

GEOLOGICAL SOCIETY OF HONG KONG

香港地質學會

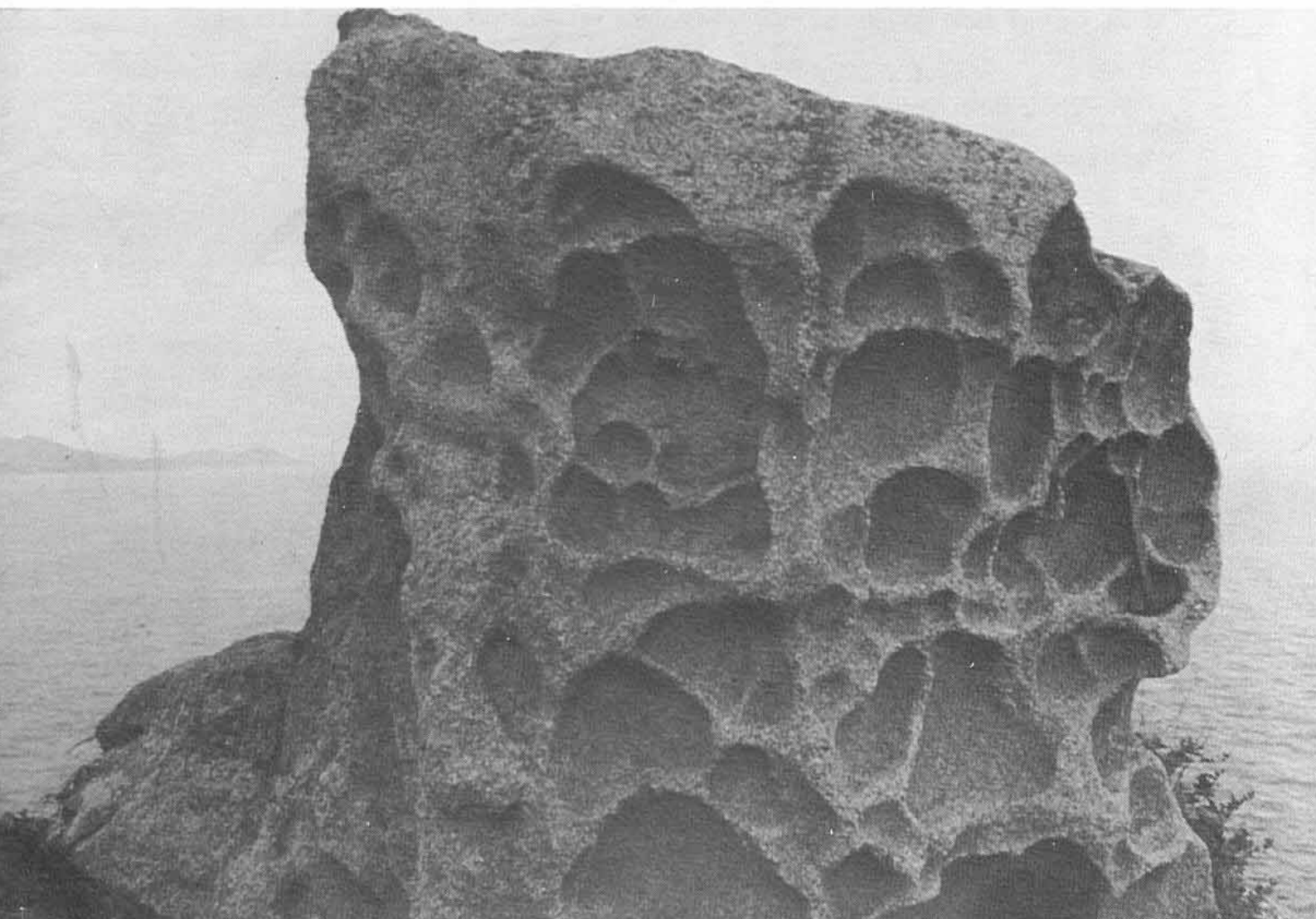
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Articles of a technical nature, as well as reports of interesting events, reviews and other topical items are welcome. Contributions must be short, although exceptions may be made at the discretion of the Society. Figures, tables, and half-tone plates must be kept to a minimum and must be all on separate sheets.

Typescripts must be accurate and in their final form. Two complete copies should be sent to the Secretary. Typescripts should be double-spaced, including references, on one side only of the paper only with a 2.5cm margin on each side. A4 paper is preferred. All pages should bear the author's name, and be numbered serially.

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References: The author is responsible for ensuring that all references are correct. Unless the list of references is extensive, references should be given in full; where used, Journal abbreviations must comply with those in the List of Serial publications held in the Library of the Geological Society of London (Geological Society, 1978).

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26.12.1989

FORTHCOMING MEETING

Karst geology in Hong Kong

Saturday 6 January 1990

A one-day conference at the

University of Hong Kong

- K K Leung Building -

Lecture Theatre LG- 09

The Society is publishing a Bulletin and holding a one-day conference and field trips on karst geology. The conference will be accompanied by a set of published Abstracts. Please pre-register for this conference, and express your interest in the field excursions, by filling out the reply slip. Cancellation can be accepted later if you are unable to attend. Pre-registrants will receive further details in December. Registration will also be possible on the day of the conference at the University, but advance notice must be provided of attendance on the field trips.

Bulletin No 5 "Karst Geology in Hong Kong" is intended to contain papers with a strong geological emphasis on such topics as karst, solution features and caverns, stratigraphy, structure, palaeontology, geophysics and hydrogeology. Papers can cover both the local and regional aspects, in both the Palaeozoic and related Mesozoic rocks. We also hope to attract contributions on site-specific examples of geological problems. The emphasis is on Hong Kong, but relevant contributions from elsewhere in the region may be included.

If you or any of your colleagues have information on karst geology or related topics of particular relevance to Hong Kong, we would very much like to publish this. Please contact the conference organizer, Dr R L Langford (tel 3-667916, fax 3-690007) c/o Geotechnical Control Office, 6/F Empire Centre, 68 Mody Road, Tsim Sha Tsui East, Kowloon if you would like further information on preparing papers. Please return the reply slip if you would like to participate.

Timetable

- 4 Jan 1990 - Field trip to Northwest New Territories
- 5 Jan 1990 - Field trip to marble quarry in Shenzhen
- 6 Jan 1990 - Conference at Hong Kong University

Costs

The cost of attending the conference is HK\$100, and will include the Abstracts, Bulletin and light refreshments. The cost of the field trip to the Northwest New Territories will be a nominal charge for transport and refreshments. The Shenzhen field trip will require individuals to purchase a visa (HK\$50). Transport will be arranged at low cost.

Bulletin No 5 should cost HK\$70 (members HK\$50), and Abstracts No 6 should cost HK\$20 (members HK\$20). There will be an additional charge for surface or air mail postage outside Hong Kong.

EXPERIMENTAL AND NATURAL RATES OF SUBSURFACE EROSION AND PIPING INITIATION IN WEATHERED GRANITE IN HONG KONG AND THE SUDAN

Bryan P. Ruxton

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Abstract: Chemical weathering of granite forms silt and clay from the feldspars in a framework of coarse quartz grains. At and near a free face the clay may be washed out by laterally flowing subsurface water. Experiments with weathered granite in tubes under constant head showed low eluviation after an initial flush of clay. Varying heads caused some extra eluviation. Drying and escape of entrapped air, however, gave rise to severe clay shift. With debris of bulk density of 1.84 t/m^3 channelling commenced after eight hours whereas with debris of bulk density of 1.89 t/m^3 no channelling occurred in 14 days. With debris of bulk density of 2.06 t/m^3 clay expansion burst the tube. Under steady conditions the long experiments showed final rates of about $30 \text{ ug g}^{-1} \text{ day}^{-1}$.

An example of eluviation is shown by a Han tomb buried 2000 years ago in grade VI granite at Li Cheng Uk, Hong Kong. The average rate of eluviation was $250 \text{ ug g}^{-1} \text{ year}^{-1}$. Present conditions are only wet enough for eluviation twelve days a year. A natural occurrence of lateral flushing and channelling occurs on the upper pediment at Jebel Qasim in the Sudan. Here clay is shifted at about $2 \text{ ug g}^{-1} \text{ year}^{-1}$ with activating storms occurring about every eleven years.

INTRODUCTION

Three types of subsurface erosion by circulating water have been recognised, solution or chemical eluviation, the movement of fine particles through the interstices of larger ones or mechanical eluviation, and the mass transfer of material along subsurface tunnels or piping. Lateral mechanical eluviation during temporary saturation was noted in red loams in Ghana (Charter 1949) and the Sudan (Ruxton 1958). Piping was described in alluvial bottomlands in the western United States (Fletcher et al. 1954) and from Victoria (Downes 1946). Wetting and drying and air bubbles (Crandell 1971) were said to be causative factors. Subsurface erosion has been responsible for some dam failures (Terzaghi & Peck 1948) and for some landslides (Azimi & Desvarreux 1974). Lightning strikes and thunder, have been considered as factors in subsurface instability (Hanlon 1958, Williams & Guy 1973).

Since the early work research has burgeoned (Jones 1981) but still little is known about rates of subsurface mechanical erosion and its part in the general denudation of the landscape. Mass balance methods all over the world (Alexander 1988) have quantified chemical denudation rates and observations during artificial rain have measured rates of pipe growth and collapse (Yair et al 1980).

A simple experiment has been set up to help quantify the rate of mechanical eluviation in remoulded weathered granite and twelve runs were made over a four month period. The results are compared with natural dated examples at a tomb in Hong Kong and with natural estimated rates on a pediment in the Sudan. The purpose of this paper is to attempt to tie in the rates of mechanical subsurface erosion as measured in the laboratory and in the field.

