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DR HUI SZE-FAN, STEPHEN

It was with deep sorrow that we heard that Stephen Hui passed away in November. His enthusiastic support for mineral and geological activities has left a legacy that we will always be grateful for, and which his family can be truly proud of. Stephen's support went beyond the generous financial contribution he made to our Society, and he will be sadly missed in the geological community.

Dr Hui's family have kindly supplied a copy of his biography, which is reproduced here in full.

Biography

Dr Stephen S F Hui was born on 13 June 1912 in Tsamkong, Kwungtung, China. After graduating from the Diocesan Boys' School in Hong Kong, he pursued his studies at St John's University in Shanghai, majoring in civil engineering, and furthered his studies at the Colorado School of Mines, Golden, Colorado, USA. In 1940 he graduated with a double degree in mining engineering and geological engineering.

When he returned from the United States, Dr Hui explored and developed ferrous and non-ferrous mineral deposits in Kwangsi, China. In Hong Kong he held managerial and executive positions in shipping, mining and investment companies, as well as being a member of the Court of the University of Hong Kong since 1977.

Dr Hui was a philanthropist and a scholar. He contributed a sum of money towards the cost of construction of the Hui Oi-chow Science Building at the University of Hong Kong and established scholarships for Chinese students from China, Hong Kong and Taiwan to further their studies and research in earth and environmental sciences or similar subjects at the University of Hong Kong, The Hong Kong Baptist College, The Imperial College of Science and Technology of London, UK, and his Alma Mater, the Colorado School of Mines, USA.

Some of the awards bestowed upon him were:

Medallist of Distinguished Achievement Award in the fields of Mineral Engineering, Colorado School of Mines, USA.

Honorary Degree of Doctor of Laws (Hon L.L.D.), University of Hong Kong.

Honorary Degree of Doctor of Engineering (Hon D.Eng.), Colorado School of Mines.

Honorary Associateship of the Royal School of Mines (Hon ARSM). Imperial College of Science and Technology, London.

Dr. Hui was married with two sons and one daughter. He passed away at the age of 78 at the Hongkong Adventist Hospital on 21 November 1989.



THE CHARACTERISTICS OF FOSSIL PLANTS AND AGE OF THE STRATA OF PING CHAU ISLAND, MIRS BAY, HONG KONG

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Introduction

Ping Chau Island lies in the northeastern corner of Hong Kong in Mirs Bay (Figure 1). The island is approximately 2 km long and 0.5 km wide.

The sedimentary rocks exposed on the island are unlike any other rocks exposed either in Hong Kong or on the opposite mainland around Shuitousha of Baoan County, Shenzhen.

The island's geology had been studied by Williams (1943), Davis (1953), Ruxton (1960), Allen & Stephens (1971), Peng (1970, 1971), Nau (1979), Nau et al (1984), Lai (1986) and Lee (1987). Although much work has been done, the question of the age of the sedimentary sequence has not been settled.

Fossil plants were collected on the island by the authors in July 1987. These may help to solve the chronological problem of the sedimentary sequence. The purpose of this paper is to give an account of the characteristics of the fossil plants and to discuss the possible age of the strata.

Lithology and stratigraphy

The sedimentary rocks of the island are composed of greyish black, thinly bedded and slaty, calcareous and dolomitic siltstone, silty mudstone, mudstone and marlstone.

Along the west coast of the island (Figure 2), a conspicuous greyish white layer is found. This layer is 0.8 to 0.9 m thick, formerly identified as cherty sandstone, cherty ash and cherty siltstone by Williams (1943), Ruxton (1960) and Nau (1979) respectively, has been recently recognised as lacustrine tuff by the authors. The rock is composed mainly of feldspar with minor quartz, hornblende and zircon, and the matrix has been altered first by carbonatisation and later by silicification. Paternoster-like or nodular structure can be observed in the layer. A sample of this layer collected at Lung Lok Tsui was studied microscopically by Mr Liang Bai-he and Ms Zhu Su-lin, both of the Department of Geology, Zhongshan University.

A sample of slaty mudstone collected at Lan Guo Shui, studied microscopically by Li Qiang and Lu Ren-xiong, both of the Department of Geology, Zhongshan University, has been found to contain cordierite, most of which was replaced by calcite.

Many of the rock layers contain granular and prismatic zeolite (analcite and natrolite), prismatic or radiating aegirine, dolomite, calcite, apatite and pyrite (Peng 1970; 1971). Many of these minerals, especially zeolite and aegirine, commonly fill crystal casts of a salt mineral, possibly gypsum. On the other hand, there are abundant vitritised or bitumenised fossil plant remains on the bedding planes. Evenly laminated bedding is well developed. Cross bedding, shrinkage cracks and slump structure are also common.

The characteristics mentioned above indicate that the sediments are mainly of terrestrial origin, but locally of volcanic origin. The sedimentary environment is suggested to be lacustrine or lagoonal with intermittent volcanic eruption during a dry and warm climate. The Xiasha Fault (labelled as F1 on Figure 1) and the Lai Chi Kok-Tolo Channel fault

(F2 on Figure 1) located near the island may account for the silicification of the matrix of the lacustrine tuff and the occurrence of cordierite in the slaty mudstone.

The Ping Chau rocks were originally given the name Ping Chau Formation by Williams (1943). This is accepted by the authors.

Characteristics of the fossil plant assemblage

The Ping Chau strata have furnished abundant plant remains. Although most of these are poorly preserved and indeterminable, some can be identified. Collection localities of the plant fossils described in this paper are shown in Figure 2. The fossil plants identified include *Baiera* sp, *Brachyphyllum obesum* Heer, *Brachyphyllum* sp, *Czekanowskia rigida* Heer, *Czekanowskia* sp, *Ginkgoites hongkongensis* sp nov, *Otozamites pingchaunensis* sp nov, *Pagiophyllum* sp, *Sphenobaiera* sp and pinnule of *Otozamites*.

The geographical distribution of the fossil plants is as follows: at Lan Guo Shui the strata yield pinnule of *Otozamites*, *Brachyphyllum* sp, *Pagiophyllum* sp and *Ginkgoites hongkongensis* Wu et Nau (sp nov); at Kang Lau Shek the strata yield *Brachyphyllum* sp and *Otozamites pingchaunensis* Wu et Nau (sp nov); at Lung Lok Tsui the strata yield *Brachyphyllum obesum*, *Pagiophyllum* sp, *Baiera* sp, *Czekanowskia rigida* and *Czekanowskia* sp; at Cham Keng Chau the strata yield *Czekanowskia rigida*, *Czekanowskia* sp, *Sphenobaiera* sp, *Brachyphyllum obesum*, *Pagiophyllum* sp and pinnule of *Otozamites*.

Among the plant fossils mentioned above, the material described as *Brachyphyllum obesum* (Plate 2: 2, 3, 4) is considered to be representative owing to its extensive distribution and abundance in the strata as well as being easy to distinguish. The small pinna described as *Otozamites pingchaunensis* Wu et Nau (sp nov) (Plate 1: 1a, 1b, 1c) is a variant member of the genus *Otozamites* in the strata. Pinnae and pinnules of this species can be frequently found elsewhere on the island. The largest and quite well preserved plant fossil of this assemblage is a foliage described as *Ginkgoites hongkongensis* Wu et Nau (sp nov) (Plate 2: 1a, 1b); a detailed description of the study specimens is given below.

The above flora can be named as the *Brachyphyllum obesum* - *Otozamites pingchaunensis* assemblage based on the abundance and distribution of the plant fossils in the strata. The assemblage is composed of 8 species (including 4 of uncertainty) of 6 genera. Among them, 2 species (including 1 of uncertainty) are ascribed to the genus *Bennettitales*; 3 species (including 1 of uncertainty) are referred to 3 genera of *Ginkgoales*; and 3 species (including 2 of uncertainty) are regarded as 2 genera of *Coniferopsida* of uncertain affinities.

Description of fossil plants

The following plant fossils occur in the Ping Chau Formation, Ping Chau Island, Mirs Bay, Hong Kong, and are kept in the Department of Geography and Geology, University of Hong Kong.

Phyllum	GYMNOSPERMAE
Class	CYCADOPSIDA
Order	BENNETTITALES
Family	WILANDIELLACEAE
Genus	<i>Otozamites</i> Braun, 1843

Once-pinnate leaf. The pinnae, borne alternately and attached to the upper surface of the rachis, are circular, broadly oval or lanceolate. The base of each pinna is lobed with the large distal lobes more pronounced. The adjacent pinnae are overlapping. Veins spread out radially from the base and arching toward the margins of the pinna.

Distribution and age: Found in all parts of the world and in rocks of Late Triassic to Early Cretaceous.

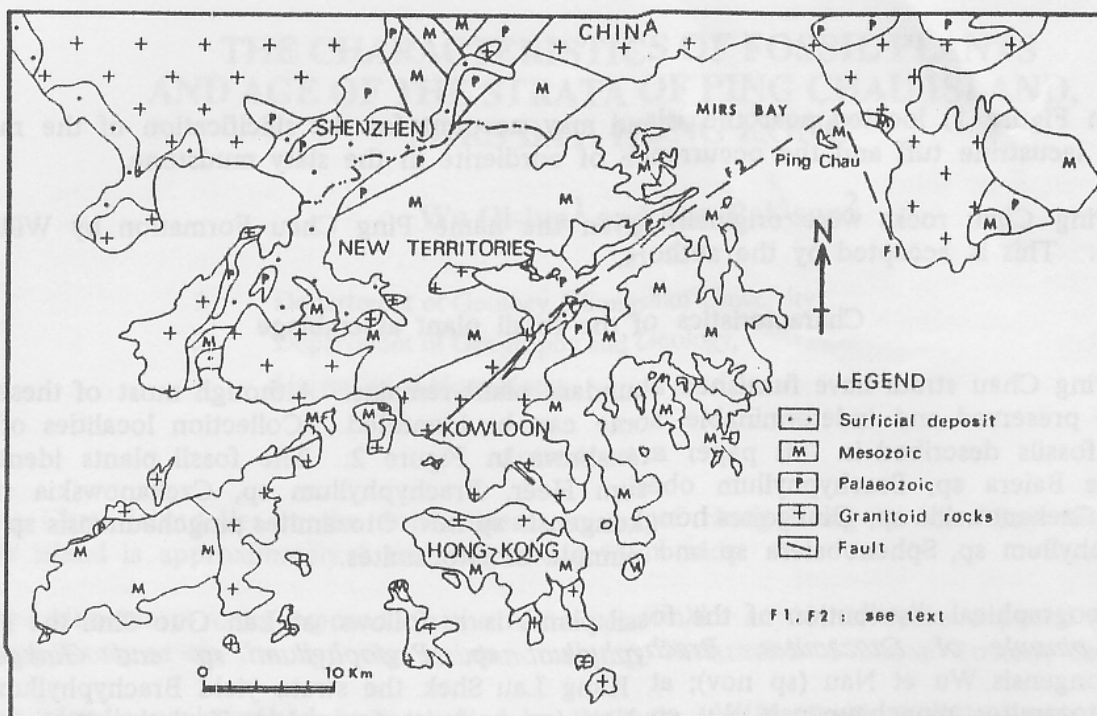


Figure 1 Simplified geological map showing the location of Ping Chau Island

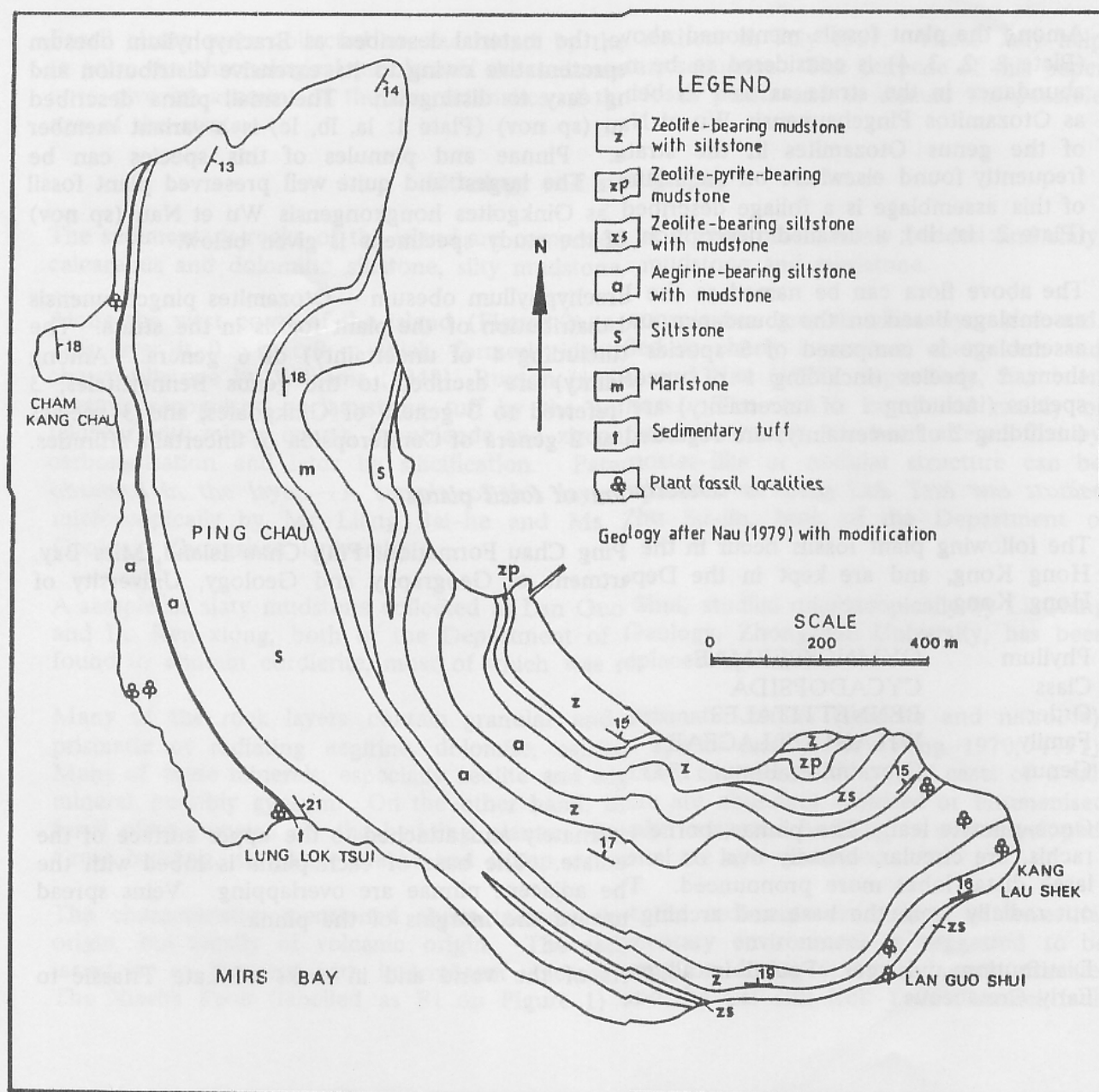


Figure 2 Geological map of Ping Chau Island

Species *Otozamites pingchaunensis* Wu et Nau (sp nov)
(Plate 1; 1a, 1b, 1c)

