

# Chapter 4

## Mesozoic Sedimentary and Volcanic Rocks

### Tai O Formation

Mesozoic sedimentary rocks are only exposed in the extreme western corner of the district. They form the eastern limit of an outcrop of Mesozoic sedimentary rocks along the North Lantau coast extending from Tai O in the southwest to San Shek Wan in the northeast. These rocks were previously assigned to the Carboniferous on the basis of lithological similarity (Langford *et al.*, 1995), although the presence of a rhyolite lava flow intercalated with the sedimentary rocks at San Chau raised the possibility that the upper part of the succession may be of Jurassic age. The recent discovery of macrofossils in the rocks near Tai O have now confirmed a Middle Jurassic age.

The Tai O Formation mostly comprises an interbedded succession of grey, fine-grained sandstone alternating with siltstone and sandy siltstone. Occasional beds of dark grey graphitic siltstone are also present. The Tai O Formation is in fault contact with volcanic rocks belonging to the Lantau Volcanic Group, and the sedimentary rocks are thermally metamorphosed within a 100 m zone near the contact. Little structural data is available from outcrops of Tai O Formation within the district. However, to the west at San Shek Wan, the formation is considered to dip moderately to the south. Farther west at Sham Wat Wan, the formation is tightly folded into a series of anticlines and synclines. The Tai O Formation has an estimated thickness of c. 400 m (Langford *et al.*, 1995).

Jones (1996) considers that the Tai O Formation was deposited on an alluvial plain, crossed by small- to moderately-sized rivers. Fossils recovered from the Tai O Formation at Tai O include several late Early to early Middle Jurassic plants including *Ptilophyllum contiguum*, *Otozamites hsiangchiensis*, *Tyrmia cf. nathortsi*, and *Eretmophyllum?* sp.

### Tsuen Wan Volcanic Group

Volcanic rocks of the Tsuen Wan Volcanic Group are not exposed in the district but have been encountered in marine boreholes along the North Lantau Coast from Sham Shui Kok to Kwai Shek. Although two volcanic formations were previously identified in onshore areas of North Lantau Island (Langford *et al.*, 1995), the volcanic rocks are now all considered to belong to one formation: the Yim Tin Tsai Formation, comprising lapilli-bearing coarse ash crystal tuff with minor intercalated fine ash crystal tuff. A sample of the fine ash crystal tuff from Yam O Wan (HK11821) has yielded a U–Pb age of  $164.5 \pm 0.2$  Ma (Davis *et al.*, 1997).

### Yim Tin Tsai Formation

The dominant lithology is lapilli-bearing coarse ash crystal tuff. The tuff is generally rhyodacitic in composition and is typically massive, although it may occasionally exhibit foliation. Minor intercalated fine ash tuff horizons are present in isolated boreholes (DH10/30023, DH11/30023). The lapilli lithic volcaniclasts consist of dark aphanitic and strongly porphyritic lava. The clasts vary in size from less than 10 mm to 150 mm. The aphanitic volcaniclasts commonly have sharp edges suggesting that they were fragmented during chilling, whereas the porphyritic volcaniclasts have diffuse edges suggesting that ‘lava fragments’ were still partly molten at the time of deposition.

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, the proportions of these minerals are quartz 35%, alkali feldspar 25%, plagioclase 30%, biotite 7%, amphibole 3%, and trace accessory minerals. Total crystal content ( $>0.06$  mm) varies from 40 to 60%. The overall thickness of the Yim Tin Tsai Formation in the district is estimated to be 500m.

The internally massive and structureless character of the Yim Tin Tsai Formation suggests that it represents the product of 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 cooling and crystallisation of the magma started well before eruption and this is likely to have been from a relatively shallow level magma chamber (e.g. Clemens & Wall, 1984).

## Lantau Volcanic Group

The Lantau Volcanic Group largely occupies the Lantau Caldera (Langford *et al.*, 1995) in central Lantau Island, although correlatives of the group (Lai Chi Chong Formation) are known from the eastern New Territories (Sewell *et al.*, 2000). Formations have been not yet been formally identified on Lantau although one member, the Pak Kok Member, has been mapped (Langford *et al.*, 1995). Within the district, the volcanic rocks remain largely undifferentiated except for locally prominent siltstone, sandstone, tuffite, crystal tuff and mudstone beds. Two U–Pb ages have been obtained from volcanic rocks on Lantau Island, but outside the district these have returned ages of  $147.5 \pm 0.2$  Ma to  $146.7 \pm 0.2$  Ma respectively (Davis *et al.*, 1997; Sewell *et al.*, 2000).

### Main Lithologies

*Undifferentiated.* Most of the volcanic rocks mapped within the district remain undifferentiated. Included within this grouping are large areas dominated by vitric tuff and porphyritic rhyolite lava. The porphyritic rhyolite lavas generally contain euhedral phenocrysts of quartz and feldspar, but some of these crystals have been mechanically broken as a result of fragmentation during eruption. Banded porphyritic rhyolite lava is exposed on the summit of Por Kai Shan (1398 1633) and on the south side of the hill (1394 1626), the lava grades into rhyolite breccia. The volcanic lithologies in this part of the district, and to the northwest, are weakly metamorphosed. Metamorphosed tuff is commonly pale red to reddish white but may also vary to brownish white. Metamorphism is considered to be dominated by hydrothermal alteration associated with intrusion of silicic magmas and channelling of silica-rich fluids along the northern boundary fault system of the Lantau Caldera (Langford *et al.*, 1995). Minor fine ash crystal rhyolitic tuff and tuffite are intercalated sporadically within the main succession, generally separating thick successions of rhyolite lava and banded rhyolite lava.