THE EXPERIMENT

The apparatus consisted of an aspirator leading to a by-pass whereby air could be passed instead of water and thence to the sample tube. The sample tube was 32cm long and 3.2cm in diameter and was sealed at both ends by 200 mesh gauze (0.076 mm). At the outlet a funnel shaped glass was installed to allow even eluviation through the mesh and a draining tube led to a beaker to collect the water and clay. Deionised water was used in the experiments.

The weathered granite used was completely decomposed with texture preserved. It had 4 per cent gravel 88 per cent sand and 8 per cent silt and kaolinitic clay. Samples with 13 per cent silt and clay were used later and gave comparable results. The granite debris was remoulded dry, damp, and wet and packed into the tube at varying bulk densities. Vacuum wetting was tried in two experiments. Individual experiments were continued for up to 15 days and the head of water was varied, airlocks passed through, and the sample shaken at intervals to simulate lightning strikes.

RESULTS

In all experiments there is an initial flush of clay tailing off to a negligible value if there is a constant rate of percolation and a constant head. The rate of clay shift increases with decreasing bulk density to 0.5g in four hours with a bulk density of 1.81kNm^{-3} (Table 1).

TABLE 1. DETAILS OF FOUR EXPERIMENTAL RUNS

	Flow rate First 400ml 1 hr^{-1}	Clay Shift $\text{g } 400\text{ml}^{-1}$	Time for Eluviation of 1g minutes	Weight Density kNm^{-3}	Head cm	Remarks
RUN A	0.179	0.504	240	1.81	75	Channelled after 500 minutes
RUN B	0.085	0.843	500	1.83	67.2	Filled dry
RUN C	0.015	0.465	12,900	1.85	137.6	Filled wet
RUN D	0.059	0.231	-	2.02	172.2	Tube burst at 812ml

Clay shift was greatly accelerated by wetting and drying, the passing of air, fluctuations of head and shaking. The results of one experiment are shown in figure 1. Figure 1 simulates common conditions in the field, the rain stopping and starting and the soil draining only to be followed by a more severe storm. The result was the formation of channels (macropores) 2 to 3mm in diameter after eight hours. Experiments C and D did not show channelling and this might be due to the higher bulk density. Similar erosion pipes were noted in experiments by Kalin (1977).

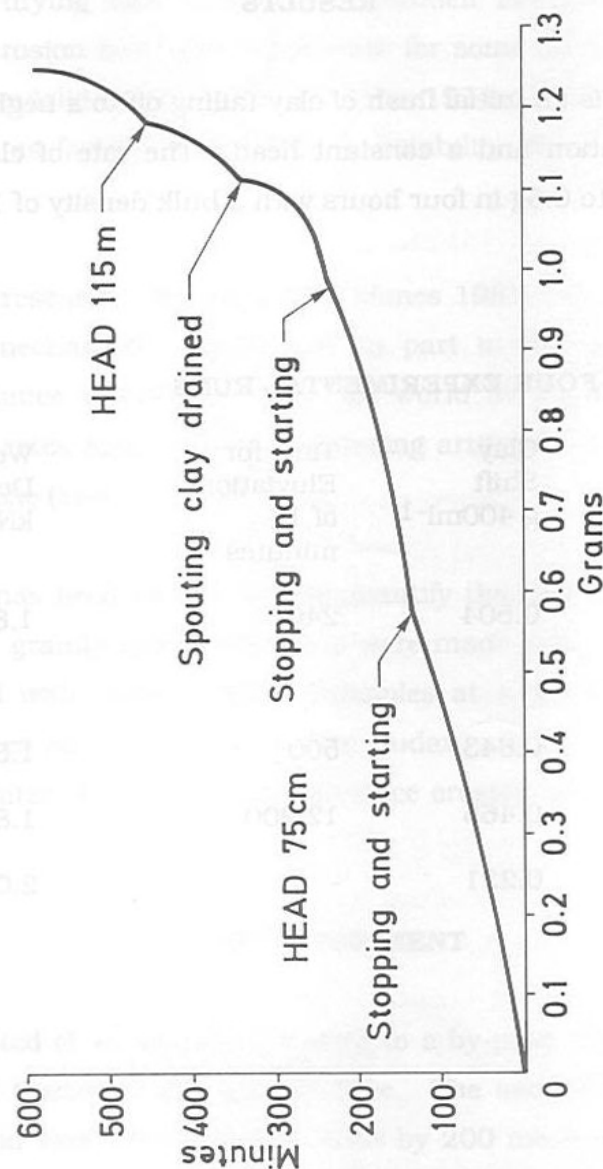


Figure 1. The results of the experiment with bulk density of 1.84 t/m^3

The rapid initial clay shift is the clay moving out of the matrix near the free face. This is common in nature too where quite small pipes flare out at their exits. The longer slower eluviation from the larger pores of the main mass leads to channelling. Matrix eluviation is active at the head of the channels (cf. Terzaghi & Peck 1948). The flow is laminar except when bubbling occurs then there is local turbulence. The slowest water flow with channelling is $3 \times 10^{-5} \text{ m/s}$ (cf Nash and Dale 1984) and the corresponding rate of air flow is up to $1.8 \times 10^{-3} \text{ m/s}$. Natural weathered granite has bulk densities of 1.2 to 1.8 kN/m^3 and all of it may pipe. In experiment D bulk density was 2.02 k/m^3 and clay shift was 13 mg/hour at 465 mg/l (Table 2). The head was 172 cm and the hydraulic gradient 10. The tube broke across the middle after 820 ml flow. Excessive clay shift blocked the flow and hydraulic fracturing occurred (Seed and Duncan 1987).

TABLE 2. BULK DENSITY, POROSITY AND PERMEABILITY OF REMOULDED COMPLETELY DECOMPOSED GRANITE

	EXPERIMENT		GRANITE COLLUVIUM HONG KONG		
	MASS DENSITY t/m^3	POROSITY %	PERMEABILITY 10^{-6} MS^{-1}	MASS DENSITY t/m^3	PERMEABILITY ² 10^{-6} m/s
RUN A	1.84	31	64.2	1.50	50-350
RUN B	1.865	30	33.7	1.60	5-20
RUN C	1.89	29	2.7	1.70	$7 \cdot 10^3$
RUN D	2.06	23	-		

1. Lai and Taylor 1984
2. Geotechnical Control Office 1982
3. Decomposed Granite (Grades IV to VI)

THE HAN TOMB

At Li Cheng Uk in Hong Kong a brick tomb 4 m high in the centre was emplaced in completely decomposed granite between 100BC and 300AD (Ruxton & Berry 1957). The bricks of the end walls were loosely fitting and over the years the fines from the weathered debris outside filtered through and filled one third of the tomb. From two tonnes of debris outside the tomb one tonne was eluviated into the tomb by micropiping and matrix eluviation. At first some coarse material accompanied the fines and the rate of shift declined with time. The average rate of clay shift is 240 to 295 ug/g/year . The process is analogous with internal piping (Sherard et al. 1963).

The seasonal rainfall in Hong Kong is 2134mm, with an average of 12.13 days with more than 50 mm rain, and the mean annual temperature is 21.60C. Usually even intense storms would not wet below 3m and so temporary saturation from perched water tables generated by the backing hillslope would probably be responsible. Such flow is unlikely to occur more than twelve days a year and so a possible rate for an active day is 22ug/g. This corresponds to the least clay shift after fourteen days in the experiments. The clay minerals are kaolin and halloysite and the kaolin averages 0.5 um in diameter.

JEBEL QASIM

Annual weeping at a concentric seepage line parallel with the hillside characterizes Jebel Qasim in the savanna of the east-central Sudan. The weeping is accompanied by a mixture of kaolin and montmorillonite clay which paints a finger-like pattern on the lower pediment clearly visible on the aerial photographs. The clay comes from the matrix and channels in the coarse decomposed granite of the upper pediment (Ruxton 1958). Sheetfloods do not occur and lateral planation is not a factor in slope retreat.

The annual rainfall is 650mm and the mean annual temperature is 28.50C. The granite has a grain size of between 3 and 6mm and is composed of 72 microcline, 24 quartz with the remainder oligoclase and biotite. The hill is 600 by 200m and stands 45 metres above the plain. A small rock cliff passes down into a 24° hillslope which flattens out into a concave pediment of slope 5-10. Mineral counts show that 3.4m granite contracts to 2.5m weathered debris with a bulk density of 1.7 t/m³. Subsurface erosion is intense by solution, lateral mechanical eluviation and micropiping. From the experiments it is suggested that eluviation was by matrix eluviation and channelling and that the channels collapsed allowing the weathered debris to contract (cf. Yair et al 1980). Several layers of collapsing pipes may occur together (Bryan et al 1978)

TABLE 3. A COMPARISON OF SIZE CHARACTERISTICS OF THE COMPLETELY DECOMPOSED GRANITES¹

	Esupon	Qasim		Hong Kong	
	Zone 11	Normal	Eluviated	Zone 11	Zone 1
MEDIAN DIAMETER mm	0.38	3.02	3.47	0.45	0.75
INMAN SORTING	2.47	-	2.50	-	-
per cent fines	8.00	18.00	4.00	33.00	35.00
PER CENT CLAY	2	2.5	1	4	17
BULK DENSITY t/m ³	1.84-2.06	1.3-2.1	Variable	1.3-1.8	

1. Some of these samples can be compared with piping soils in Arizona (Masannat 1980).

With such coarse granite debris (Table 3) the pore sizes are expected to be 1mm or more in places and readily lead to 2-3mm channels. Bigger pipes develop from the root holes of a line of trees along the seepage line and grow to at least 11m in length. They are still infilled by loosely packed quartz grains and are ephemeral disjunct pipes (Jones 1979).