The once-pinnate leaf (Plate 1: 1a) is 12.6 mm long and 4.2 mm broad with 6 oblong pinnae (each pinna is 3.3 mm long and 2.5 mm broad) borne slightly overlapping on a rachis. The tip of the first pinna can be seen slightly overlapping the base of the second pinna. The asymmetrical pinnae have entire margins, rounded apices and lobed bases. Spacing between the bases of two alternately-borne pinnae is 2.2 mm. The width of the lower portion of the rachis, which has longitudinal striae, is 1.8 mm. Venation of the pinna may dichotomise 2 to 3 times from the base to produce 40 to 45 veins arching toward the margins of the pinna. Tips of the pinnae are directed toward the rachis axis.

The material is a twiggy pinna and its segments are widely distributed in the rocks. It differs from other *Otozamites* in the Mesozoic strata in southeastern China in having small pinnae and rather thick segments, striate rachis and the tips of the pinnae directing toward the rachis-axis. As this material associates with *Pagiophyllum* sp, etc, it is considered to be a variant member of the genus *Otozamites* which extended into the Early Cretaceous.

Class GINKGOPSIDA
Order GINKGOALES
Genus SPHENOBAIERA FLORIN, 1936

Laminae that lack distinct petioles are cuneate, narrow deltoid or linguiform and tapering gradually toward the base. The laminae are more or less deeply dissected into two to five lobes, and each of these lobes may be sub-divided one or more times into ultimate segments. Venation is fan-shaped. Each segment contains more than four veins

Distribution and age: Found in rocks of Early Permian to Early Cretaceous in almost all parts of the world, but much more abundant in the Northern Hemisphere.

Species *Sphenobaiera* sp
(Plate 1; 2)

The imperfect fragmentary lamina is 40 mm long and 10.3 mm broad. It is slightly restricted at the lower part. Venation is dense and fine with 41 veins. The slightly wedge-shaped lamina with dense venation shows that it can be assigned to the genus *Sphenobaiera*.

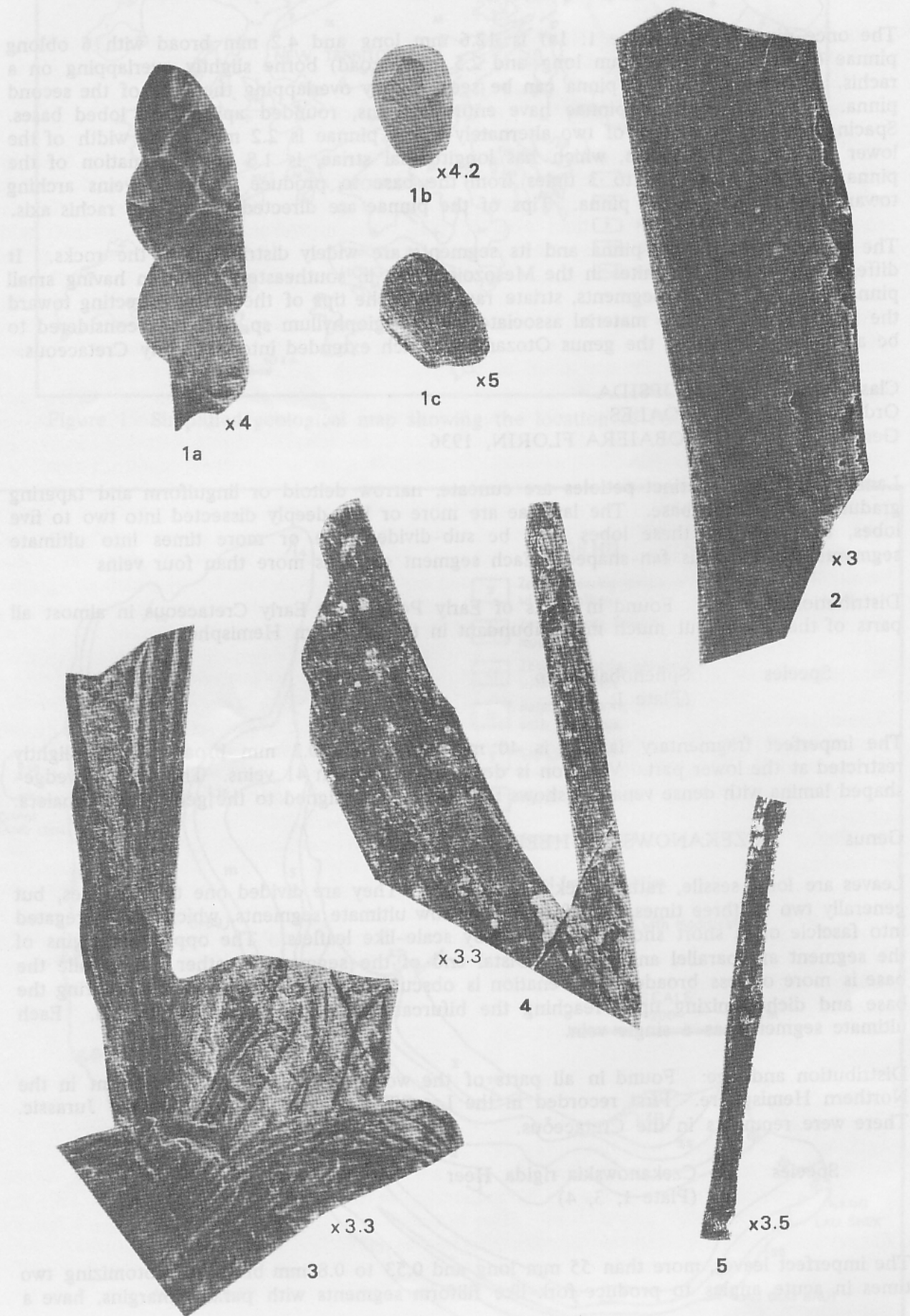
Genus CZEKANOWSKIA HEER, 1876

Leaves are long, sessile, rather thick and leathery. They are divided one to five times, but generally two to three times, into fork-like narrow ultimate segments, which are aggregated into fascicle on a short shoot surrounded by scale-like leaflets. The opposite margins of the segment are parallel and entire. Distal end of the segment is rather sharp while the base is more or less broadened. Venation is obscure. There is a single vein entering the base and dichotomizing upon reaching the bifurcations of the segmented lamina. Each ultimate segment has a single vein.

Distribution and age: Found in all parts of the world, but much more abundant in the Northern Hemisphere. First recorded in the Late Triassic and flourished in the Jurassic. There were remnants in the Cretaceous.

Species *Czekanowskia rigida* Heer
(Plate 1; 3, 4)

The imperfect leaves, more than 55 mm long and 0.53 to 0.8 mm broad, dichotomizing two times in acute angles to produce fork-like filiform segments with parallel margins, have a



long wedge shape and are sessile. Each segment has 2 to 5 veins. Epidermis structure of the material has not been studied.

There is no great difference in gross morphology in comparison with that described by Si Xing-jian et al (1963 p 248-249; Figure 6 in Plate 83). However, this specimen has narrower segments, each of which has two to five veins.

The material shown in Plate 1; 5 is a filiform segment of *Czekanowskia* sp

Genus *GINKGOITES* SEWARD, 1919, emend FLORIN, 1936

The lamina, having long petiole and a fan-shaped venation pattern, is fan-shaped, kidney-like or wedge-shaped with deep central sinus. Each leaf is usually dissected into 2 to 8 segments and each of these segments has 4 to 6 or more parallel veins. The lamina is similar to the present-day *Ginkgo biloba* in shape.

Distribution and age: Found in rocks almost all over the world from the Middle Triassic to the Late Tertiary but flourished in the Jurassic to the Early Cretaceous.

Species *Ginkgoites hongkongensis* Wu et Nau (sp nov)
(Plate 2; 1a, 1b)

The specimen is half of a fan-shaped leaf which has central sinus. It is deeply divided into 11 segments without sinus and they still remain in contact with each other. However, 3 of them have dichotomized once at the distal end. The leaf is 31 cm in length. Each segment has rounded apex and tapers toward the base with the widths of the distal end, the middle portion and the base ranging from 18 to 25 mm, 12 to 20 mm and 5 to 8 mm respectively. The segments contain 42 to 60 close and parallel fine veins. The veins may occasionally dichotomise at the distal ends.

The material is large in size when compared with other known Jurassic species of the genus *Ginkgoites* in China. It can be distinguished from *Baiera* and *Ginkgo* by its long segments (longer than 20 cm) with constricted bases, and great number of veins (for each segment more than 20) which may occasionally dichotomise at the distal ends. It can also be distinguished from *Phoenicopsis* by its conspicuous tapering segments with constricted bases and conspicuous changing of widths of the middle and upper portions of the segments.

Class CONIFEROPSIDA INCERTAE SEDIS
Form genus *BRACHYPHYLLUM* BRONGNIART, 1828

Alternating shoots of *Brachyphyllum* have helically arranged leaves which are scale-like, thick, stout and without obvious veins. The length of the free part of each leaf is less than the width of the basal cushion. Occasionally, they may have pitted stomas on the hypodermis producing longitudinal grooves. This form genus may have relation with the *Hirmerelloidea* of the *Voltziaceae*.

Distribution and age: Found in all parts of the world and recorded from the Late Triassic to the Cretaceous, but quite common in the rocks ranging from the Jurassic to the Early Cretaceous.

Species *Brachyphyllum obesum* Heer
(Plate 2; 2, 3, 4)

The materials are preserved as short shoots having stout and scale-like leaves which are densely-imbricated and helically arranged. The leaves are rhomboidal in shape with pointed apices. Venation is not clear. They closely resemble the material shown in the Atlas of Palaeontology of Central-South China (1977 Vol 3; Figures 7 & 8 in Plate 97).



Genus **PAGIOPHYLLUM HEER, 1881**

The shoots of *Pagiophyllum* have helically arranged and closely-imbricated leaves which have a broad basal cushion. The free part of the leaf is longer than the width of its cushion. Leaves, with thin and entire margins, as well as pointed apices, are thick and triangular. The abaxial surface of the leaf is swelling up or has a coarse rib. The adaxial surface is concave or convex. Venation is not clear.

Distribution and age: Recorded in rocks ranging from the Jurassic to the Cretaceous in all parts of the world.

Species *Pagiophyllum* sp
(Plate 2; 5,6)

The materials are preserved as short shoots, on which the densely-imbricated leaves are small, thick, triangular in shape, and spirally arranged. Each entire leaf, showing no venation, has a broad basal cushion and a rather pointed apex which spreads away from the shoot axis so that the leaf is somewhat crescent-like.

In comparison with the material described by Si Xing-jian et al (1963 p305; Figure 10 in Plate 94), the study specimens have smaller shoots, crescent-like leaves with narrower basal cushions, and the apices of leaves are much more pointed. As only a small number of specimens of this species have been obtained and only short shoots found, it is impossible to render a definite determination of species for the moment.

Discussion on the age of the Ping Chau strata

Fossils in the Ping Chau rocks were first found by Williams (1943). These included ?*Ptilophyllum* or ?*Otozamites*, ?*Neuropteris*, and a fossil insect described as *Otiorynchites williamsi* Cockerell. The plant fossils point to a Jurassic age while the fossil insect may be Cretaceous, Eocene or late in age. However, no definite age for the Ping Chau rocks was given.

Allen and Stephens (1971) attributed the rocks to the Repulse Bay Formation of Middle Jurassic age, but without satisfactory evidence.

Some years ago, Nau collected plant remains and a fragmentary tortoise(?); this was identified as ?*Anooteria lingnanica* by a palaeontologist in China in 1985, but it could be a fossil insect) from the Ping Chau rocks some years ago. The plant fossils, including *Otozamites* sp, ?*Neocalamites* sp, and a fragmentary lamina of ?*Dicotyledones* (Plate 2; 7), point to Triassic to Jurassic age or later. The fragmentary tortoise(?) suggests a Cretaceous age.

Lai (1985), based on the lithology, structural and palaeogeographical features, has considered that the rocks resemble those of the Buxin Formation, in the Sanshui basin of Guangdong Province. The age of those rocks is regarded as Eocene.

