tidal swamp or fluvial-deltaic environment. The presence of small-scale cross-bedding in the fine-grained sandstones suggests shallow water conditions whereas intercalated carbonaceous material may indicate neritic conditions.

Mesozoic Rocks of the Tsuen Wan Volcanic Group

Classification and Distribution

Volcanic rocks of the Tsuen Wan Volcanic Group are dominantly exposed in the northern and western parts of the Territory forming thick sheet-like successions of tuff, tuffite and intercalated volcanigenic sedimentary rocks. They are thought to be genetically related to the plutonic igneous rocks of the Lamma Suite (Sewell *et al,* 1992). Two formations are represented within the district; a lower, relatively uniform, lapilli-bearing, coarse-ash crystal tuff which is assigned to the Yim Tin Tsai Formation and an upper, texturally variable, lapilli-bearing, coarse- to fine-ash crystal tuff of the Shing Mun Formation.

Yim Tin Tsai Formation

Lapilli-bearing coarse-ash crystal tuff of the Yim Tin Tsai Formation is chiefly exposed in the northern part of the district on Ma Wan and the Tsing Chau Tsai peninsula (Plate 2). The formation is generally rhyodacitic in composition and is typically massive in outcrop although may occasionally exhibit flow foliation. Very rare intercalated fine-ash tuff horizons are found on the northern tip of Ma Wan and these are considered to be close to the top of the succession. Flow-banded lava clasts, up to 150 mm in diameter, commonly have sharp edges. Petrographically, the Yim Tin Tsai tuff has relatively equal proportions of quartz and alkali feldspar but plagioclase content may vary. The chief mafic minerals are biotite and amphibole, and accessory minerals comprise zircon, apatite, monazite, and magnetite. In a typical thin section from north Lantau Island, the proportions of these minerals are quartz 35%, alkali feldspar 25%, plagioclase 30%, biotite 7%, amphibole 3%, and trace accessory minerals (Plate 3). Total crystal content (>0.06 mm) varies from 40 to 60%. The overall thickness of the Yim Tin Tsai Formation succession in the district is estimated to be 500 m.

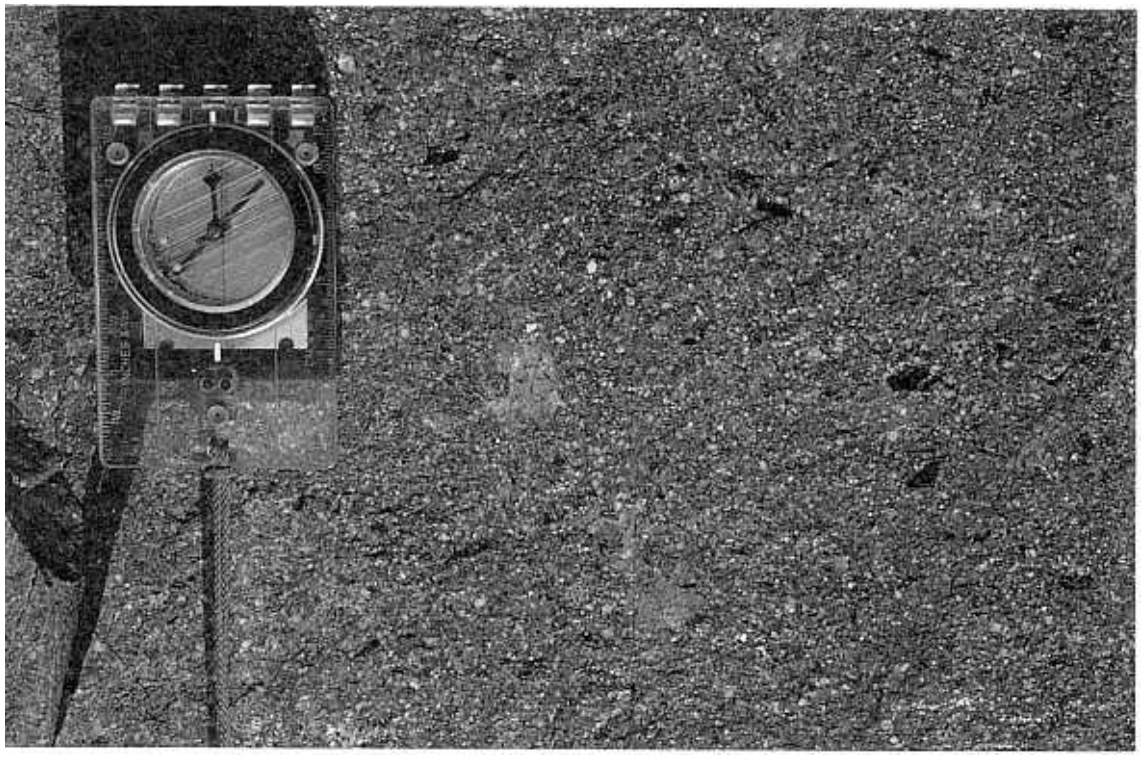

Plate 2 - Massive Coarse-ash Crystal Tuff of the Yim Tin Tsai Formation Exposed on Tang Lung Chau (24590 22340)