During storms the aquifer on the upper pediment, some 100m in length is confined and it is estimated that the head of water will vary from 1 to 6m. The painting of the lower pediment with clay only occurs every eleven years corresponding with intense late storms. The lower pediment is furrowed and in one furrow of 6000m² it would need at least 0.25 tonne of paint to coat the surface. This is equivalent to eluviation of 23ug/g/storm from a width of 25m across the upper pediment. If the triggering storms are every eleven years then the rate of mechanical subsurface erosion is 2ug/g/year. The rate of denudation is not known at this site and other data from granite in savanna areas in Africa were examined. The lowest rate of denudation was in Rhodesia at 5.8mm/1000 years where the rain fall was 920mm (Owens and Watson 1979). To apply these figures to Jebel Qasim the loss by weathering from the original granite needs to be calculated. Ruxton (1958) used quartz as a constant and in all the sedentary samples from the upper pediment there is a loss of 61 per cent from the original rock. It was estimated that 34 per cent of this was in solution giving a granitic soil and 27 per cent was by mechanical eluviation causing a lowering of the surface. A 27 per cent loss causes a lowering of up to 0.9m from 3.4m soil which on Rhodesian figures would take 155,000 years; therefore 27g/100g/155,000 years equals 1.74ug/g/year, and this is in reasonable agreement.

DISCUSSION

1. DISLODGEEMENT OF CLAY

In the experiments clay was dislodged by stopping and starting, draining and wetting, drying and wetting, raising the head, bubbling air through and vibrations. In nature salt causes dispersion too. It has long been known that unequal wetting and the compression and release of entrapped air causes matrix disintegration (Baver 1940) and that wetting of dry clay causes microexplosions. At Jebel Qasim raising the head during intense storms and wetting and drying may be the main causative factors of dislodgement of clay (Sullivan and Koppi 1988). Wetting and Drying particularly in coarse textured mixtures, causes changes to the microfabrics (Prabowe and Chittleborough 1988). The water used in the experiments had 1ppm solids so pure water caused dispersion (Sherard & Decker 1977).

A permeability of 10^{-6} m/s has the drag force to dislodge particles 0.5 micron in diameter (Aitchison & Wood 1965) and flow at 10^{-4} m/s can dislodge particles 5um in diameter.

2. CLAY REMOVAL

The lowest mechanical eluviation rate from repacked debris in the experiments after 15 days and 14 litres of flow as 30 ug/g/day. This corresponds with an estimated 256ug/g/12 day flow from sedentary weathered debris at the tomb and 19ug/g/11 year storm from sedentary weathered debris at Jebel Qasim.

Clay shift through the matrix is confined to near the free face. In a few cases the cause was obvious as the end centimetre of the sample boiled if the tube was horizontal. Boiling was averted if the tube was inclined (cf. Kalin 1977). Pores gradually connect up to give a network of macropores (Beven and Germann 1982, Brand et al 1984) allowing clay shift to move into the mass of the soil. Some clay shift is entirely by this method (Douglas and Spencer 1985). The macropores, channels and pipes are important for debris removal (Jones 1987, Walsh and Howells 1988). The experimental channels are partly up against the glass and simulate channels against boulders in the matrix.

3. CLAY ILLUVIATION

Illuviation of clay into debris on the lower part of the slope thereby moving springs up the slope was claimed by Azimi and Desvarreux (1974) in the French Alps and was thought to cause mudflows. On Jebel Qasim the seepage line moves slowly upslope as the weathered granite becomes illuviated and compacted. In Hong Kong with high backing slopes the red loams on the footslope are illuviated laterally and have a high content of fines (up to 47 per cent), as at Li Cheng UK.

4. LANDSLIDES

Some landslides may be connected with piping and mechanical subsurface erosion (Nash and Dale 1984, Brand et al 1986). The problem is whether pipe development causes slides or whether the blocking of pipes, or pipe collapse causes landslides as in the bottle landslides of Tanzania (Temple and Rapp 1972, Lundgren and Rapp 1974). In Hong Kong landslides are caused by rainfall intensities of 70mm/hr or more (Brand et al. 1984) and with the air and water pressures involved dislodgement of clay would be high and it might block underground openings at the constrictions, as between boulders. Fragments are loosened and dislodged too and block openings. Shift of clay can be so rapid that it blocks the pores (Free, Browning and Musgrave 1940) and builds up pressure.

Some blocked pipes cause a build up of head and in some cases hydraulic fracturing results in a fan of fractures. Water floods in and if the slope is ripened a landslide occurs. Eye witness reports of blocks popping out at the initiation of landslides also testify to localised very high air or pore water pressures.

5. FOOTSLOPES

The hillfoot problem is how does the surface lower when it is covered by a layer of colluvium from the hillslope? Subsurface erosion followed by gullying in cycles answers this question. The excess water causes excess weathering and eluviation, and boiling may occur in the lower slopes (Jones 1982).

Dams are often constructed on footslopes and measures to prevent piping in earth structures are given by Aitchison & Wood (1965). Salt is neutralized and bulk density is increased.

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A NEW LOWER JURASSIC FOSSIL LOCALITY - THE SOUTH COAST OF PAK KOK SHAN, HONG KONG

K.W. Lai

Geotechnical Control Office, Hong Kong Government

The Geological Survey Section of the Geotechnical Control Office is currently undertaking the field mapping of the north coast of Tolo Channel. During this survey, marine fossil ammonites and bivalves were found along the intertidal zone of the south coast of Pak Kok Shan (5080 3915) (Figures 1 & 2).

The fossil ammonites have been identified by Mr G X He, and the bivalves by Mr J H Chen. Investigations are still continuing and more marine fossils have been found by Mr C M Lee of Hong Kong Polytechnic, Mr G X He, Mr J H Chen and Ms S Q Ng, palaeontologists from the Nanjing Institute of Geology and Palaeontology, Academia Sinica, currently in Hong Kong undertaking research at Hong Kong Polytechnic.

The stratigraphy of the north coast of Tolo Channel is shown in figures 1 and 2.

Devonian Bluff Head Formation composed mainly of greyish white sandstone with conglomerate and siltstone forms a series of low hills parallel to the northeast-trending coastline.

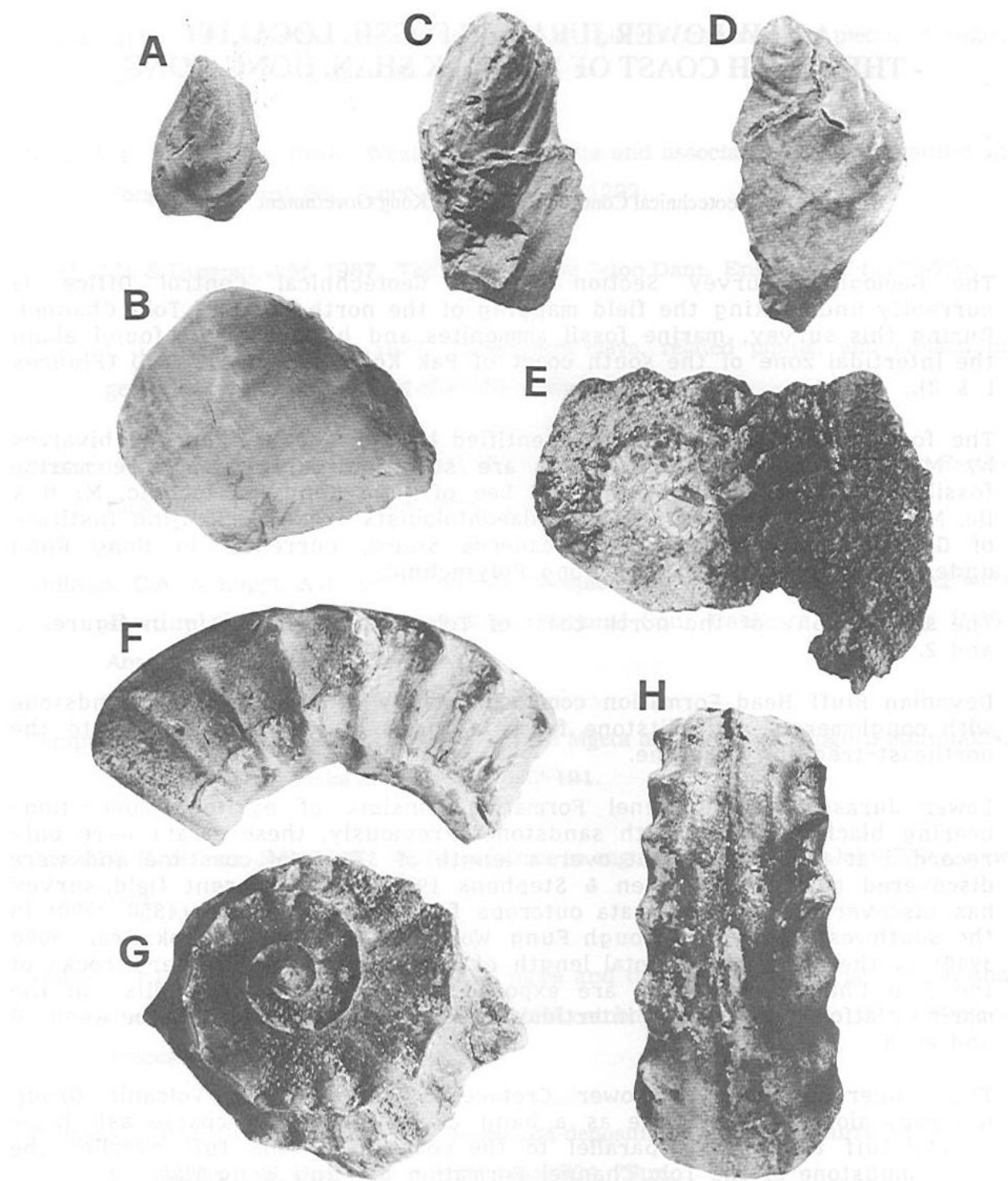
Lower Jurassic Tolo Channel Formation consists of pyritous concretion-bearing black mudstone with sandstone. Previously, these strata were only recorded at Fung Wong Wat over a length of 375 m of coastline and were discovered before 1971 (Allen & Stephens 1971). The present field survey has discovered that the strata outcrops from Wong Wan Tsai (4850 3790) in the southwest, passing through Fung Wong Wat Bay to Pak Kok Tsai (5090 3940) in the northeast, a total length of about 3 km. Sedimentary rocks of the Tolo Channel Formation are exposed at the base of the hills, on the marine platform and in the intertidal zone, with a total width of between 30 and 80 m.