Lee (1985) has suggested that the rocks may be attributed to Late Cretaceous, as the rocks may be comparable with the black mudstone intercalated in the Nanxiong Group in Guangdong Province.

So far, there is no agreement on the chronological division of the strata. However, based on the *Brachyphyllum obesum* - *Otozamites pingchaunensis* assemblage described in this paper, which includes different species of several genera, an approach on the age of the rock sequence can be made.

The main member of the assemblage is *Brachyphyllum obesum*, which has conspicuous morphological features. It occurs in the Lower Cretaceous strata in South China, being

found frequently in strata of this age in Zijin County of Guangdong Province, Rong County of Guangxi Province and Yong An County of Fujian Province.

Pagiophyllum sp, a subordinate member of the assemblage, is usually found in China in strata ranging in age from the Jurassic to the Cretaceous. For example, it occurs in Lower Cretaceous strata in Lian County of Northern Guangdong.

Czekanowskia rigida, another subordinate member of the assemblage, occurs extensively in the Jurassic strata in China and elsewhere in the Northern Hemisphere, but it can be a survival member in the Early Cretaceous layers.

The genus *Ginkgoites* occurs mainly in strata with a time interval ranging from the Late Jurassic to the Cretaceous in the Northern Hemisphere. In North China it also occurs in strata of the Middle Jurassic to the Cretaceous, although in Hubei and Hunan provinces of South China it can only be found in the Jurassic strata. As the study material described as *Ginkgoites hongkongensis* Wu et Nau (sp nov) differs from the other Jurassic species of this genus as mentioned above, and it occurs together with *Brachyphyllum obesum*, *Pagiophyllum* sp and so on, it may be a member of the genus *Ginkgoites* which had extended into the Cretaceous.

The genus *Otozamites*, of Late Triassic to Early Cretaceous age, is distributed widely in the world, such as China, Russia, Korea, Vietnam, North America and South Africa. In South China there are 7 species of Late Triassic to Early Jurassic age of this genus found in the strata in Sichuan Province, and more than 9 species of Late Triassic to Middle Jurassic age of this genus found in the strata in Hunan, Guangdong and Fujian provinces, but no Cretaceous species have been reported. However, the study material described as *Otozamites pingchaunensis* Wu et Nau (sp nov) differs from the species of Late Triassic to Jurassic age in having small pinnae, small pinnules with their tips directed to the rachis axis and striate rachis. Moreover, it occurs together with *Brachyphyllum obesum*, *Pagiophyllum* sp and *Ginkgoites hongkongensis* in the Ping Chau Formation. This suggests that the study material is a survival species of the genus *Otozamites* having extended into Cretaceous.

All in all, the assemblage contains common Cretaceous species and some variants of older species that could have extended into the Cretaceous. The plant fossils are comparable with the Early Cretaceous plant fossils commonly found in Guangdong, Fujian and Hunan provinces. Taking into account the fossil plant assemblage and the fossil insect mentioned above, the age of the Ping Chau Formation is suggested to be late Early Cretaceous to early Late Cretaceous.

Acknowledgments

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References

- ALLEN, P M & STEPHENS, E A. 1971. Report on the geological survey of Hong Kong. Government Printer, Hong Kong, 107p
- DAVIS, S G. 1953. The geology of Hong Kong. Government Printer, Hong Kong, 210p.

- GEOLOGICAL BUREAU OF HUNAN PROVINCE. 1982. Geological Memoirs Series 2 No 1: The palaeontological atlas of Hunan. Geological Publishing House (In Chinese)
- HUBEI INSTITUTE OF GEOLOGICAL SCIENCE, et al. 1977. The palaeontological atlas of Central-South China Vol 3: Mesozoic. Geological Publishing House (In Chinese)
- LAI, K W. 1986. A preliminary discussion on the Mesozoic fault-basins of Hong Kong. The Geography Bulletin (Education Department of Hong Kong). No 17 pp 38-47 (In Chinese)
- LEE, C M. 1987. Introduction to Hong Kong geology. Guangdong Geology Vol 2 No 1 pp 32-35 (In Chinese)
- NAN, Y. 1978. Summary of stratigraphy of Guangdong Province, China. Journal of Guangdong Geological Science and Technology No 1 (In Chinese)
- NAU, P S. 1979. Geological notes on the sedimentary rocks of Ping Chau Island, Mirs Bay, Hong Kong. Annals of the Geographical, Geological and Archaeological Society, University of Hong Kong No 7 pp 33-41
- NAU, P S, ARTURTON, R S & WORKMAN, D R. Field excursion to Ping Chau. Geological Society of Hong Kong Newsletter Vol 2 No 2 pp 11-14
- PENG, C J. 1970. Occurrence of zeolites in Upper Jurassic rocks of Hong Kong. Abstract: IMA-IAGOD Meetings, Tokyo p 225
- PENG, C J. 1971. Acmite and zeolite-bearing rocks of Hong Kong. A new and unusual occurrence. Abstracts: VIII International Sedimentary Congress, Heidelberg pp 76-77
- PENG, C J. 1978. Hong Kong minerals. Government Printer, Hong Kong (In English or Chinese)
- RUXTON, B P. 1960. The geology of Hong Kong. Quarterly Journal of the Geological Society of London Vol 115 pp 233-260
- SI, X J, LI, X X, et al. 1963. Plant fossils of China Vol 2: Mesozoic plant fossils. Science Press (In Chinese)
- SOUTHWEST INSTITUTE OF GEOLOGICAL SCIENCE. 1978. The palaeontological atlas of Southwest China: Sichuan Volume No 2. Geological Publishing House (In Chinese)
- WILLIAMS, M Y. 1943. The stratigraphy and palaeontology of Hong Kong and New Territories. Transactions of the Royal Society of Canada Vol 37 Section IV pp 93-117
- ZHANG, Z H. 1979. Summary of the stratigraphy of Fujian. Regional Investigation Team of Fujian Geological Bureau (In Chinese)

LANDSLIP WAS FACTOR IN CHERNOBYL BLAST , EXPERT SAYS

The Soviet nuclear disaster at Chernobyl was caused by land subsidence and mistakes in civil engineering rather than by scientists involved in unauthorized experiments, an expert on satellite imaging claimed yesterday.

The new evidence contradicts the official versions of the world's worst nuclear accident. Mr Peter Fend, an American expert in satellite imaging, who presented the evidence to a gathering of United Nations-backed scientists in Venice, said the explanations given by Soviet and Western governments were crucially flawed.

He also alleged that there had been a deliberate cover-up to suppress the truth, particularly by West Germany.

Mr Fend claimed the German authorities had confiscated satellite pictures, providing crucial evidence that official versions were wrong, from one of their own scientists.

Various reasons could lie at the heart of these attempts to hide the truth, he said - not least the risk posed to a string of other Russian reactors along the banks of the Pripyat river, where Chernobyl was built, by land slip and subsidence. He feared they, too, had been built on unsound ground and might have shaky foundations.

According to scientists at the Open University in Milton Keynes, Buckinghamshire, Mr Fend's New York-based company, Ocean Earth, is recognized internationally for its supply and analysis of satellite images of river and ocean basins.

Evidence for Mr Fend's claims are based on a series of satellite pictures taken before, during, and after the Chernobyl disaster in April 1986. The shots reveal a dark line cutting across the reactor that officials, including the US Geological Survey Department, maintained was the shadow of a smoke plume cast across the area as the nuclear pile burned.

Mr Fend, however, is convinced that the dark slash is a fault in the land, which gave way under the weight of the Chernobyl plant, causing the collapse of Reactor 4. He said the prevailing winds at the time were blowing in the wrong direction for the contention that the dark line was a smoke shadow to be sustained.

Mr Fend argues that the line was still in place more than two weeks after the explosion, although the fire had long since been extinguished.

Further evidence that planners in Moscow sited the plant on unsafe ground comes from scientists at the Open University. Dr Steve Drury, of the Earth Sciences Department, said yesterday that his researchers discovered that the dark line was faintly but clearly revealed in satellite photographs taken before the accident.

Dr Drury said this refuted the smoke plume claim, and a subsequent claim by Soviet authorities that the dark line was caused by blast damage.

There is a growing conviction among scientists that the expanding dark line is evidence of water seepage from the river into a land fault, and that this was what triggered a land slip. The sand and clay ground probably also had peat deposits that made it unstable.

The Health and Safety Executive's Nuclear Installation Inspectorate in London disputed Mr Fend's claims, saying its officials agreed with the International Atomic Energy Authority, which backs the Soviet Government's explanation that human error and unauthorized experiments were to blame.

The Times , 27 September 1989

THE SEISMIC CONDITION OF THE DAYA BAY REGION - DISCUSSION ON "HOW SAFE IS DAYA BAY ?" BY MR M.J. ATHERTON

Ding Yuanzhang
Guangdong Bureau of Seismology

Since last January, various newspapers in Hong Kong have reported the discovery of a seismic fault made by M J Atherton. His article "How safe is Daya Bay" appeared in the March 1989 issue of the Geological Society of Hong Kong Newsletter. Based on the "Lithospheric Dynamic Map of China & Neighbouring Sea Area" compiled by Ma Xingyuan in 1986, Atherton said there was a "new fault" 7 km away from the Daya Bay nuclear power site in the Dapeng Peninsula that was absent in the map compiled by the Geological Institute, State Seismological Bureau, in 1979. The two maps are tectonic maps at a very small scale of 1:4 million. It was then necessary to simplify the way in which the geological structure was shown. But dealing with the geological structure on the site of a nuclear power station, the detailed geological maps of larger scale are much more useful.

From 1980 to 1981, when the selection of the Daya Bay site for the nuclear power station was underway, careful investigations were carried out on the geological structure in the neighbouring area of the site. One of the task was to compile a geological map at 1:50 000 scale. Since then, the geology in Daya Bay has been studied in a much more detailed way than ever before. According to the geological map mentioned above, it is clear that there are several discontinuous faults of northwest trend on the Dapeng Peninsula (Figure 1).

The above results of investigations and studies are reflected in "Site Selection Report on Guangdong Nuclear Power Station" prepared by the Guangdong Electric Power Design Institute in December 1981, which serves as the basis for the site selection. These faults have been mentioned in the dissertation and printed on the maps concerning the geological structure along the coastal area of Guangdong Province.

It is clear that the "fault across the Dapeng Peninsula" disclosed by Atherton is not a "new discovery". To be more precise, there is not only one fault; it is actually made up of several discontinuous faults spreading over the Dapeng Peninsula.

Someone may ask if they are active; this was the same question for us in 1980-81. Exhaustive surveys were carried out to see whether the large and small faults on the peninsula showed any new activity. Research work carried out by the Geological Institute, SSB, was to study the group of faults of northwest trend on the peninsula (Figure 2).

At some points over the peninsula, a flat and complete layer belonging to the mid-Pleistocene epoch covers the northwest-trending faults (Figure 3). Within this young sediment layer there is neither disturbance nor deformation. Spore-pollen analysis shows that the age of the layer is in the range from 700 000 to 150 000 years BP. Therefore, the faults covered by the layer of the mid-Pleistocene epoch are not "capable faults". There is no capable fault in the Dapeng Peninsula; in other words, no capable fault within a radius of 20 km of the nuclear power station.

Atherton pointed out that some Chinese geologists stated an active fault existed within 7 km of the power station site. We must ask what is an active fault and how long is the activity period set by researchers in the field. At present, different scholars have different criteria for the classification of active faults. Some set a longer active period for active faults, for example the Neogene Period (about 25 million years ago) is adopted by Liu Yixuan, and the Late Neogene (about 10 million years ago) is adopted by Ma Xingyuan and Zheng Jiandong. All of them are mentioned by Atherton and some others in Hong