Shing Mun Formation

The Shing Mun Formation crops out in the vicinity of Yam O Wan and is typically composed of lapilli-bearing, fine-ash crystal tuff although it may vary from coarse-ash crystal tuff to tuffite. The formation is generally massive in outcrop but may sometimes exhibit a weakly developed flow fabric defined by oriented lava lapilli. The contact between the Yim Tin Tsai Formation and overlying Shing Mun Formation is gradational. Within the district, the Shing Mun Formation is generally rhyolitic in composition with less modal plagioclase compared with the Yim Tin Tsai Formation. The slightly more evolved character of the Shing Mun Formation is reflected by whole-rock silica contents in the range 71-75 wt% and lower titanium contents compared with the Yim Tin Tsai Formation (Table 3). In a typical thin section, the Shing Mun Formation rocks have the following modal mineralogy; quartz 30%, alkali feldspar 20%, plagioclase 20%, biotite 5%, amphibole 1%, with trace amounts of magnetite, zircon, apatite and titanite. The matrix (<0.06 mm) comprises approximately 24% of the mode.

Depositional Environment

The internally massive and structureless character of the Yim Tin Tsai Formation suggests that it represents the product of a large, relatively homogenous, ash flow eruption. Welded fabrics have not been observed, suggesting that the ash had cooled considerably by the time the flow came to rest. The crystal-rich nature of the deposit indicates that crystallisation of the magma was well-underway at the time of eruption (eg Clemens & Wall, 1984). The slightly lower crystal content and fine-grained character of the Shing Mun Formation compared with the Yim Tin Tsai Formation implies slightly different magmatic conditions during crystallisation. The Shing Mun deposits are also considered to have originated by ash flow eruption but the textural variability within the formation, and appearance of tuffite (epiclastic) beds points to intermittent activity separated by periods of erosional and volcanic quiescence.