The Upper Jurassic to Lower Cretaceous Repulse Bay Volcanic Group outcrops along a fault zone as a band of lapilli-bearing coarse ash lithic crystal tuff that trends parallel to the coastline. This tuff overlies the black mudstone of the Tolo Channel Formation at Fung Wong Wat.

A series of faults occur on the north coast of Tolo Channel trending NE 60° and dipping northwest at an angle of 80°. Faulted contacts mark the boundaries between the sandstone of the Bluff Head Formation and the mudstone of the Tolo Channel Formation, and between the tuff of the Repulse Bay Volcanic Group and mudstone of the Tolo Channel Formation.

Marine fossils, consisting of ammonites and bivalves, were found in the mudstone of the Tolo Channel Formation. The ammonites are *Coroniceras* sp. (Figure 3 F, G & H) and ? *Sulciferites* sp. (Figure 3E), the bivalves are *Parainoceramus matsumotoi* Hayami (Figure 3 A, B, C & D).

These fossil faunas indicate that this part of the Tolo Channel Formation was deposited during the Sinemurian Age of the Lower Jurassic.



- A. *Parainoceramus matsumotoi* Hayami, x 2.9
 B. *Parainoceramus matsumotoi* Hayami, x 2.9
 C. *Parainoceramus matsumotoi* Hayami, x 8.3
 D. *Parainoceramus matsumotoi* Hayami, x 8.3

- E. ? *Sulciferites* sp., lateral view, x 2.3
 F. *Coroniceras* sp., lateral view, x 3.4
 G. *Coroniceras* sp., umbilical view, x 3.4
 H. *Coroniceras* sp., ventral view, x 3.4

Figure 3 Fossils from the coast of Pak Kok Shan Area.

Acknowledgements

The author wishes to express his appreciation to Mr G X He and Mr J H Chen, palaeontologists of Nanjing Institute of Geology & Palaeontology, Academia Sinica, for their help in identifying the fossils, also to Mr C C Mak for his assistance in field work, collecting fossils and drawing figures. This paper is published with the permission of the Director of Civil Engineering Services of the Hong Kong Government.

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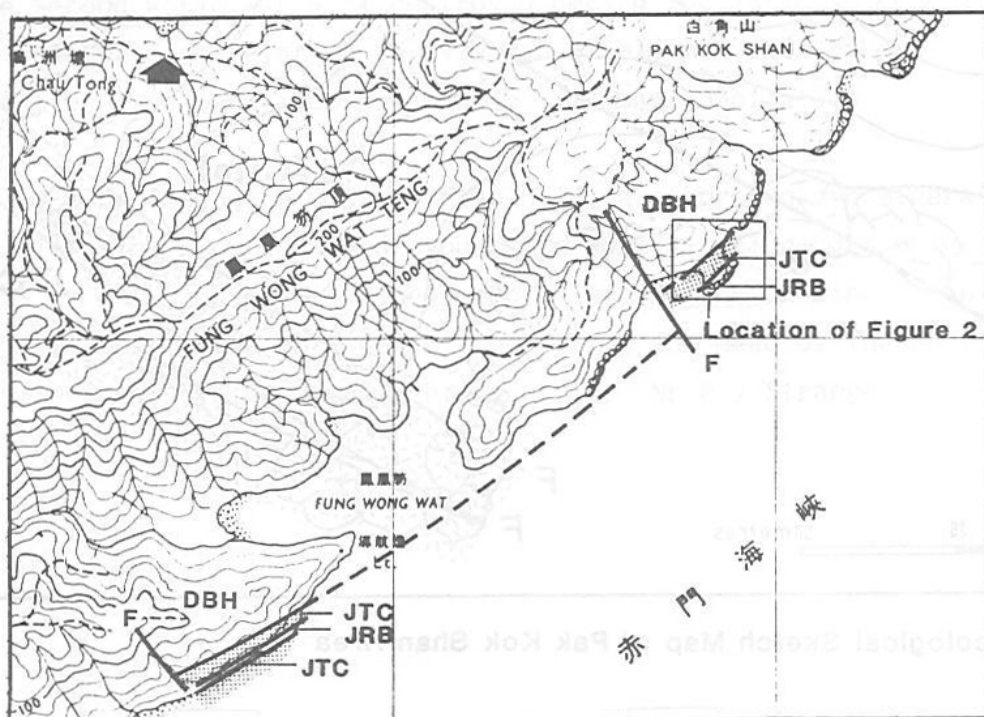


Figure 1 Distribution of Tolo Channel Formation



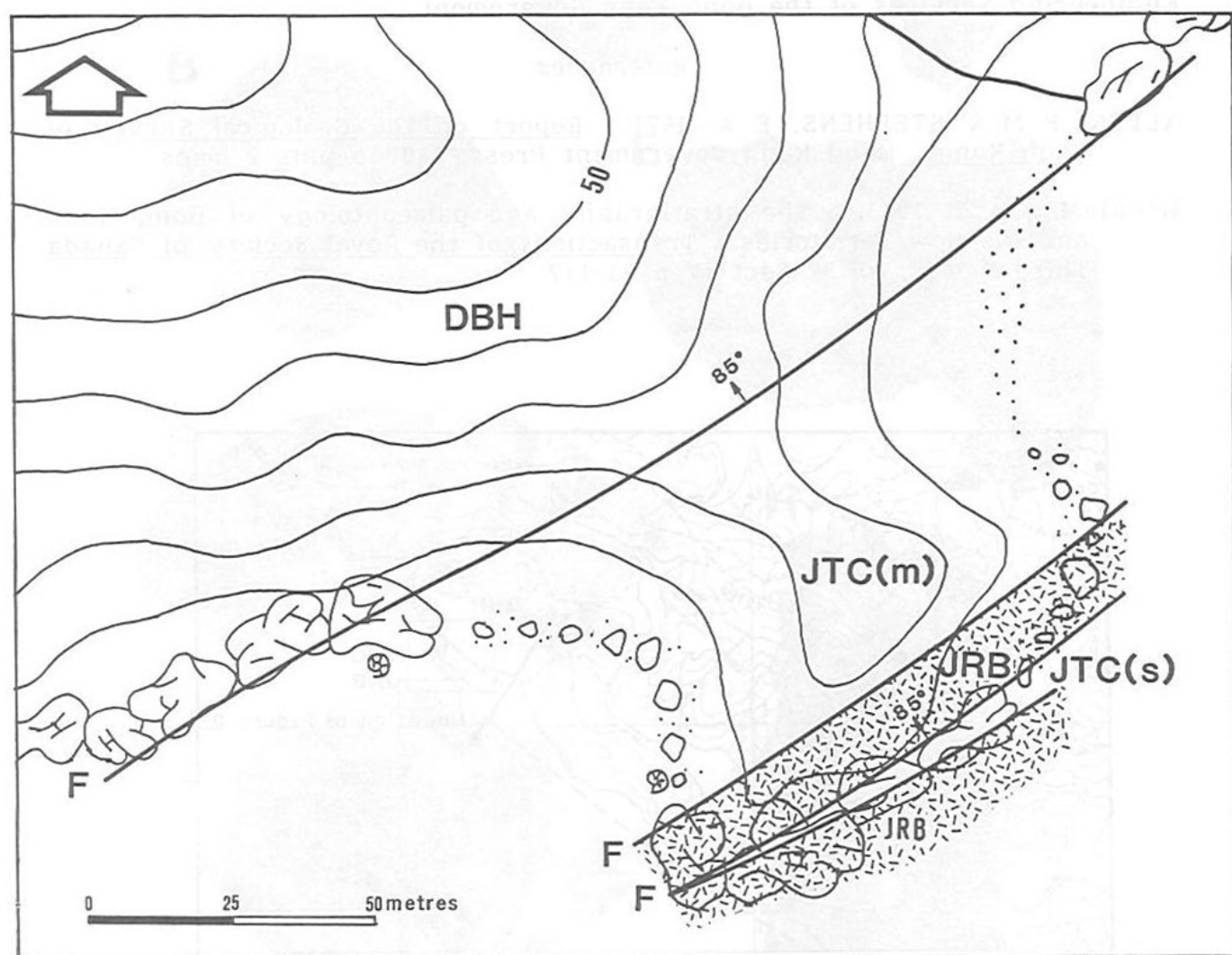


Figure 2 Geological Sketch Map of Pak Kok Shan Area

 JRB	Repulse Bay Group : tuff	 JTC(s)	Tolo Channel Formation : sandstone	 JTC(m)	Tolo Channel Formation : black siltstone
 DBH	Bluff Head Formation : sandstone & conglomerate	 F	Strike & dip of fault		Location of fossil

Figure 3 Fossils from the Pak Kok Shan Area

Mines, Mineral Prospects,
Mineral Occurrences and Quarries
in Hong Kong

The Urban Council publication "Hong Kong Minerals" by C J Peng, published in 1978, included a location map of mines, mineral prospects and quarries in Hong Kong. At the request of the Museum of History, the Hong Kong Geological Survey has prepared a new, more detailed map at 1:100 000 scale. This map is reproduced here at a reduced scale with the permission of the Director of Civil Engineering Services, Hong Kong Government.