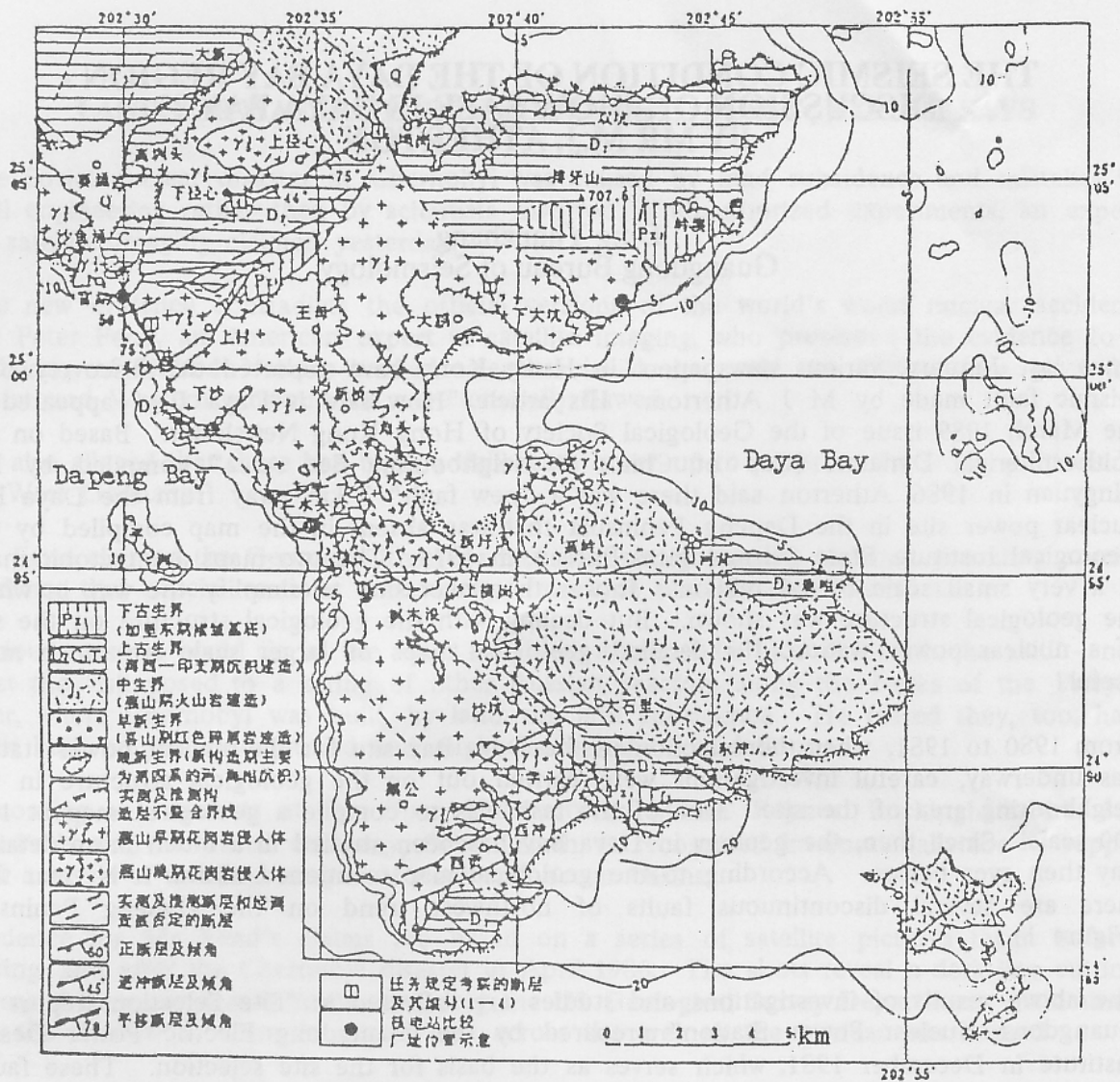


Figure 1 Geological map of the Dapeng Peninsula compiled in 1980-81

Kong. But many other scholars set a shorter time scale, for example the Quaternary Period (about 2 million years ago) or the Late Pleistocene (150 000 years ago), or even the Holocene (10 000 years ago). However, the geological conditions for various engineering constructions are well-defined. These requirements have to be protected, and engineering projects have not been changed just because of the different views held by different scholars.

It is exactly due to the various views in respect of the definitions of activity periods for active faults that the American Nuclear Power Regulatory Commission (NRC 1975) not only adopts a well-defined period also uses the special term "capable fault" to differentiate it from the term "active faults" in general. A capable fault refers to one which has one activity in the past 35,000 years, or several activities in the past 500,000 years. The NRC stipulates that "No capable faults should exist within 8 km radius area of any nuclear power site".

If someone argues that there is an active fault in the peninsula, he should give the evidence to support the conclusion. The public are told that there were two earthquakes with magnitude about 1 along the northwest trending faults, according to a map of "Collection of Maps of Natural Resources and Economic Development of Shenzhen" (1986); this information was released by the Guangdong Bureau of Seismology. Two or three earthquakes with magnitude $M_s = 1, 2$ or even 3 in this area cannot be used to draw conclusions about active faults, otherwise there would be many active faults in Hong Kong as well as in Guangdong Province. The epicentre maps produced by the Hong Kong Royal Observatory and the Guangdong Bureau of Seismology may show many events with magnitude above $M_s = 1$ occurring in Hong Kong and in Guangdong in recent years. Because of the nature and extent of the seismic network of this region, earthquakes with magnitude less than $M_s = 2$ are too small to be located accurately.

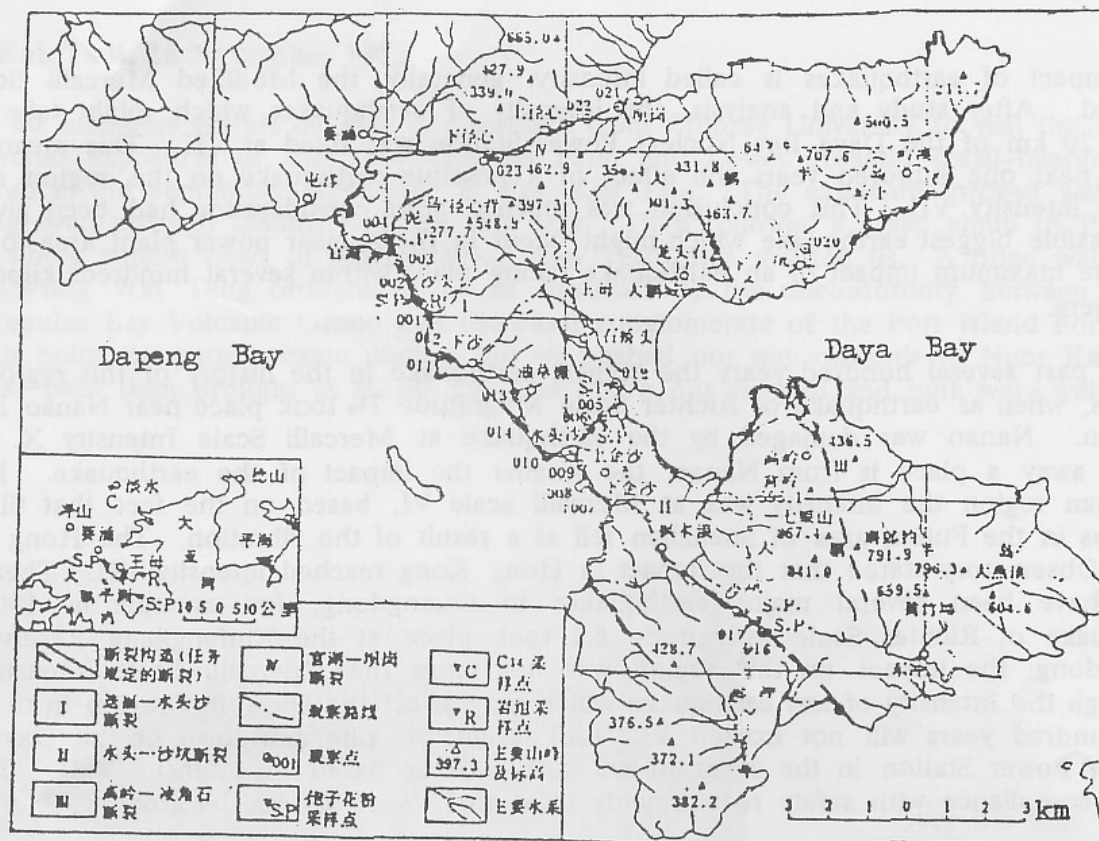


Figure 2 Map showing the points where the detailed work was carried out to study the new activity of the faults (According to the Geological Institute, SSB, 1981)

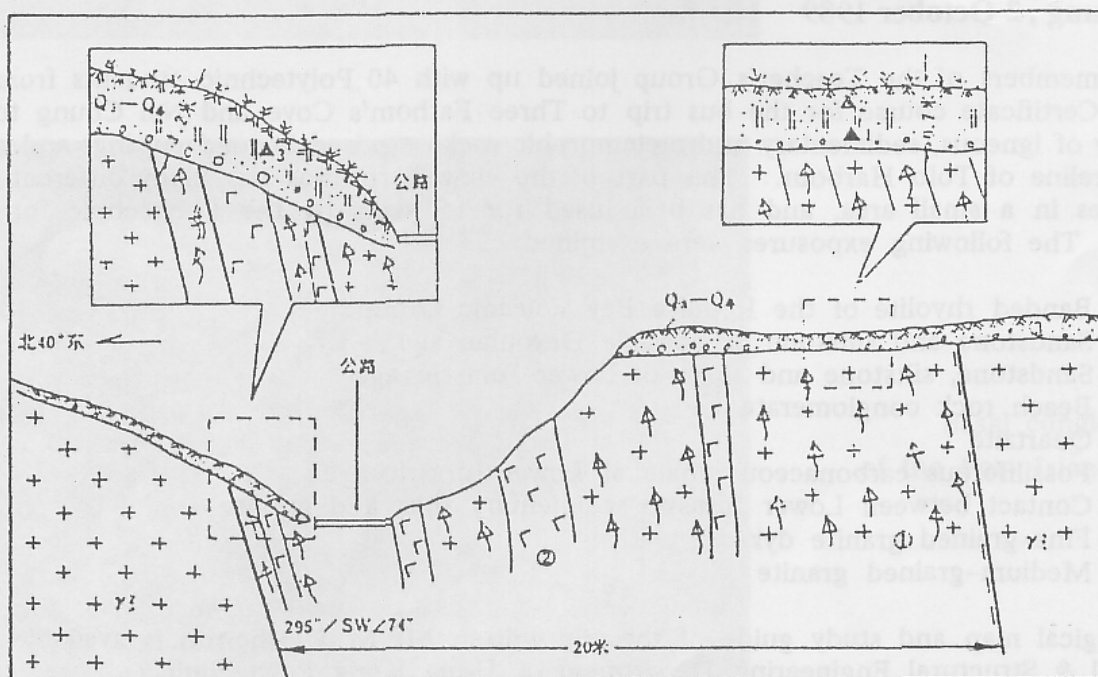


Figure 3 Geological section showing the relationship between Quaternary sediments and the faults

The impact of earthquakes is called intensity; generally, the Modified Mercalli Scale is adopted. After study and analysis, the intensity of earthquakes which might take place within 20 km of the Daya Bay Nuclear Power Station was fixed at VII. This means that in the next one hundred years the effect of a possible earthquake on this region cannot exceed intensity VII. This conclusion was reached after consideration had been given to the possible biggest earthquake which might occur in the nuclear power plant area together with the maximum impact of an earthquake taking place within several hundreds kilometres from here.

In the past several hundred years the biggest earthquake in the history of this region was in 1918, when an earthquake of Richter Scale Magnitude $7\frac{1}{4}$ took place near Nanao Island, Shantou. Nanao was damaged by the earthquake at Mercalli Scale Intensity X. The farther away a place is from Nanao, the smaller the impact of the earthquake. In the Shenzhen region the intensity was at Mercalli scale VI, based on the fact that tiles on rooftops in the Futian area of Shenzhen fell as a result of the vibration. The Hong Kong Royal Observatory stated that the impact in Hong Kong reached intensity VII. Thereafter there have been several major earthquakes in Guangdong, for example in 1962 an earthquake of Richter Scale Magnitude 6.1 took place at the Xinfengjiang Reservoir in Guangdong; the impact on this region was not more than Mercalli Scale Intensity VI. Although the intensity of any earthquake which may affect the Daya Bay region in the next one hundred years will not exceed VII, the design for safe shutdown of the Daya Bay Nuclear Power Station in the event of an earthquake is based on intensity VIII. This is in full compliance with safety requirements after analysis of seismic hazards.

REPORT ON RECENT FIELD TRIPS

Nai Chung, 2 October 1989

Fifteen members of the Teacher's Group joined up with 40 Polytechnic students from the Higher Certificate course for the bus trip to Three Fathom's Cove and Nai Chung to see a variety of igneous, sedimentary and metamorphic rocks exposed in road cuttings and along the shoreline of Tolo Harbour. This part of the New Territories has many different rock exposures in a small area, and has been used for 15 years by the Polytechnic for field studies. The following exposures were examined:

- Banded rhyolite of the Repulse Bay Volcanic Group
- Sandstone and siltstone of possible Devonian age
- Sandstone, siltstone and shale of Lower Jurassic age
- Beach rock conglomerate
- Quartzite
- Fossiliferous carbonaceous shale of Lower Jurassic age
- Contact between Lower Jurassic sedimentary rock and granite
- Fine-grained granite dyke
- Medium-grained granite

A geological map and study guide of the trip written by Mr M J Atherton is available from the Civil & Structural Engineering Department of Hong Kong Polytechnic.

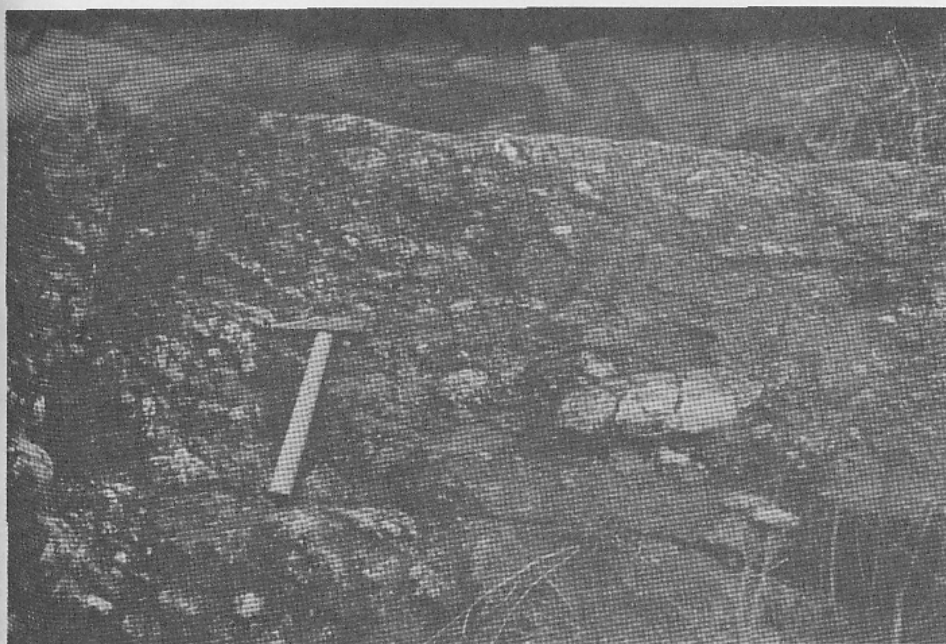
Field trips were also made to Tate's Cairn road tunnel on 11 November and the Teacher's Group went to Central to see building stones on 18 November 1989.