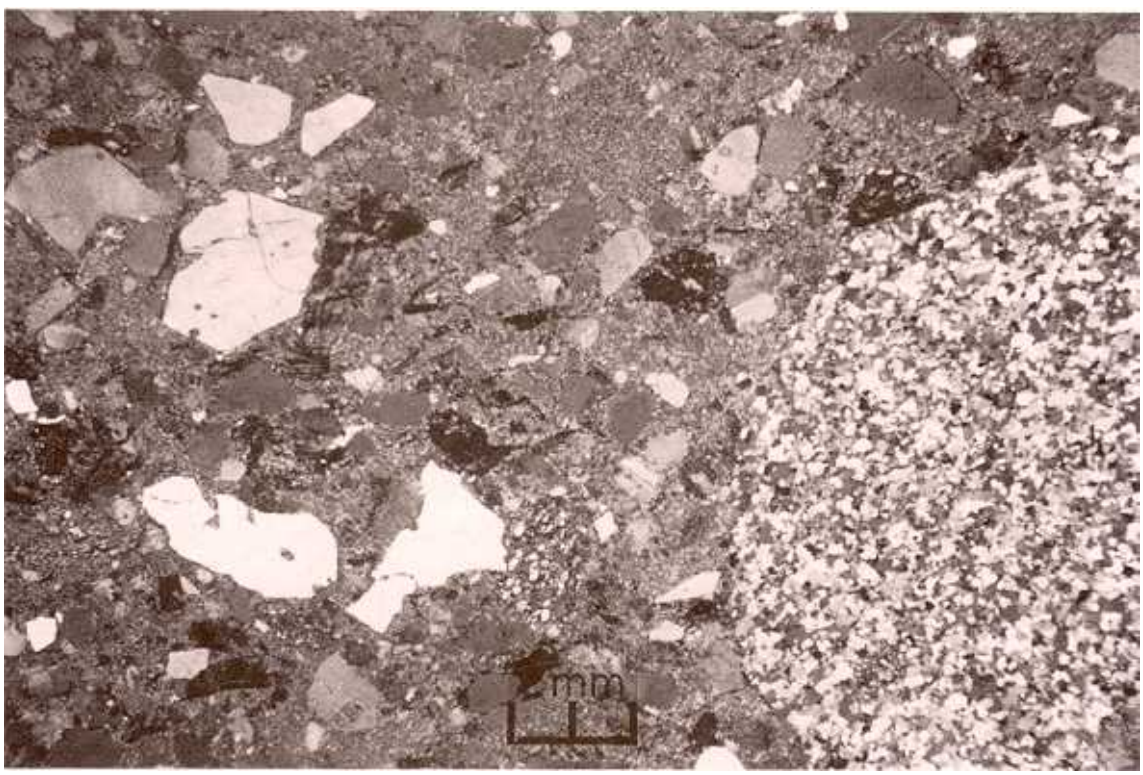

Plate 3 - Thin Section of Lapilli-bearing Coarse-ash Crystal Tuff of the Yim Tin Tsai Formation from North Lantau Island (23190 22830); XPL

Table 3 - Whole-rock Major- and Trace-element Geochemistry for Representative Rock Types in North Lantau Island and Ma Wan. Major oxides in wt%, trace elements in ppm

Sample	HK10235	HK9947	HK10877	HK10234	HK10876	HK9770	HK10231	HK10112	HK10048	HK9834
Unit	JYT	JSM	gdf	gm	gm	rf	μg	JLT	rq	b
SiO_2	69.09	69.38	72.2	70.84	77.5	72.77	74.73	74.23	77.82	61.42
TiO_2	0.53	0.51	0.33	0.4	0.07	0.32	0.2	0.22	0.04	1.44
Al_2O_3	14.68	14.24	13.64	13.57	11.98	14.01	12.73	12.16	12.38	14.35
$Fe_2O_3^*$	3.48	3.82	2.49	2.98	0.94	2.56	1.56	1.81	0.43	8.52
MnO	0.06	0.09	0.04	0.06	0.05	0.03	0.03	0.09	0.01	0.12
MgO	0.78	0.98	0.61	0.87	0.08	0.36	0.3	0.21	<0.01	1.87
CaO	2.44	2.84	1.76	2.69	0.71	0.64	1.53	1.46	0.1	3.81
Na_2O	3.1	2.99	2.98	3.06	2.93	2.89	2.82	3	3.72	3.2
K_2O	4.48	4.17	4.94	4.25	5.01	5.78	5.21	4.77	4.79	3.29
P_2O_5	0.13	0.13	0.07	0.09	<0.01	0.07	0.03	0.03	<0.01	0.42
Total	98.77	99.15	99.06	98.81	99.27	100.23	99.14	97.98	99.29	98.44
LOI**	1.16	0.81	0.75	0.83	0.66	0.8	0.5	1.74	0.56	1.33
Mg#	30.74	33.69	32.67	36.64	14.42	27.3	27.58	18.68	-	30.3
Cr	16	10	10	16	18	10	8	9	5	12
Ni	4	7	12	1	6	7	4	4	8	4
Co	12	4	5	6	5	3	2	4	4	14
Cu	4	8	1	3	1	1	15	3	1	5
Pb	25	33	25	27	59	20	35	17	19	21
Zn	44	53	26	47	15	35	-	98	7	90
Sn	3	10	-	8	-	2	6	7	9	2
Rb	192	186	257	213	402	291	269	199	462	170
Ba	635	578	397	416	23	513	342	380	7	768
Sr	265	235	160	208	28	125	131	149	8	368
Nb	13	13	17	12	18	19	14	19	62	23
Zr	173	165	119	132	76	244	101	141	115	259
Y	32	48	47	23	21	41	26	42	124	45
Th	27	28	33	35	37	34	36	29	51	13
U	5	6	7	7	10	6	25	6	10	3

* total iron as Fe_2O_3. ** loss on ignition (LOI) at 1000°C, Mg# is 100Mg / Mg + Fe^{2+}

1.	HK10235	Coarse-ash Crystal Tuff	817435E 819430N
2.	HK9947	Fine-ash Crystal Tuff	818860E 820430N
3.	HK10877	Porphyritic Fine-grained Granodiorite	824395E 823831N
4.	HK10234	Medium-grained Granite	817315E 819395N
5.	HK10876	Medium-grained Granite	824710E 823290N
6.	HK9770	Feldsparphyric Rhyolite	822350E 820200N
7.	HK10231	Porphyritic Microgranite	820890E 821120N
8.	HK10112	Crystal-bearing Vitric Tuff	815580E 815035N
9.	HK10048	Quartzphyric Rhyolite	817490E 818550N
10.	HK9834	Basalt	822130E 821940N