The map was compiled by the Geological Survey in conjunction with the Mines Division, Labour Department, using Geological Survey archives and Mines Division records of prospecting licence, mining licence and mining lease applications. However, many records are incomplete, and all records prior to the Second World War were destroyed during the Japanese occupation. Field observations relating to evidence of old mineral workings and mineral occurrences have been incorporated in this map compilation.

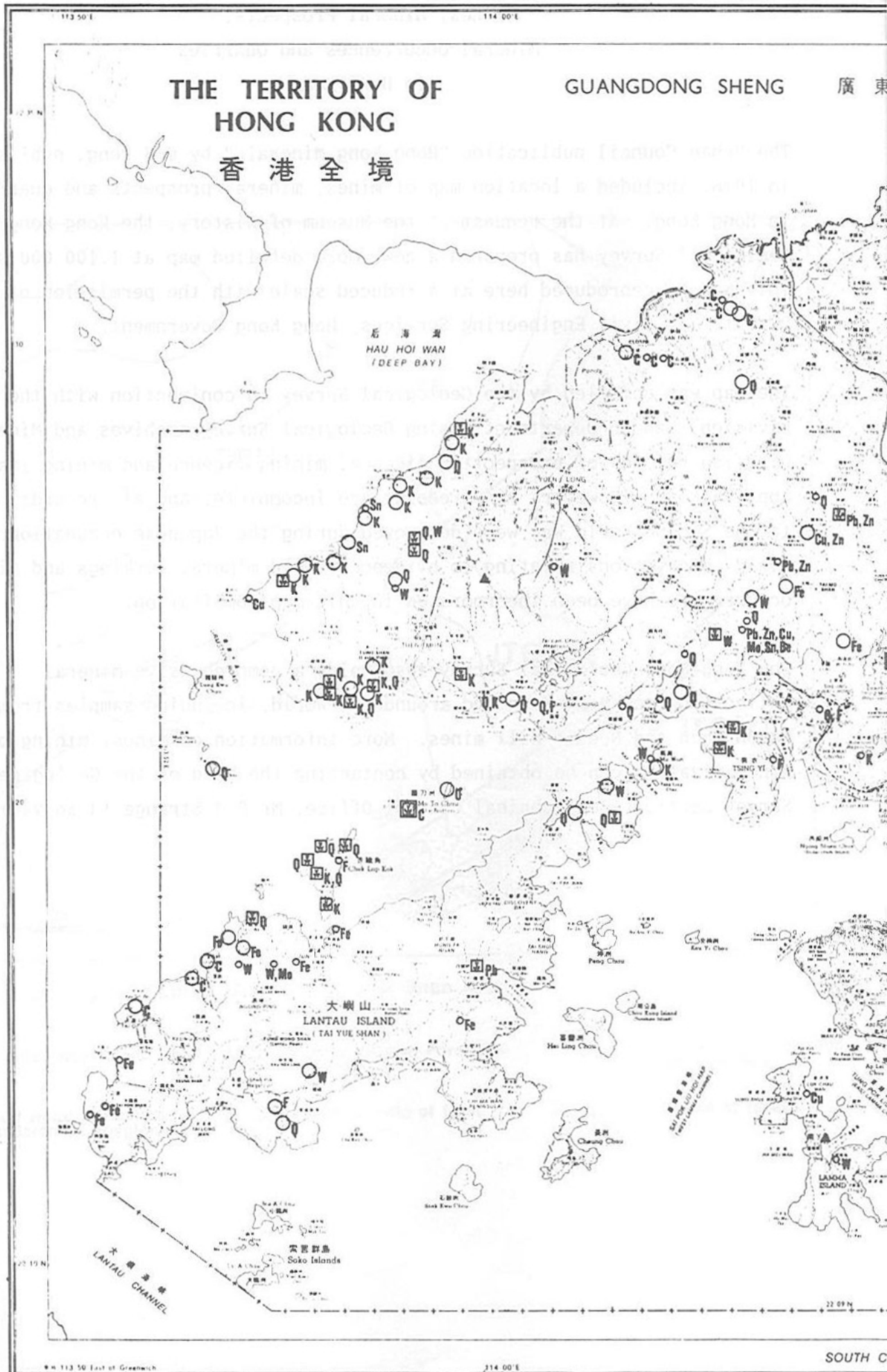
The Hong Kong Geological Survey also holds a comprehensive mineral collection from Hong Kong and around the World, including samples from the Ma On Shan and Needle Hill mines. More information on mines, mining or mineralization can be obtained by contacting the head of the Geological Survey Section, Geotechnical Control Office, Mr P J Strange (3-663946).

THE TERRITORY OF
HONG KONG

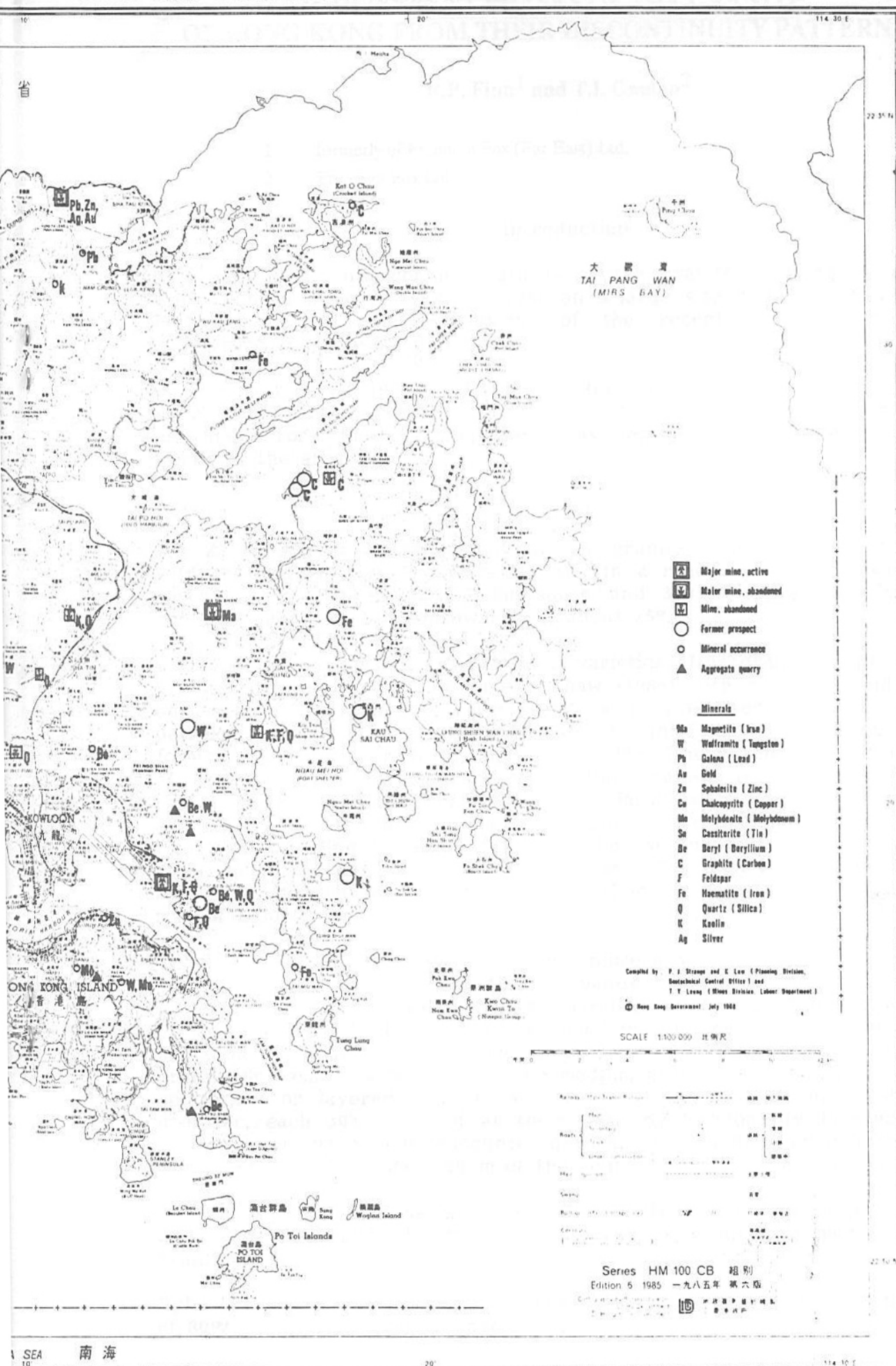
香港全境

GUANGDONG SHENG

廣東



OCCURRENCES AND QUARRIES IN HONG KONG



AN INTERPRETATION OF THE COOLING HISTORY OF DIFFERENT PHASES OF THE GRANITE OF HONG KONG FROM THEIR DISCONTINUITY PATTERNS

R.P. Finn¹ and T.I. Gamon²

1 formerly of Freeman Fox (Far East) Ltd.

2 Freeman Fox Ltd.

Introduction

This paper presents certain features of the granite of Hong Kong which were exposed between 1982 and 1986 on a large site in Quarry Bay. These features support the conclusions of the recent geological remapping programme (Strange & Shaw, 1986).

Data were derived initially from an extensive site investigation. A large volume of additional data was obtained from logging of temporary and permanent rock faces during the excavation period, and from tunnelling works in the area.

Geology

The 22 ha site is underlain entirely by granite, with the nearest contact with the Repulse Bay Volcanics exposed in a roadside quarry towards the summit of Mt Parker some 2 km south and 300 m above the site. The contact appears to dip southwards at about 25°.