Pak Kok Tsui, 26 November 1989

Some 40 members set off by junk and sampan from Chinese University to visit the recently discovered exposures of the Tolo Channel Fault and Lower Jurassic fossil-bearing shale featured in the September Newsletter at Pak Kok Tsui. The exposures proved well worth visiting even through landing was not too easy. Then followed a steep climb to Pak Kok Shan where superb views of the northeast New Territories awaited us. A ridge walk along Fung Wong Wat Teng brought us to an exposure of the unconformity between tuff of the Repulse Bay Volcanic Group and the basal conglomerate of the Port Island Formation. At this point the path became unclear but we pushed our way onwards to Ngor Kai Teng; an easy path then brought us to Fu Tan Sha where our sampan and junk were waiting for us.



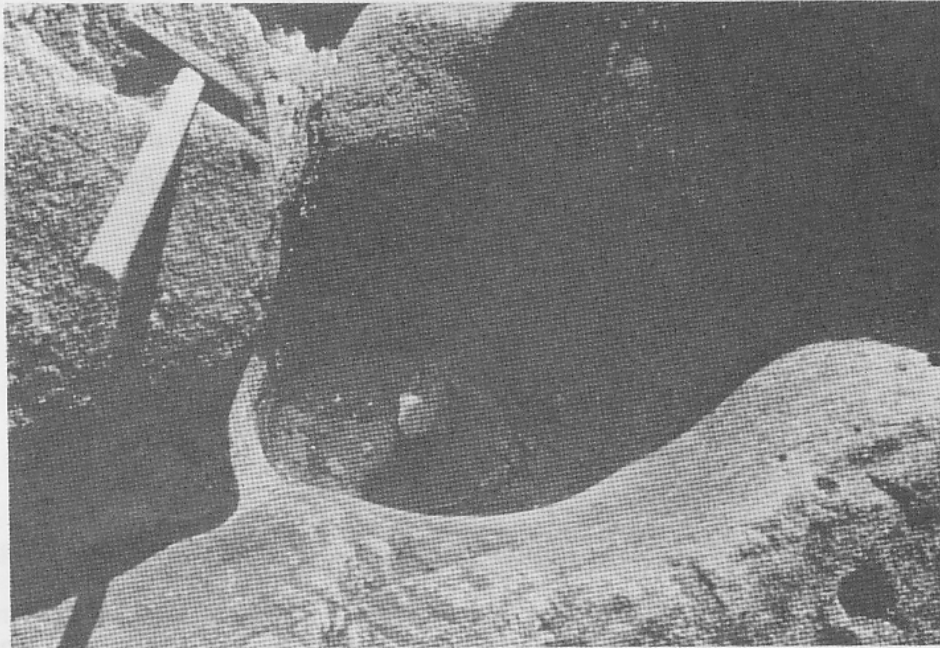
Over the hills and far away
at Pak Kok Tsui



Basal conglomerate
of the Port Island Formation

Nam Chung, 2 December 1989

Seven members of the Teacher's Group met at Fanling station for the minibus trip to Luk Keng where we set off up the Nam Chung River valley to look for potholes in the river bed. The Nam Chung River cuts through the Port Island Formation of sandstone, shale and pebble beds in a series of waterfalls, rapids and plunge pools in an exceptionally beautiful part of the New Territories. Many potholes were seen ranging from a few centimetres to a metre across, some containing spherical pot hole stones. An added bonus to the trip was a visit to the part of the valley containing the great thrust plane described by Williams, Ruxton and Allen & Stephens in their memoirs. The exposure proved so interesting that it is planned to run a trip to this location in the spring of 1990.



Nam Chung pothole

Daya Bay, 10 December 1989

Fifty-five members and friends set off at 8:30 am from Middle Road, Kowloon, by a new deluxe double decker Citybus to Sha Tau Kok. After a speedy transit of immigration and customs we transferred to smaller buses more suited to the roads of China for the trip to the nuclear power station at Daya Bay. Much construction work was noted along the north shore of Mirs Bay 'en route'. A photo stop was made to see Shark River village.

At the power station we were treated to an overall view of the plant and taken into the reactor building to see the nearly completed civil works. Following lunch, members inspected models of the power plant.

At 2 pm we set off to Xichang Bay at the southern point of Daibeng Peninsula. The bay, like much of the coastline seen on the trip, shows signs of recent uplift of about 5 metres. A major fault runs down the west side of the bay, faulting granite against Devonian sandstone, and forms a fault valley in which a reservoir has been constructed.

On the return trip an all too short stop was made to see the charming old village of Dai Beng before arriving at Kowloon at 7:30 pm.



All aboard for China!



The 'raised beach' at Xichong

TEXTURAL FEATURES, FIELD CHARACTERS AND GEOCHEMISTRY OF APHANITIC VOLCANIC ROCKS OF EASTERN HONG KONG

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Introduction

The Hong Kong Geological Survey's 1:20 000 mapping of the Sai Kung and Clear Water Bay areas is now complete. This work has stimulated a reappraisal of the aphanitic volcanic rocks in order to aid field identification of mappable units, the correlation of isolated outcrops and the determination of their petrogenesis.

The origin of certain aphanitic pyroclastic rocks in Hong Kong may be identified by the presence of a matrix of devitrified welded glass shards (Workman 1985, Tam 1983, Strange & Shaw 1986). In an evaluation of these rocks numerous thin sections have been studied in order to determine the variation in abundance of phenocrysts, their types and their morphologies. During this study it was found that similar rocks from the Sai Kung area, particularly around High Island, while lacking the distinctive shardic fabric within their matrix possess similar proportions and types of phenocrysts. On these criteria the High Island rocks may be linked petrogenetically with known pyroclastic rocks.

Widely occurring flow-banded aphanitic rocks from the Sai Kung and Clear Water Bay areas, known to be lavas, have different proportions of phenocrysts with morphologies different from those in the welded tuffs of High Island, in a matrix which concords with a purely magmatic origin.

The study was then extended to include aphanitic rhyolite dyke-rocks. Assessment of the morphologies of crystals in dyke rocks confirms features originating during magmatic processes as opposed to pyroclastic processes. Finally an evaluation was made of other flow-banded rocks from Sham Chung, Ma On Shan and Shek Nga Shan.

Detailed petrographic examination as well as point-counting of crystals has been carried out, with the aim of producing a simple qualitative and quantitative record of the characteristic textural features which could help in determining affinities and the petrogenesis of similar rock suites.

In addition a small number of geochemical analyses are now available and these confirm the affinities indicated by the microscope studies.

The volcanic rocks all belong to the Repulse Bay Volcanic Group of Upper Jurassic to Lower Cretaceous age and the intrusive rocks are also believed to be Upper Jurassic to Cretaceous in age (Allen & Stephens, 1971). Most of the samples examined were collected during the GCO's geological re-mapping programme of sheets 7, 8, 11 and 12 (Figure 1). The rock names used in this paper follow the nomenclature of Addison (1986) and Strange and Shaw (1986) in their published maps and memoirs.

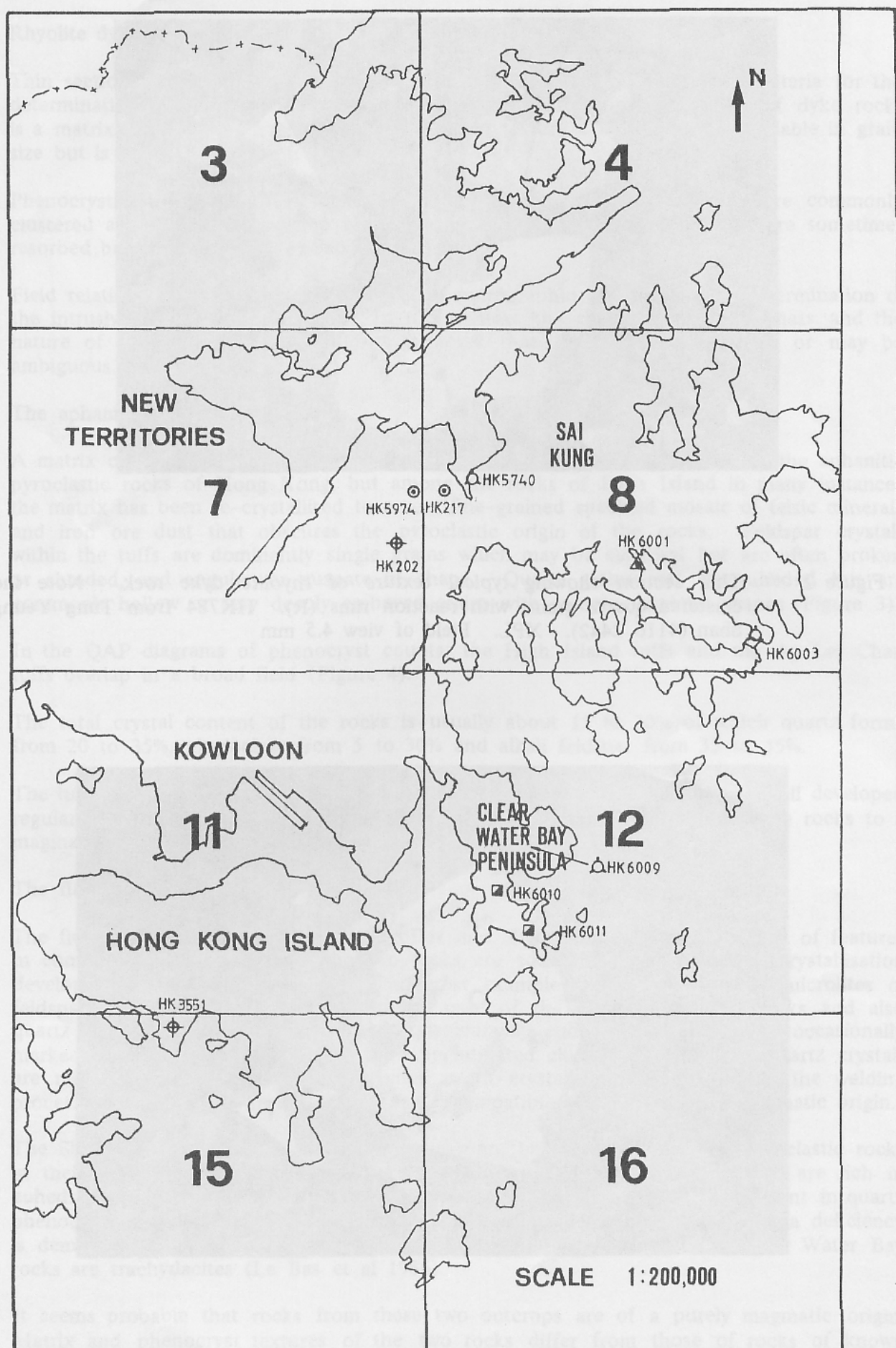


Figure 1 Map of eastern Hong Kong showing localities of geochemical samples

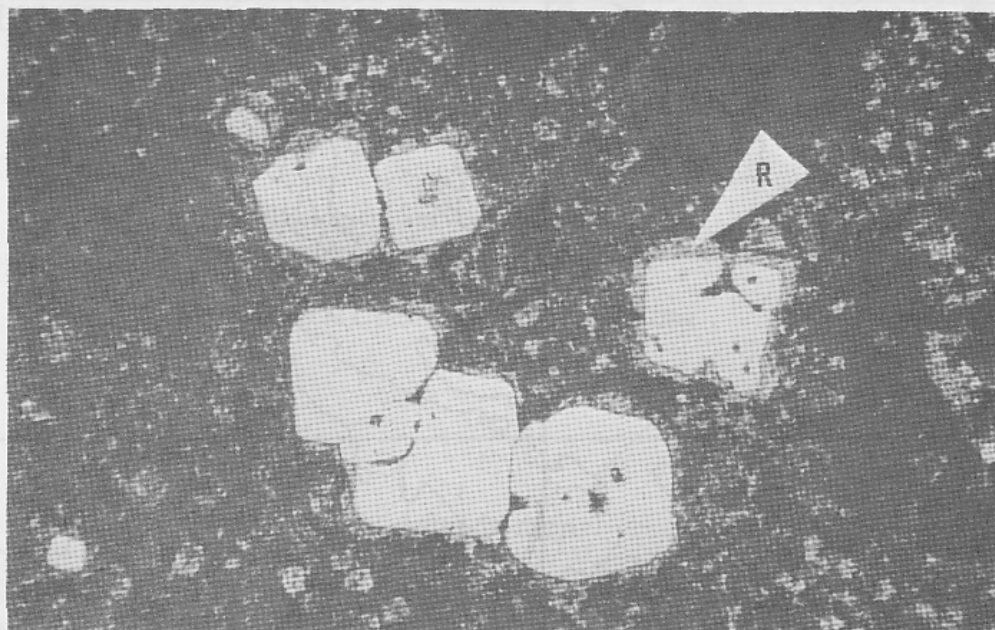


Figure 2 Thin section showing typical texture of rhyolite dyke rock. Note the clustered quartz grains with reaction rims (R). HK784 from Tung Yeung Shan (4116 2442). XPL. Field of view 4.5 mm