*Crystal Tuff.* A feature-forming outcrop of crystal tuff has been mapped to the northwest of Por Kai Shan (1375 1650), where it conformably overlies a thick band of tuffite. The crystal tuff varies locally to crystal-bearing vitric tuff and is weakly bedded. In places, a weak foliation has developed and the tuff also shows evidence of thermal metamorphism (Plate 2). The crystal tuff is estimated to be approximately 110 m thick.

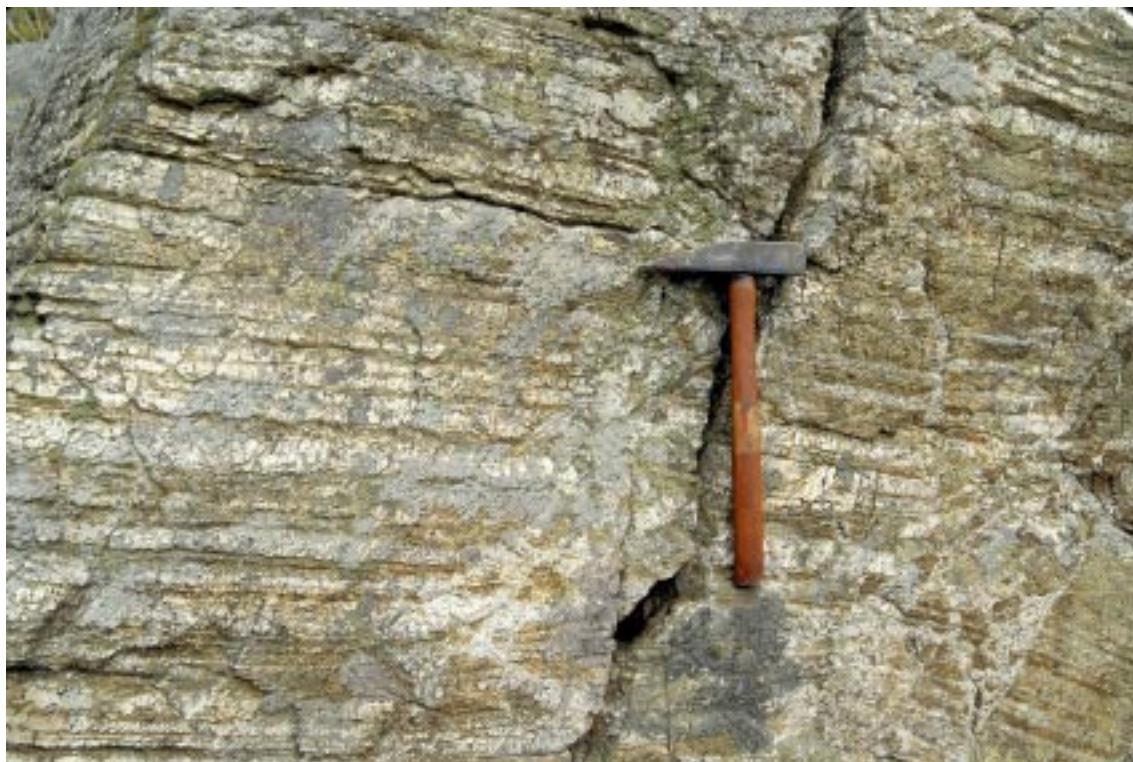


Plate 2 - Altered, Silicified, Banded Coarse Ash Crystal Tuff Exposed on Pok To Yan (1350 1587)

*Tuffite*. A prominent outcrop of banded tuffite, comprising pale grey tuffaceous sandstone, dark grey tuffaceous mudstone, and grey crystal-bearing vitric tuff has been mapped on the northwestern flanks of Por Kai Shan (1360 1650). The tuffite dips at 35° to the east and is estimated to be approximately 140 m thick. Large corestones of vitric tuff occur within the tuffite, which has been weakly thermally metamorphosed. A small (0.002 km<sup>2</sup>) outcrop of tuffite has been mapped within the main Lantau volcanic succession in the far southeastern corner of the district. The tuffite consists mostly of cherty tuffaceous siltstone and sandstone.

*Siltstone*. Grey, finely laminated tuffaceous siltstone is exposed to the east of Pok To Yan (1385 1570) in the southeastern part of the district. The siltstone is weakly thermally metamorphosed and forms a prominent feature-forming bed up to 60 m thick, dipping to the east at up to 36°. The siltstone bed is exposed for approximately 750 m in a north-south orientation, and thins out rapidly to both north and south.

*Mudstone*. Grey to light or reddish-grey, laminated mudstone with minor intercalated tuffaceous sandstone is exposed as a feature-forming unit 300 m to the southeast of Por Kai Shan (1420 1608) in the southeastern part of the district. The mudstone unit can be traced southeastward for approximately 500 m and is possibly up to 80 m thick. Load structures displayed by the mudstone unit indicate that it is the right way up and dips approximately 17° to the southeast. A second, less prominent, feature-forming mudstone unit is exposed approximately 300 m upslope of the main mudstone outcrop. This upper mudstone unit is similar lithologically to the lower mudstone unit and displays a similar bedding attitude. The upper mudstone unit is exposed in an east-west orientation and can be traced laterally for approximately 200 m. The unit is up to 50 m thick.

*Sandstone*. A very minor outcrop of tuffaceous sandstone has been mapped between the upper and lower mudstone units southeast of Por Kai Shan (1455 1573). The unit is approximately 6 m thick, and can only be traced for approximately 25 m in an east-west orientation. The tuffaceous sandstone is typically light-grey, and either massive or poorly bedded.