The granite occurs in two distinct varieties, fine-grained and medium-grained, as identified by Strange & Shaw (1986) with petrology and texture on the site generally in agreement with this work. Some detailed petrological data are given in Table 1, and the detailed outcrop at formation level is given in Figure 1. The fine-grained granite has an average grain size of 1 mm and the medium-grained granite has an average size of 2-3 mm. The latest grain size classification (Strange, 1985) uses medium-grained to classify grains between 2 and 6 mm, and differs from that used by Allen & Stephens (1971), who use the term medium-grained to refer to grain sizes between 1 and 5 mm. For this reason the site was shown as medium-grained only on the Allen & Stephens (1971) geological map of Hong Kong.

The fine-grained granite contains numerous thin (0.1 mm) coarse feldspar/quartz pegmatites and mafic bands, usually horizontal and up to 10 m long. These could either be parallel to flow directions within the granite or parallel to the original cooling surface. Microgranite veins occasionally occur, but their relationship to contacts with medium-grained granite or basalts is not clear. The medium-grained granite rarely contains pegmatites or layered structures. A number of geodes, up to 0.5 m in diameter, each 30% occupied at their base by horizontally layered quartz and feldspar, have been encountered within the medium-grained granite at a level of +75 mPD, within 50 m of the contact between the two phases.

Four basalt dykes cross the site. Three (D1 to D3) are located entirely within the fine-grained granite, and one (D4) within the medium-grained granite (see Figure 1).

Dykes D1 and D2 are about 0.5 m thick with approximate dip/dip directions of 80°/280° and 80°/250° respectively.

Dyke D3 comprises a swarm of thin (0.1 to 0.5 m) dykes in a 2 m wide chloritised zone which persists across the entire site for almost a kilometre. The approximate orientation is $80^{\circ}/280^{\circ}$. The zone locally contains numerous granite xenoliths exhibiting closely spaced, vertical jointing which must have formed prior to dyke intrusion.

D4 varies from a single vertical 1 m thick dyke to a swarm of 0.1 m to 0.3 m wide dykes dipping at 70° , in a zone several metres wide. The strike of this dyke varies around 350° . It can be observed in a nearby disused quarry (Allen & Stephens, 1971) where it contains xenoliths of medium-grained granite and appears to be sheared at low angles.

D1 and D3 show reasonable agreement with either joint set P1 or P8 in Nau (1985), and D2 and D4 with either P3 or P6.

Contact between the fine-grained and medium-grained granite

The fine-grained granite overlies the medium-grained variety, with a gentle southward dipping contact above +90 mPD in the southern part of the site. Erosion has removed the contact above this level in the northern part of the site. Below +90 mPD the contact becomes sub-vertical, interdigitating on small and large scales, and may even be inverted. The contact is generally sharp, but can be mixed and gradational over a zone up to 20 m wide. Pegmatites in the fine-grained granite are especially frequent adjacent to the medium-grained granite where they are low angle and approximately normal to the contact. A chilled margin, where developed, appears to be more clearly formed in the fine-grained granite. Xenoliths of medium-grained granite have been observed within the fine-grained granite, generally within a few metres of the contact, and with partly reacted feldspars.

The contact does not appear to be faulted, although major joints in the immediately adjacent medium-grained granite, run parallel to it.

Discontinuity patterns in the fine- and medium-grained granite

From a previous study of the granite as a whole (Gamon & Finn, 1984) the granite appears to possess discontinuity sets perpendicular and parallel to cooling surfaces or contacts. A set at 45° to the cooling surfaces does not appear to be strongly developed, although it has been encountered in other areas. This has been supported by a preliminary study of discontinuities in the fine- and medium-grained granite at this particular location (Table 1). Joint orientations recorded in Strange & Shaw (1986) were mainly vertical with no dominant strike. Subhorizontal joints were only significant in the south-east quadrant of the 1:20 000 scale Survey Sheet 11, which includes this site area and would correspond to Set A (Table 1).

A detailed examination of the discontinuity data from this site indicates that the overall discontinuity pattern is controlled by the proximity of the overhead cooling surface against the volcanic country rock. Additional discontinuity sets are present within the fine-grained granite which appear to be related to the orientation of the contact between the two phases. Typical discontinuity sets for the medium- and fine-grained granites at the contact are presented in Figures 1, 2 and Table 1. Table 1 also gives possible equivalent sets from Nau (1985), but it should be noted that this discussion concerns one location only. Nau also suggests that only set P4 may not be tectonic. The discontinuity pattern in the medium-grained granite is unaffected by distance from the contact, but additional