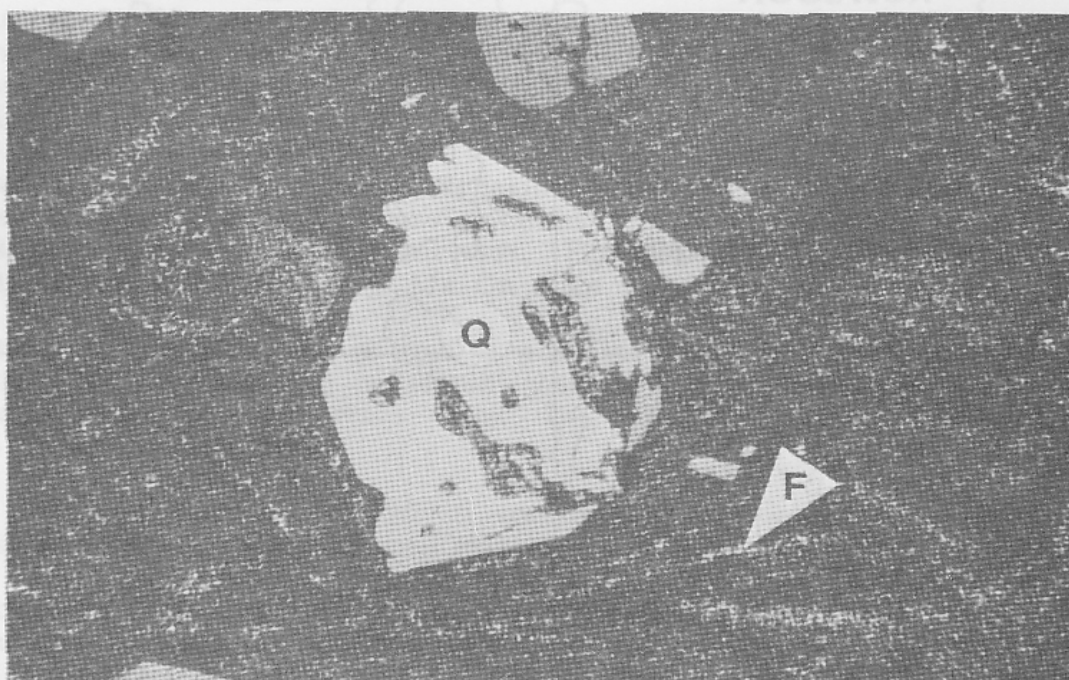


Figure 3 Thin section of welded tuff of the High Island Formation (HK6226). Showing deeply embayed quartz (Q) and flow fabric (F). XPL. Field of view 4.5 mm

Textural features and field characters

Rhyolite dyke rocks

Thin sections of rhyolite dyke rocks were examined in order to establish criteria for the determination of an intrusive and magmatic origin. The common feature of dyke rocks is a matrix which shows a granular devitrification texture. This texture is variable in grain size but is essentially uniform in character.

Phenocrysts within the dyke rocks are almost always euhedral. Grains are commonly clustered and sometimes develop reaction rims (Figure 2). Quartz crystals are sometimes resorbed but rarely develop skeletal outlines.

Field relations may be more important than petrographic criteria for the determination of the intrusive origin of rock units. In this context the shape of the rock mass and the nature of its contacts are significant, however these may not be exposed or may be ambiguous.

The aphanitic pyroclastic rocks

A matrix composed of devitrified welded glass shards is a typical feature of the aphanitic pyroclastic rocks of Hong Kong, but among the rocks of High Island in many instances the matrix has been re-crystallised to a very fine-grained speckled mosaic of felsic minerals and iron ore dust that obscures the pyroclastic origin of the rocks. Feldspar crystals within the tuffs are dominantly single grains which may be euhedral but are often broken or abraded, and angular or cusped in shape. Quartz grains may be euhedral but are commonly hollow or very deeply embayed grains with complex skeletal shapes (Figure 3).

In the QAP diagrams of phenocryst counts, the High Island tuffs and the Ap Lei Chau tuffs overlap in a broad field (Figure 4).

The total crystal content of the rocks is usually about 15 to 30% of which quartz forms from 20 to 35%, plagioclase from 5 to 30% and alkali feldspar from 35 to 55%.

The tuffs of High Island and the Ap Lei Chau Formation commonly display well developed regular columnar jointing (Workman, 1985); use of this character to link these rocks to a magmatic origin is clearly misleading.

The flow-banded lavas

The flow-banded rocks of Clear Water Bay and Sham Chung have a number of features in common. The matrices of the two rocks are somewhat recrystallised (recrystallisation developing along the flow-banding), but most examples show flow oriented microlites of feldspar. Phenocrysts of feldspar, in the case of the Clear Water Bay rocks and also quartz in the Sham Chung rocks, are conspicuously euhedral (feldspars are occasionally markedly elongate) and commonly form agglutinated clusters (Figure 5). Quartz crystals are rarely embayed. Although microlites might crystallise in a tuff during the welding process, these crystal textures are probably incompatible with an explosive magmatic origin.

The Sham Chung and Clear Water Bay rocks are broadly similar to the pyroclastic rocks in their total phenocryst contents (12 to 47%) but the Sham Chung rocks are rich in euhedral quartz crystals (Figure 4) while the Clear Water Bay rocks are deficient in quartz phenocrysts (7% of phenocrysts, Figure 6) and relatively rich in feldspar. Silica deficiency is demonstrated by chemical analyses (Table 1), which indicate that the Clear Water Bay rocks are trachydacites (Le Bas et al 1986).

It seems probable that rocks from these two outcrops are of a purely magmatic origin. Matrix and phenocryst textures of the two rocks differ from those of rocks of known

- 1 HK 6001 Flow banded rhyolite, High Island
- 2 HK 217 Flow banded rhyolite, west of Three Fathoms Cove
- 3 HK 6010 Trachyte, Clear Water Bay
- 4 HK 6011 Trachyte, Tai Miu Wan
- 5 HK 6003 Welded fine ash tuff, High Island
- 6 HK 6009 Welded fine ash tuff, Clear Water Bay
- 7 HK 5974 Flow banded rhyolite, Sai O Tunnel
- 8 HK 5740 Welded fine ash tuff, east of Three Fathoms Cove
- 9 HK 3551 Welded fine ash tuff, Ocean Park
- 10 HK 202 Welded fine ash tuff, Pyramid Hill

- △ Welded tuff of High Island
- ◆ Welded tuff of the Ap Lei Chau Fm
- Trachyte, Clear Water Bay
- Rhyolite Lava of Sham Chung
- Rhyolite of Shek Nga Shan and Three Fathoms Cove
- ▲ Rhyolite Lava of High Island

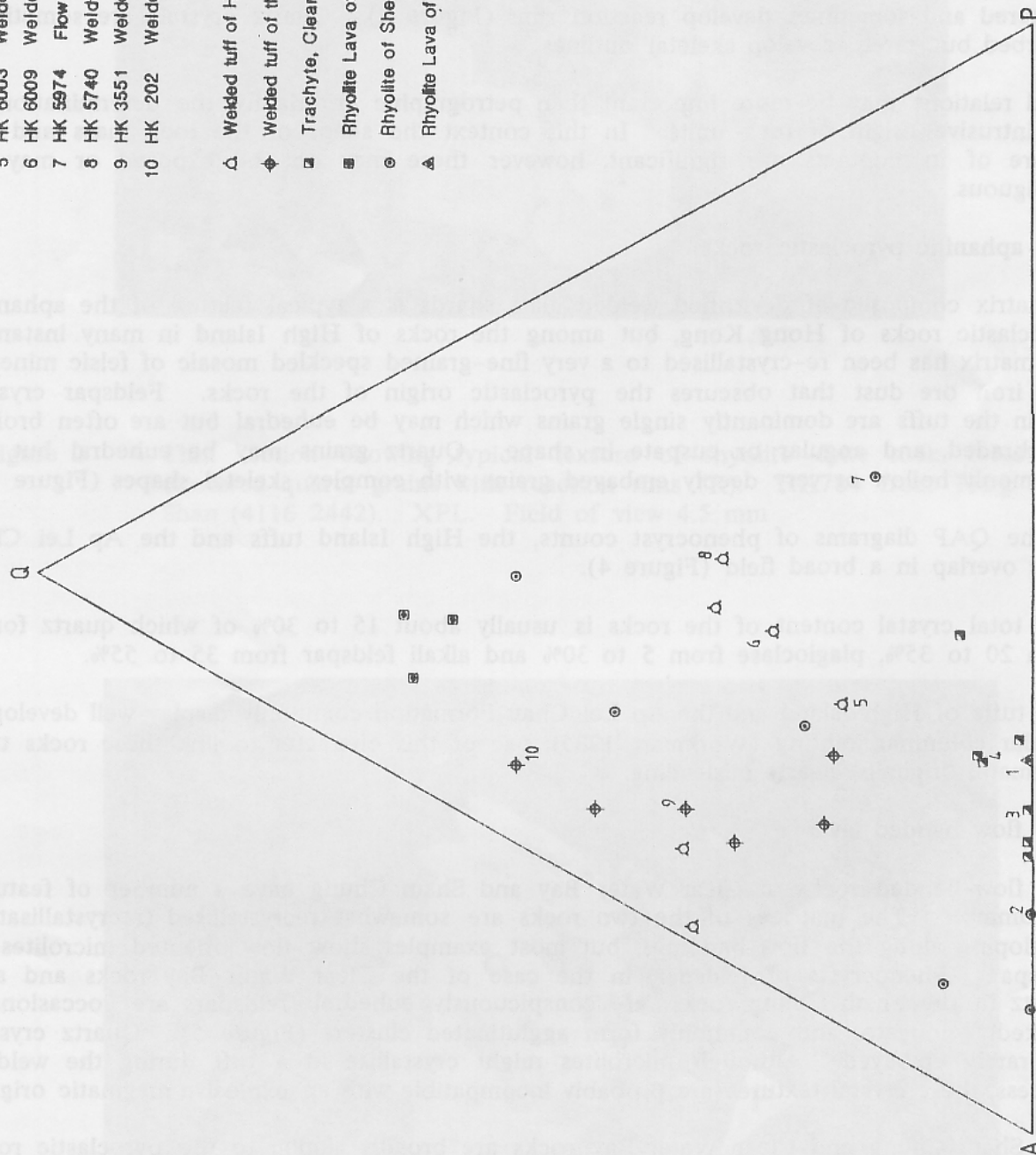


Figure 4 QAP diagram of aphanitic volcanic rock types

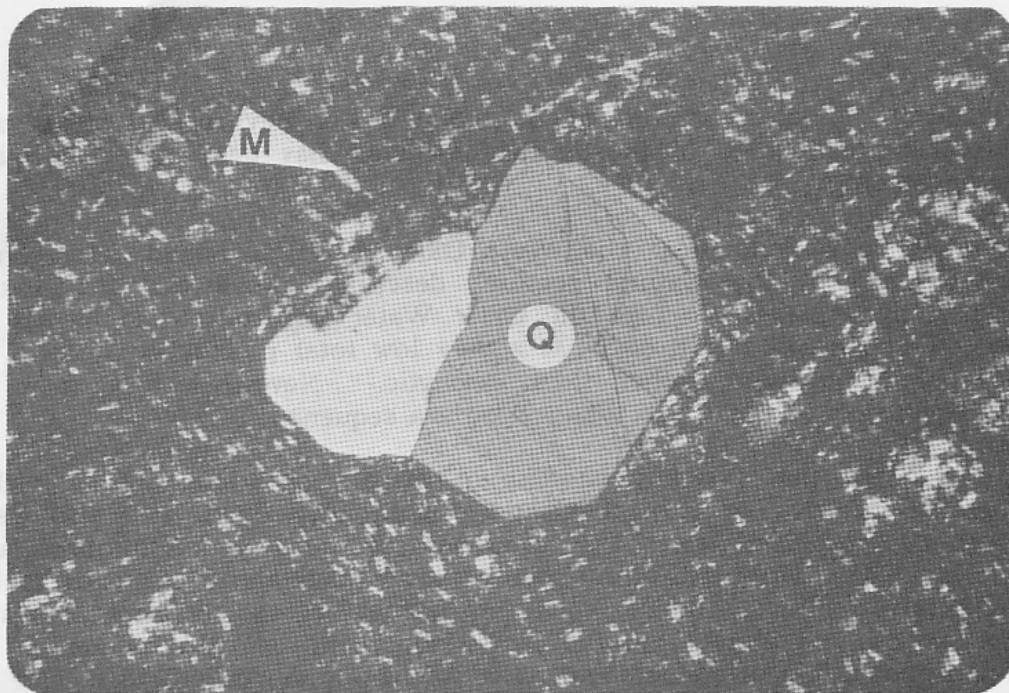


Figure 5 Thin section of flow banded rhyolite (HK5752) from Sham Chung (4718 3353). Note the feldspar microlites (M) and clustered quartz (Q). XPL. Field of view 4.5 mm