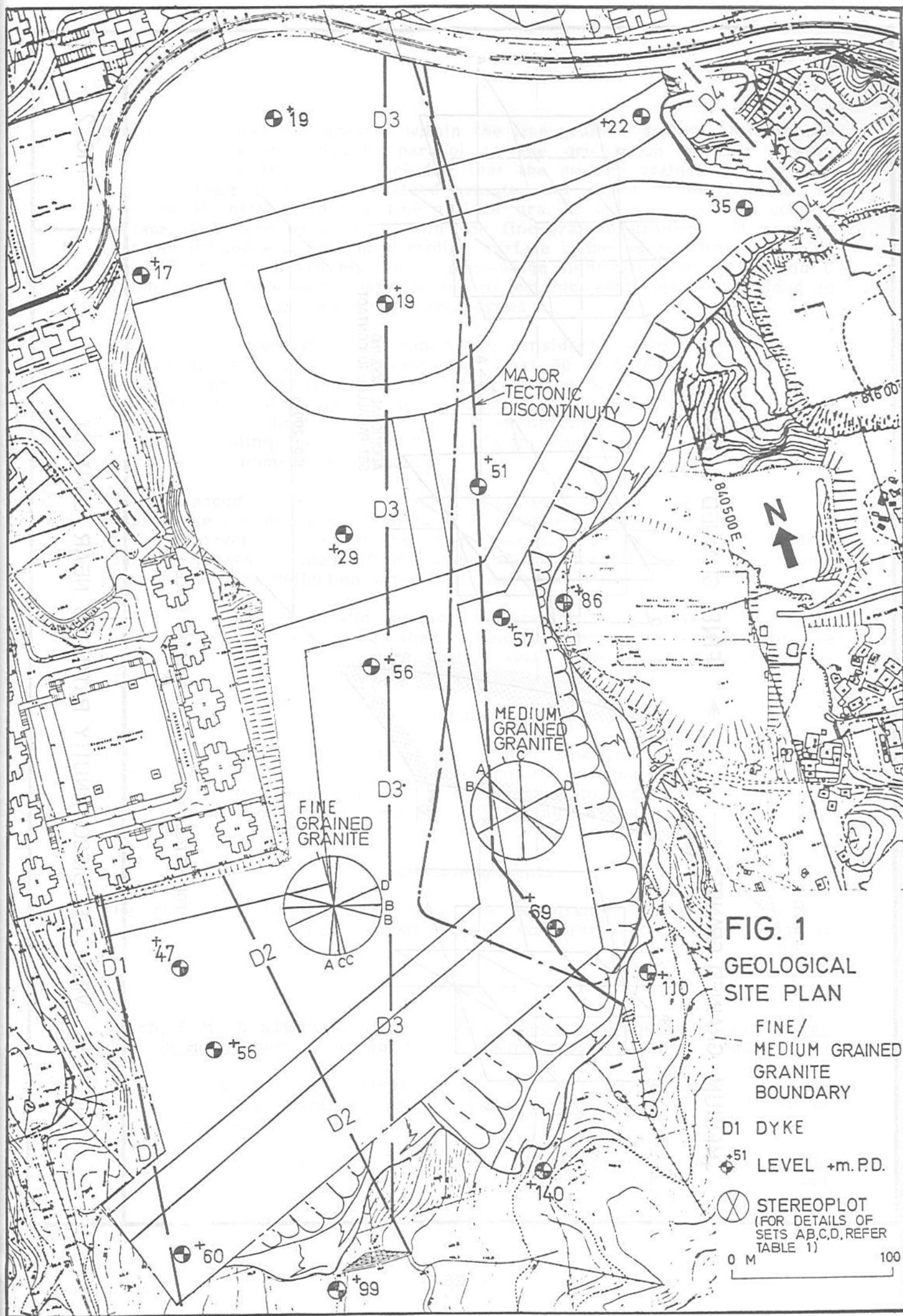


FIG. 1
GEOLOGICAL
SITE PLAN

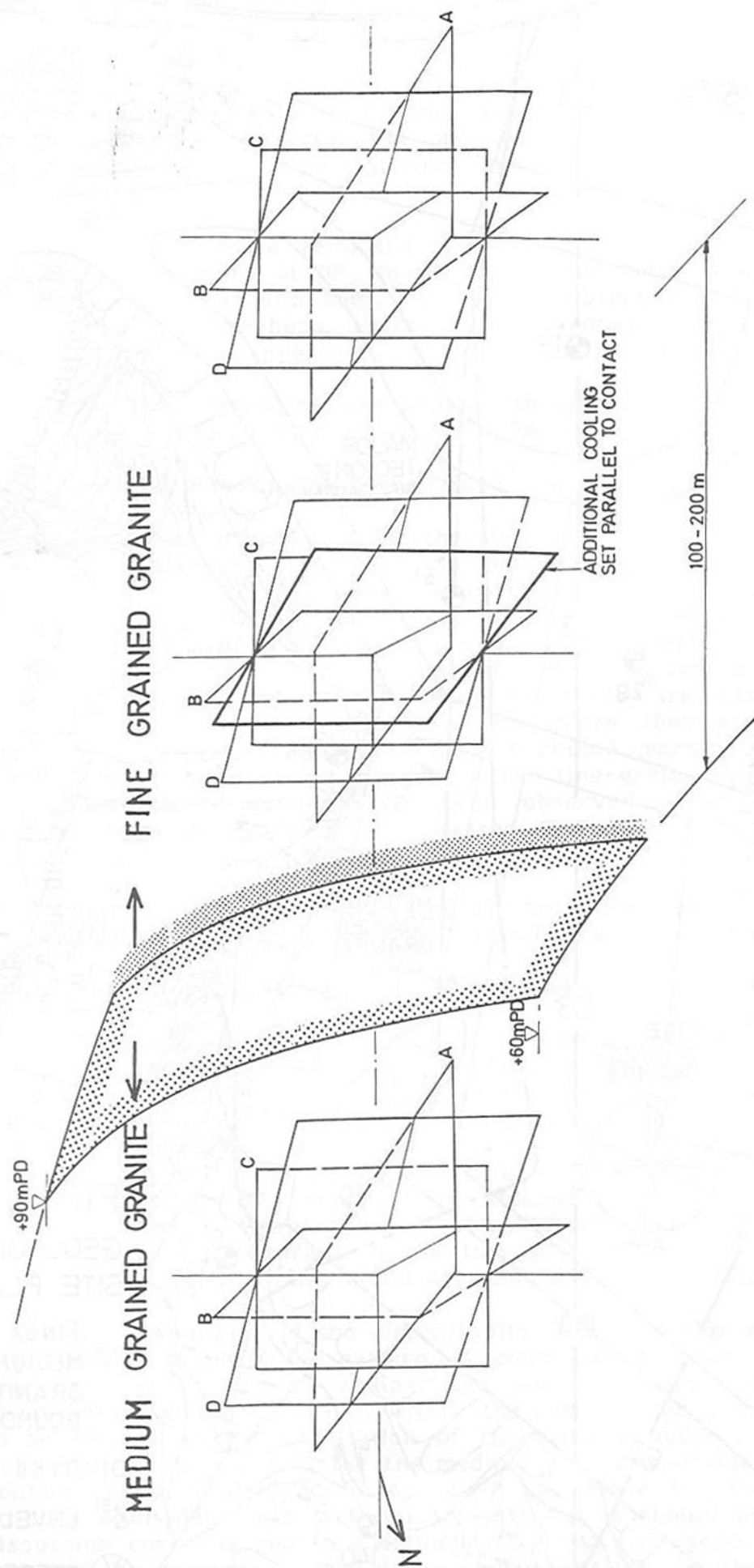
FINE/
 MEDIUM GRAINED
 GRANITE
 BOUNDARY

D1 DYKE

+51 LEVEL +m.P.D.

STEREOPLOT
 (FOR DETAILS OF
 SETS A,B,C,D, REFER
 TABLE 1)

0 M 100



(FOR DETAILS OF SETS A,B,C,D, REFER TABLE 1)

FIG. 2

ISOMETRIC VIEW OF DISCONTINUITY PATTERNS NEAR CONTACT

discontinuity sets are present within the fine-grained granite close to the contact, which are roughly parallel to the orientation of this cooling surface. It is therefore concluded that the medium-grained granite was intruded prior to the fine-grained granite, and was sufficiently cooled at the time of intrusion of the fine-grained granite to act as a local cooling surface, and form xenoliths within the fine-grained granite. It appears that the influence of this local cooling surface is limited to within 150 m of the contact. The relatively higher percentage significance of sets B and C (Table 1) in both granites may be due to tectonic joint sets being added to primary cooling sets, particularly near dykes.

The low angle sets in each granite are considered primary because they are found, often in small swarms, at least 50 m below original ground surfaces where sheeting processes may not be active. They also show little change in orientation with variation in the original topography of the site. Few true sheeting joints have been observed on this site. Typical spacing of cooling joints is 0.5 to 1 m in the fine-grained granite and 2 to 4 m in the medium-grained variety.

Closely spaced, sub-vertical discontinuity sets are developed parallel to basalt dyke D3 in zones up to 10 m wide on either side. Such zones are less well developed around the other basalts. The spacing of individual joints increases to about 10 m outside these zones. Some major tectonic joints show clear deflection where they meet the contact.

There is no characteristic surface texture or mineralisation to enable different sets to be distinguished. However, tectonic discontinuities are observed to displace low-angle cooling sets. They may also cross the granite contact or be controlled by it.

Conclusions

The field relationship of the medium- and fine-grained granite in the Quarry Bay area appear to indicate that the medium-grained granite is older. The two main tectonic trends appear to strike 010° and 350°. These trends show good correlation with Strange & Shaw (1986), Nau (1985) and Gamon & Finn (1984).

Acknowledgements

The authors gratefully acknowledge the permission of Freeman Fox (Far East) Ltd and the Mass Transit Railway Corporation to publish the data contained in this article.

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Table 1 Granite petrology and structure at Quarry Bay, Hong Kong

Granite Type:	Medium-grained	Fine-grained		
<u>Petrology:</u> (from hand specimen and thin section)				
Biotite	5%	3 - 5%		
Plagioclase	10 - 15%	10 - 20%		
Orthoclase/Microcline	15 - 60%	40 - 60%		
Quartz	25 - 60%	20 - 25%		
Accessories	10% (Pyrite not often found)	1% (Pyrite not found)		
<u>Discontinuities:</u>				
Total No. Poles (>5m persistence)	914	972	Possible equivalent set from Nau (1985)	
Major Sets dip/dip direction (% significance)	A 14°/069° (6-8% sig.)	8°/100° (6-8% sig.)	P4 11°/135°	
	B 90°/046° (>14% sig.)	88°/018° (6-8% sig.)	88°/032° (6-8% sig.)	P3a 82°/221° P3b 84°/058°
	C 80°/286° (12-14% sig.)	78°/291° (4-6% sig.)	80°/281° (4-6% sig.)	P1 74°/291° P8a 79°/270°
	D 82°/348° (4-6% sig.)	90°/354° (4-6% sig.)	P2a 84°/162° P5a 89°/360°	
A	Assumed cooling set parallel to the contact with the volcanics.			
B, C, D	Assumed cooling set perpendicular to the cooling surface with the volcanics.			
B, C	Higher significance and therefore possibly incorporating some tectonic sets.			

COMMENT ON THE SO-CALLED NEW DISCOVERY OF "SHUITOU-XICHONG CAPABLE FAULT" IN THE AREA OF THE DAYA BAY NUCLEAR POWER STATION

Liu Yixuan

South China Sea Institute of Oceanology

An article published early this year in Hong Kong (Atherton 1989) questioned the safety of the Daya Bay Nuclear Power Station. In this article one of the author's figures was cited to raise a hypothesis that the Shuitou-Xichong Fault was a "capable fault". This caused some concern in Hong Kong, so I would like to express my opinions in order to clear up relevant problems.

1 The active faults divided by the author are those faults which have been active since Neogene (22.5 million years ago). They need not be considered as faults which are active at present. They are strictly different from "capable faults" or "seismic faults". So these nouns must not be confused or exchanged when articles are cited.

2 The Shuitou-Xichong Fault is not a capable fault. It is a small fault which appears as Mesozoic fractured structure silicification and mylonitization. In the Cenozoic there is topographic contrast in some areas. But no evidence of cutting Quaternary sequences and seismic activity has been discovered. So we estimate this fault has been active since Neogene but is not active distinctly at present. We suggest it belongs to "slightly active" fault category. This kind of fault is distributed along the coast rather widely and they would not cause damage to engineering constructions.

3 Up to now no evidence of capable faults has been found in the area of the Daya Bay Nuclear Power Station (within a radius of 20 km). The author has surveyed this area in the field many times in recent years and has presided over symposiums which specially concerned the Lianhuashan Fractured Zone, structural geology and regional stability of economic developing zones along the coast. Experts inside and outside the province have paid much attention to the regional stability of the southwest segment of the Lianhuashan Fractured Zone. Many scientists have done a lot of work in this area. We have been very interested in whether faults cutting Quaternary sequences could be found. But such faults have still not been located in the field. In the southwest segment of the Lianhuashan Active Fractured Zone (including the Shenzhen fault and Haifeng faults) only three M 4.75 - 5.0 earthquakes have occurred in historical time. No strong earthquakes (M > 6.0) have occurred. So the author suggests this Fractured Zone belongs to 'weakly active' fault category. The definition of this kind of fault is different from that of capable faults (M = 6.0 strong earthquakes occur). The local experts have proved this zone, including the Dapen peninsula, belongs to the "relative stable region" from different methods and from different aspects in papers presented in symposiums. This conclusion (South China Seismological Journal, 1988, Vol 8 No 4 p 108) was recognized identically by the experts who took part in the symposium.

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ATHERTON M J. 1989. How 'safe' is Daya Bay? Hong Kong Engineer Vol 17 No 4 p 13-14. (Also Geological Society of Hong Kong Newsletter Vol 7 Part 1 p 14-15)

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M.J. Atherton replies:

We must thank Professor Liu Yixuan for taking the trouble to explain his thoughts on the Shuitou-Xichong Fault.

Professor Liu estimates that this fault is not active at the present time, but his paper suggests otherwise. I quote from his paper "Active Faults along the Coast from Pearl River Mouth to Honghai Bay":

- 1 Very weak active faults - estimated movement less than 0.001 cm/year
- 2 Shuitou-Xichong Fault - strike northwest, activity : fault scarp, dynamic metamorphic zone, earthquake
- 3 Northwest-trending faults - evolution stage - childhood
- 4 Two small recent earthquakes shown near the Shuitou-Xichong fault line

I agree that Professor Liu's paper does not suggest that the Shuitou-Xichong Fault is likely to cause a large earthquake. However, Professor Liu states in his paper that "Important structures should not be built on very weakly active fault zones". This suggests that he is worried that the Shuitou-Xichong Fault may move during the life of a structure, ie it is a capable fault. The question remains: If the Daya Bay Nuclear Power Station site is so safe, why has the seismic risk survey not been published, or at least released to Hong Kong Government?