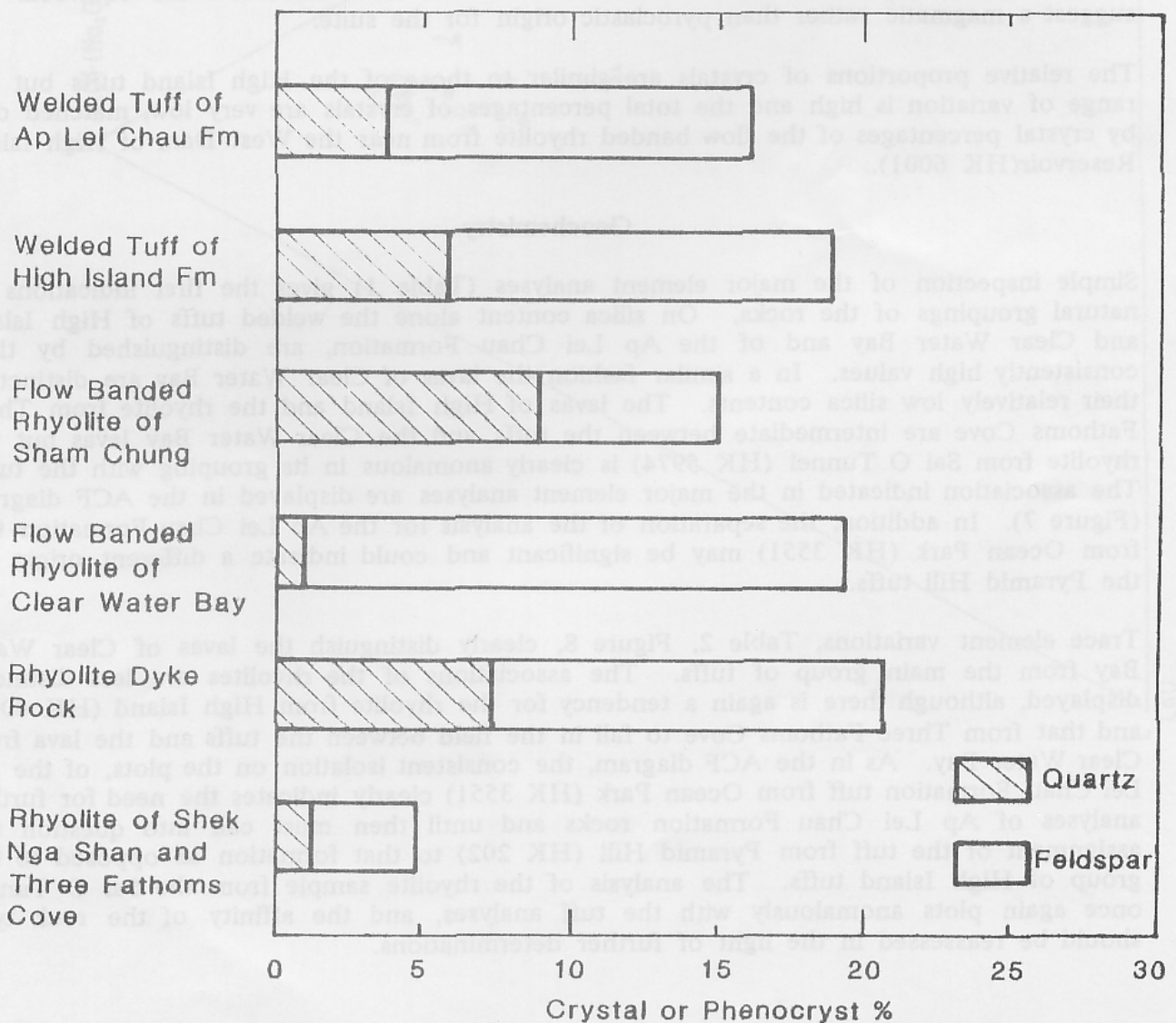


Figure 6 Bar chart showing variation in crystal percentage of the aphanitic rocks

pyroclastic origin. Field characters of the Clear Water Bay rocks support the inference of an extrusive origin. No diagnostic field evidence has been noted in respect of the Sham Chung outcrop.

A flow-banded rock from near the West Dam of High Island Reservoir (HK6001) demonstrates many of the textural features described above and in addition has an autobrecciated upper surface. Like the Clear Water Bay rocks this lava is deficient in quartz crystals (Figure 4) but it also has a very low total phenocryst content (8%) and it is rhyolitic in composition rather than trachytic. Nevertheless it may represent a differentiated portion of the Clear Water Bay lava sequence.

It should be noted that the flow-banding of these rocks does not in itself constitute evidence of an intrusive or even magmatic origin. Ash-flows may also develop flow-banding (by rheomorphism) which may even pass to the stage of autobrecciation (Fisher & Schmincke 1984). However, flow-banding within magmatic rock tends to show rather more continuous (30 cm) bands which are somewhat coarser than bands within the pyroclastic rocks. The banding in the pyroclastic rocks can also commonly be seen to be fasciculate, consisting of welded and felted shreds of devitrified glass.

The Shek Nga Shan rhyolites

A group of flow-banded rhyolite rocks outcrop on Shek Nga Shan and Pyramid Hill. These rocks have a finely recrystallised matrix which in some instances is spherulitic or perlitic. Phenocrysts in these rocks are sparse (7% of total rock, Figure 6) and include elongate euhedral alkali feldspars and clustered crystals. Quartz grains are absent or rare but strongly embayed (Addison 1986). The features in combination are equivocal but suggest a magmatic rather than pyroclastic origin for the suite.

The relative proportions of crystals are similar to those of the High Island tuffs but the range of variation is high and the total percentages of crystals are very low, matched only by crystal percentages of the flow banded rhyolite from near the West Dam of High Island Reservoir (HK 6001).

Geochemistry

Simple inspection of the major element analyses (Table 1) gives the first indications of natural groupings of the rocks. On silica content alone the welded tuffs of High Island and Clear Water Bay and of the Ap Lei Chau Formation, are distinguished by their consistently high values. In a similar fashion the lavas of Clear Water Bay are distinct in their relatively low silica contents. The lavas of High Island and the rhyolite from Three Fathoms Cove are intermediate between the tuffs and the Clear Water Bay lavas but the rhyolite from Sai O Tunnel (HK 5974) is clearly anomalous in its grouping with the tuffs. The association indicated in the major element analyses are displayed in the ACF diagram (Figure 7). In addition, the separation of the analysis for the Ap Lei Chau Formation tuff from Ocean Park (HK 3551) may be significant and could indicate a different origin for the Pyramid Hill tuffs.

Trace element variations, Table 2, Figure 8, clearly distinguish the lavas of Clear Water Bay from the main group of tuffs. The associations of the rhyolites are less distinctly displayed, although there is again a tendency for the rhyolite from High Island (HK 6001) and that from Three Fathoms Cove to fall in the field between the tuffs and the lava from Clear Water Bay. As in the ACF diagram, the consistent isolation on the plots, of the Ap Lei Chau Formation tuff from Ocean Park (HK 3551) clearly indicates the need for further analyses of Ap Lei Chau Formation rocks and until then must call into question the assignment of the tuff from Pyramid Hill (HK 202) to that formation as opposed to the group of High Island tuffs. The analysis of the rhyolite sample from the Sai O Tunnel once again plots anomalously with the tuff analyses, and the affinity of the rock type should be reassessed in the light of further determinations.

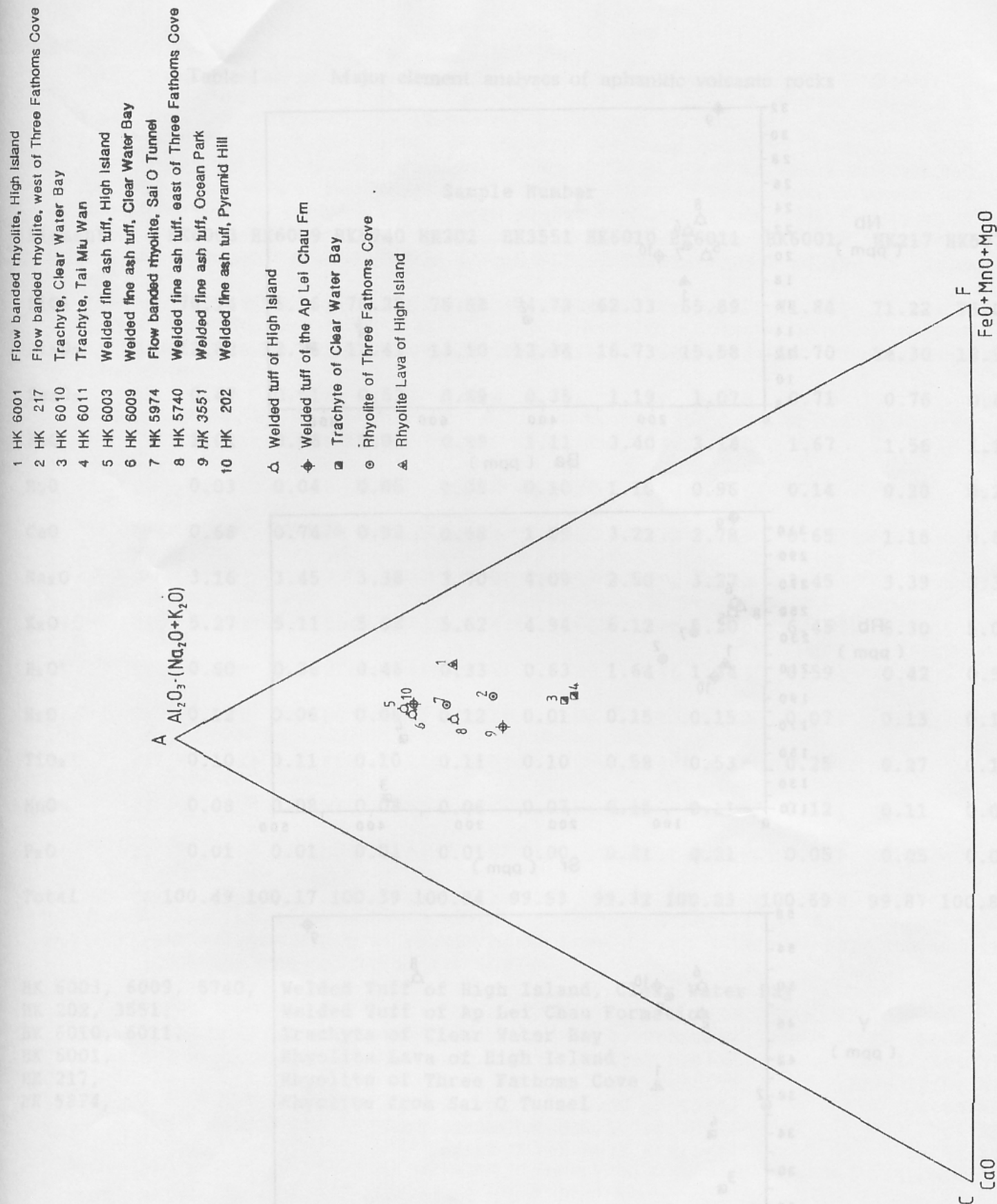


Figure 7 ACF diagram of aphanitic volcanic rock types

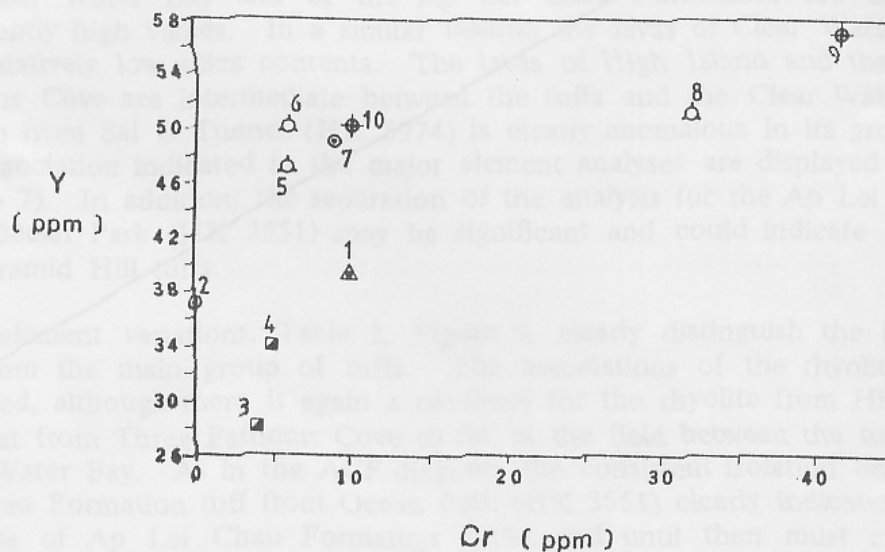
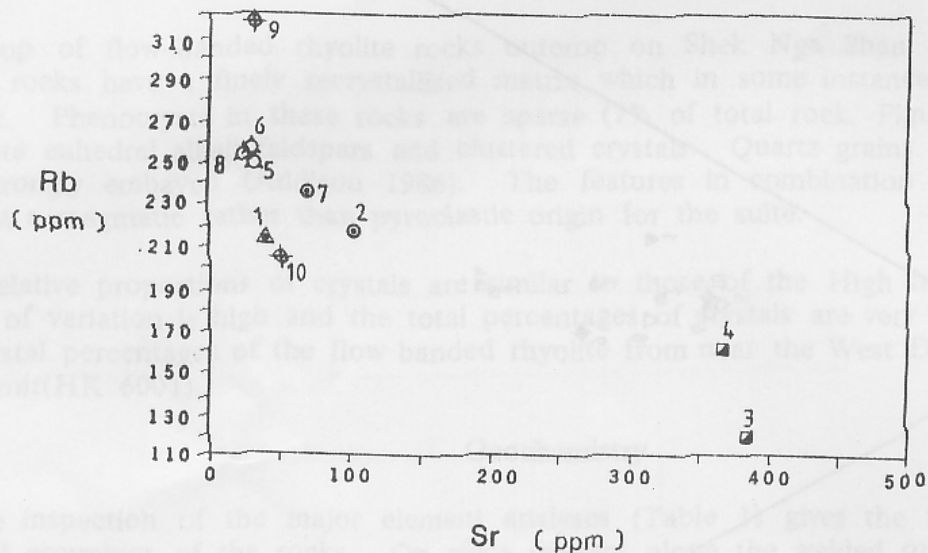
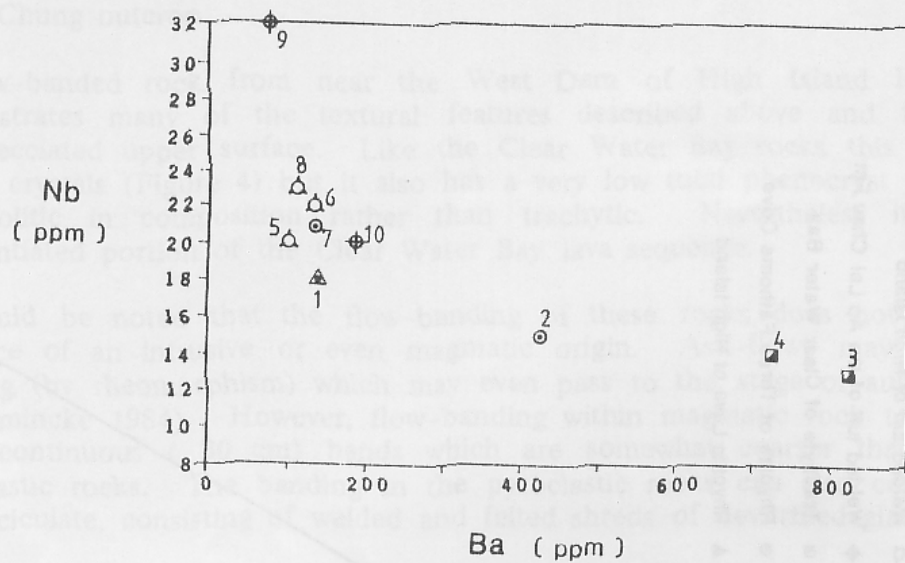


Figure 8 Selected trace element plots showing discrimination between aphanitic volcanic rock types (for keys to symbols and numbers see Figure 4)

Table 1 Major element analyses of aphanitic volcanic rocks

Element	Sample Number									
	HK6003	HK6009	HK5740	HK202	HK3551	HK6010	HK6011	HK6001	HK217	HK5974
SiO ₂	76.14	75.96	76.28	75.58	74.73	62.33	65.89	71.84	71.22	76.01
Al ₂ O ₃	12.82	12.76	12.41	13.10	12.34	16.73	15.58	14.70	14.30	12.90
Fe ₂ O ₃	0.47	0.51	0.52	0.69	0.35	1.19	1.07	0.71	0.76	0.45
FeO	1.01	0.98	1.04	0.89	1.11	3.40	3.14	1.67	1.56	1.18
MgO	0.03	0.04	0.05	0.05	0.10	1.10	0.96	0.14	0.20	0.21
CaO	0.68	0.74	0.92	0.58	1.09	3.22	2.78	0.65	1.16	0.89
Na ₂ O	3.16	3.45	3.38	3.70	4.09	2.50	3.27	3.45	3.39	3.32
K ₂ O	5.27	5.11	5.08	5.62	4.94	6.12	5.20	6.45	6.30	5.08
H ₂ O ⁺	0.60	0.36	0.46	0.33	0.63	1.64	1.34	0.59	0.42	0.50
H ₂ O	0.12	0.06	0.06	0.12	0.01	0.15	0.15	0.07	0.13	0.12
TiO ₂	0.10	0.11	0.10	0.11	0.10	0.58	0.53	0.25	0.27	0.12
MnO	0.08	0.08	0.08	0.06	0.07	0.15	0.11	0.12	0.11	0.07
P ₂ O	0.01	0.01	0.01	0.01	0.00	0.21	0.21	0.05	0.05	0.02
Total	100.49	100.17	100.39	100.84	99.53	99.32	100.23	100.69	99.87	100.87

HK 6003, 6009, 5740, Welded Tuff of High Island, Clear Water Bay
 HK 202, 3551, Welded Tuff of Ap Lei Chau Formation
 HK 6010, 6011, Trachyte of Clear Water Bay
 HK 6001, Rhyolite Lava of High Island
 HK 217, Rhyolite of Three Fathoms Cove
 HK 5874, Rhyolite from Sai O Tunnel

Table 2 Trace element analyses of aphanitic volcanic rocks (in parts per million)

Element	Sample Number									
	HK6003	HK6009	HK5740	HK202	HK3551	HK6010	HK6011	HK6001	HK217	HK5974
Pb	33	37	37	88	42	20	21	32	39	29
Zn	51	51	62	42	53	60	62	66	62	32
Ni	0	0	0	2	4	1	1	0	2	0
Cu	2	2	1	34	2	6	7	1	17	1
Co	2	2	1	2	2	7	8	2	2	1
V	1	1	51	0	0	36	40	0	0	2
Cr	6	6	32	10	42	4	5	10	0	9
Rb	250	255	255	204	318	119	162	213	220	237
Sr	35	31	32	50	33	384	370	41	106	72
Y	47	50	51	50	57	28	34	39	37	49
Zr	197	195	196	202	210	487	333	416	395	219
Nb	20	22	23	20	32	13	14	18	15	21
Th	31	29	31	27	38	13	24	23	22	30
Ce	82	94	86	130	86	94	823	88	130	79
Ba	107	136	116	190	77	827	730	143	430	140

HK 6003, 6009, 5740, Welded Tuff of High Island and Clear Water Bay
 HK 202, 3551, Welded Tuff of Ap Lei Chau Formation
 HK 6010, 6011, Trachyte of Clear Water Bay
 HK 6001, Rhyolite Lava of High Island
 HK 217, Rhyolite of Three Fathoms Cove
 HK 5974, Rhyolite from Sai O Tunnel

Figure 3 Selected trace element plots showing discrimination between aphanitic volcanic rock types (for keys to symbols and numbers see Figure 4)

Conclusions

From a comparison of the results of geochemical analysis and petrographic studies it is quite clear the examination of phenocryst assemblages can aid in characterisation of lithological units within the volcanic succession of Sai Kung and Clear Water Bay. The Clear Water Bay trachydacites, the Sham Chung rhyolites, the High Island rhyolites and the High Island tuffs all have distinctive relative proportions of phenocrysts (Figure 6) and distinctions between groups are consistent with the geochemical data. The assessment of crystal assemblages is cheaply and easily carried out and once recognised these assemblages can be used as tools for mapping and correlation of lithological units.

While it is not possible to make categorical determinations based upon them, it seems likely that certain other features such as agglutinated crystal clusters, microlitic textures and perlitic cracking are more commonly developed in magmatic effusive rocks than in pyroclastics.

Features such as flow-banding, flow-folding, autobrecciation and columnar jointing are seen in both pyroclastic and magmatic effusive rocks.

Acknowledgments

We are greatly indebted to Paul Strange for his help and advice on the petrography and field occurrences of the Sai Kung and Clear Water Bay rocks. Thanks are also due to Vitus Chan and Richard Langford for their comments during the many discussions as the studies were carried out. This paper is published with the permission of the Director of Civil Engineering Services.

References

- ADDISON, R. (1986). Geology of Sha Tin. Hong Kong Geological Survey Memoir No 1. Geotechnical Control Office, Hong Kong. 85p
- ALLEN, P M & STEPHENS, E A. (1971). Report on the Geological Survey of Hong Kong. Hong Kong Government Press. 116p plus 2 maps
- FISHER, R V & SCHMINCKE, H-U. (1984). Pyroclastic rocks. Springer-Verlag, New York. 472p
- LE BAS, M J, LE MAITRE, R W, STRECKEISEN, A & ZANETTIN, B. (1986). A chemical classification of volcanic rocks based on the total alkali-silica diagram. Journal of Petrology Vol 27 Part 3 p745-750
- STRANGE, P J & SHAW, R. (1986). Geology of Hong Kong Island and Kowloon. Hong Kong Geological Survey Memoir No 2. Geotechnical Control Office, Hong Kong. 134p.
- TAM, S W & CHAN, Y M. (1983). Late Jurassic ash-flow tuffs in the eastern part of Hong Kong, South China. Asian Geographer Vol 2 No 1 p47-69
- WORKMAN, D R. (1985). An exposure of welded tuffs at Mount Kellett. Geological Society of Hong Kong Newsletter Vol 3 No 4 p1-7

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For further details, please write to the organization or person named in each case.

16-20 April 1990

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Institute of Mechanics

Technical University Vienna

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A-1040 Vienna

AUSTRIA

6-10 August 1990

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Sixth International IAEG Congress

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CHINA

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Chengdu, Sichuan

CHINA

9-13 September 1990

26TH ANNUAL CONFERENCE OF THE ENGINEERING GROUP OF THE GEOLOGICAL SOCIETY OF LONDON: ENGINEERING GEOLOGY OF WEAK ROCK, UNIVERSITY OF LEEDS, LEEDS, UK

Dr S R Hencher

Dept of Earth Sciences

University of Leeds
Leeds LS2 9JT
UK

19-23 November 1990

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Natural Resources Division
ESCAP
UN Building
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THAILAND

27 May-1 June 1991

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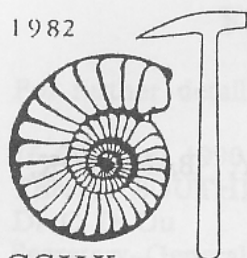
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9-13 December 1991

9TH ASIAN REGIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING, BANGKOK, THAILAND

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Division of Geotechnical and Transportation Engineering
Asian Institute of Technology
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HKIE Geotechnical Division/Geological Society of Hong Kong Joint Technical Meeting

- Date/Time : Wednesday 25 April 1990 at 5:45 for 6:00 pm
- Venue : Civil Engineering Services Department Seminar Room
12/F Empire Centre, 68 Mody Road,
Tsim Sha Tsui East, KOWLOON
- Speaker : Dr Steve Hencher
- Topic : Controls on shear strength in weathered granites

Synopsis

Dr Hencher of the University of Leeds will discuss recent research on weathered and altered granite from southwest England, Hong Kong and Nigeria. The aim of the research is to establish the influence of relict fabric on engineering behaviour and to develop simple tests that can provide guidance for the selection of design parameters.

Dr Hencher will discuss the development of new equipment and methods of analysis for investigating shear behaviour, and the use of techniques such as mercury intrusion porosimetry and transmission electron microscopy for characterizing materials.

Biographical Notes

Dr Hencher graduated in geology in 1973 and obtained his PhD from Imperial College for his research on the shear strength of rock joints under dynamic loadings.

He has worked with W S Atkins & Partners and the Geotechnical Control Office on various geotechnical projects including seismic risk analysis of power stations in the UK and geotechnical investigation of major slope failures in Hong Kong.

Since 1985 he has been a lecturer in engineering geology in the Department of Earth Sciences at the University of Leeds where he is heavily involved in the running of the MSc course in Engineering Geology and has initiated several research projects.

He is a member of the Geological Society of London Engineering Group Working Party on weathered rocks and is author or co-author of more than 20 technical papers.

Geological Society of Hong Kong publications list

- BULLETIN No 1. (1984). 177 p. Ed W W S Yim. Geology of surficial deposits in Hong Kong
BULLETIN No 2. (1985). 236 p. Ed I McFeat-Smith. Geological aspects of site investigation
BULLETIN No 3. (1987). 600 p. Ed P G D Whiteside. The role of geology in urban planning

MARINE GEOLOGY OF HONG KONG AND THE PEARL RIVER MOUTH. (1985). 96 p. Eds P G D Whiteside and R S Arthurton

MARINE SAND AND GRAVEL RESOURCES OF HONG KONG. (1988). 221 p. Eds P G D Whiteside and N Wragge-Morley

ABSTRACTS No 1. 79 p. Abstracts of papers presented at the meeting on Geology of Surficial Deposits in Hong Kong, September 1983 - OUT OF PRINT

ABSTRACTS No 2. 50 p. Abstracts of papers presented at the conference on Geological Aspects of Site Investigation, December 1984

ABSTRACTS No 3. 51 p. Abstracts of papers presented a meeting on Sea-level Changes in Hong Kong During the Last 40 000 Years, May 1986

ABSTRACTS No 4. 65 p. Abstracts of papers presented at the conference on The Role of Geology in Urban Development, December 1986

ABSTRACTS No 5. 79 p. Abstracts/Extended Abstracts of six papers presented at a meeting on Future Sea-level Rise and Coastal Development, April 1988

ABSTRACTS No 6. 58 p. Abstracts of papers presented at the conference on Karst Geology in Hong Kong, January 1990

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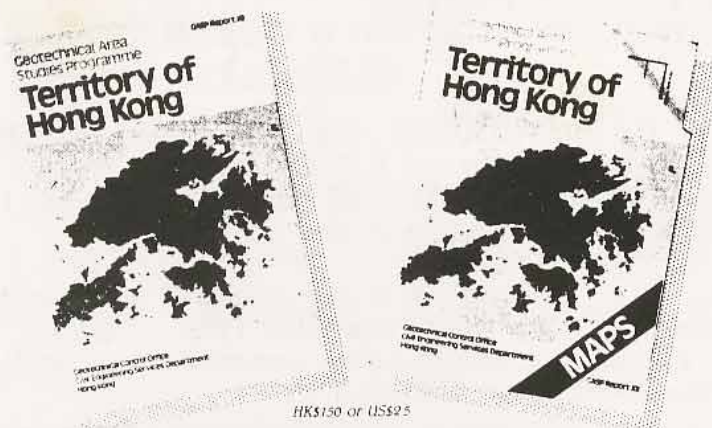
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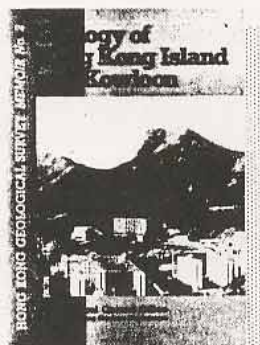
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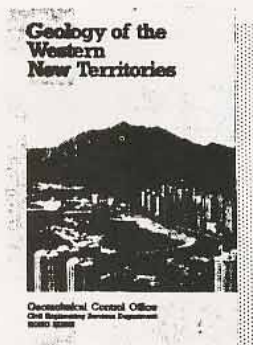
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