THE INDUCED SEISMICITY AT THE RESERVOIR ON THE XINFENG RIVER, HEYUAN, GUANGDONG, AND ITS EFFECT ON THE DESIGN OF THE DAM.

In April of last year about 20 members of the Society visited the Xinfeng River dam near Heyuan in Guangdong, 150 km NNE of Shenzhen, an excursion arranged with the assistance of the Guangdong Seismological Bureau.

The dam was built in 1958-61. It is a modified concrete buttress dam, 105 m high. It was built primarily for hydropower. The powerhouse, located in midstream at the foot of the dam, has an installed capacity of 292.5 MW.

The region has a low level of historical seismicity, but is crossed by several large faults including a regional ENE-trending fault passing within 2 km of the dam (Figure 1). As the reservoir filled, starting in 1959, earthquakes were recorded in the vicinity and detailed monitoring of the local seismicity was started. The seismic activity reached a climax in 1962 and thereafter rapidly subsided (Figure 2). Monitoring continues, so that there is now a continuous record extending over 30 years.

While information about the seismicity has been published over the years (Ding et al 1982), there has been no specific published reference to its effect on the dam until recently. The following is taken from a new publication on large dams in China (Jin & Bu 1987). The photographs were taken during the visit to the dam referred to above.

According to Jin & Bu (1987) "The seismic records prior to construction indicated a basic seismic intensity at the dam site of 5 on the Mercalli scale, which was considered to have no significant effect on the structure"

First filling of the reservoir began on 20 October 1959. By the end of October 1959 the water level had risen 14 m. The first sign of possible reservoir induced seismic activity in the reservoir region was recorded at that time from distant stations. In May 1960, when the reservoir level reached approximately 81 m, three or four seismic events occurred, and the maximum magnitude was Ms 3.1. On 18 July, with the reservoir level at 90 m, a shallow earthquake of magnitude Ms 4.3 was recorded.

Because of this seismic activity it was decided to strengthen the dam by increasing the lateral stiffness (Figure 3). As the strengthening work was approaching completion a strong earthquake of magnitude Ms 6.1 occurred on 19 March 1962. The epicentre was 1.1 km northeast of the left abutment of the dam and the focal depth was 5 km. This event occurred at the high reservoir level of 110.5 m, with a maximum water depth of 91.5 m. A horizontal crack appeared in the upstream and downstream faces of the dam at about 108.5 m elevation. The crack was 80 m in length. Sustained seepage and deposition of carbonate were seen in a length of 11 m of the crack, revealing that the crack was continuous from upstream to downstream faces. Likewise there were several discontinuous cracks appearing at about the same elevation of some lefthand buttresses (Figure 4).

It was decided at this time to modify the design criteria of the dam, adopting a seismic design intensity of 10. According to these modified criteria it was found necessary to lower the reservoir level to 109.5 m in order to meet the safety requirements. The second stage strengthening included:

- . the hollow spaces between some buttresses were back-filled with concrete to one quarter of the height of the dam (Figure 3)
- . at the abutments the buttresses were reinforced with additional concrete downstream
- . at the top of both abutments 27 boreholes each 27 m deep were drilled in buttresses, each hole provided with 5 steel anchor bolts each 28 mm in diameter
- . the spaces upstream of the front shear walls were back-filled with concrete to improve the seismic resistance

A total of 230 000 m³ of concrete were added. At the contact faces of new and old concrete, careful measures of thorough chipping, cutting keys (amounting to 20% of the area) and inserting steel bolts (two 32 mm bars per m) were taken. Contact grouting was also carried out to enhance the effect of strengthening.

In March 1965 it was concluded that since the seismic activity was gradually diminishing the criterion of intensity 10 adopted earlier was somewhat over-conservative and could be lowered half a degree. Thus the reservoir level was allowed to be raised to 110 m.

The second stage strengthening work was completed in 1967. In order to provide additional capability for rapid reservoir drawdown in the case of future strong earthquakes a 10 m diameter tunnel was driven through the massive granite of the left abutment. This was completed by 1971.

By the end of 1964 the seismometers had recorded more than 180 000 microseismic events in the vicinity of Xinfengjiang dam. An additional 120 000 events have been recorded in the following 22 years and 13 000 of them have intensities greater than 2. During inspections of June 1966 a 90 m long horizontal crack was discovered at an elevation of 97 m on the downstream faces of several buttresses (it is not stated what is believed to have caused this crack, or what was done about it).

The dam has remained in normal operation despite the seismic activity.

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D.R. Workman

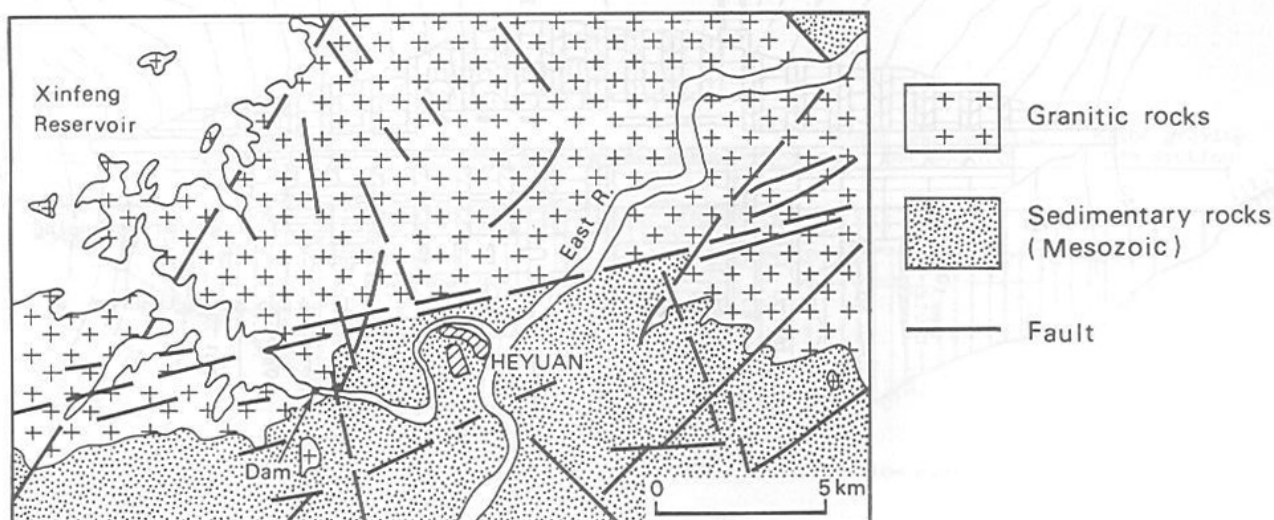


Fig.1 Simplified geological map of the area around the Xinfeng River dam

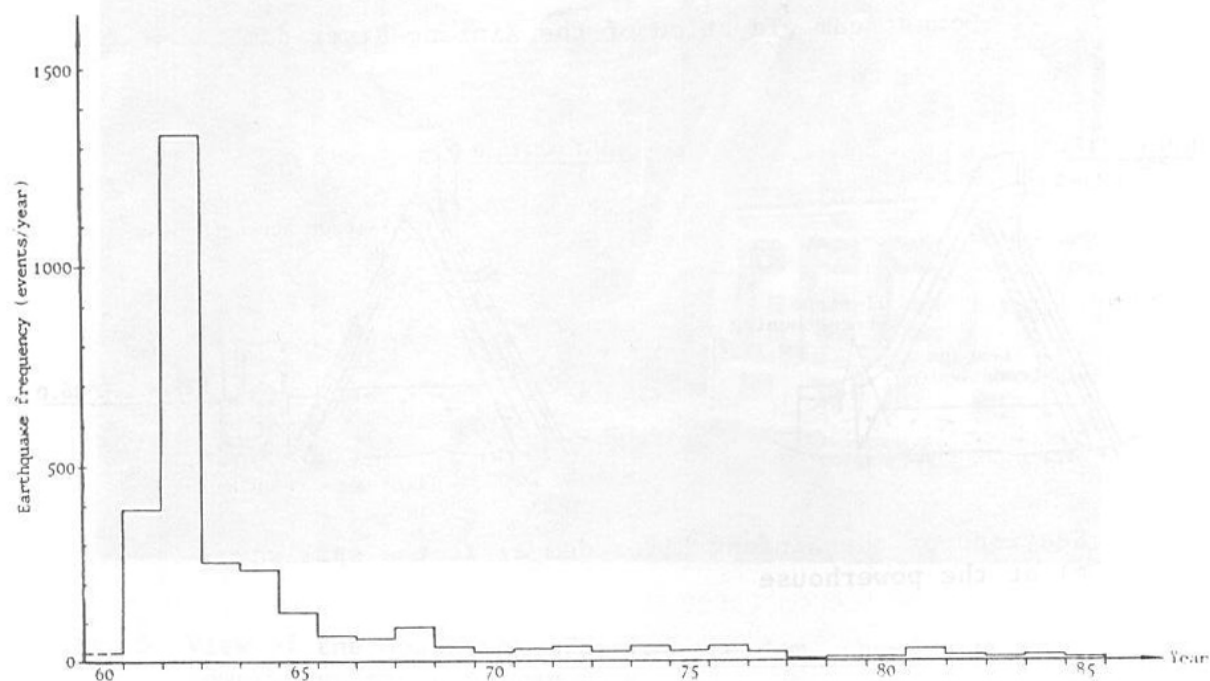
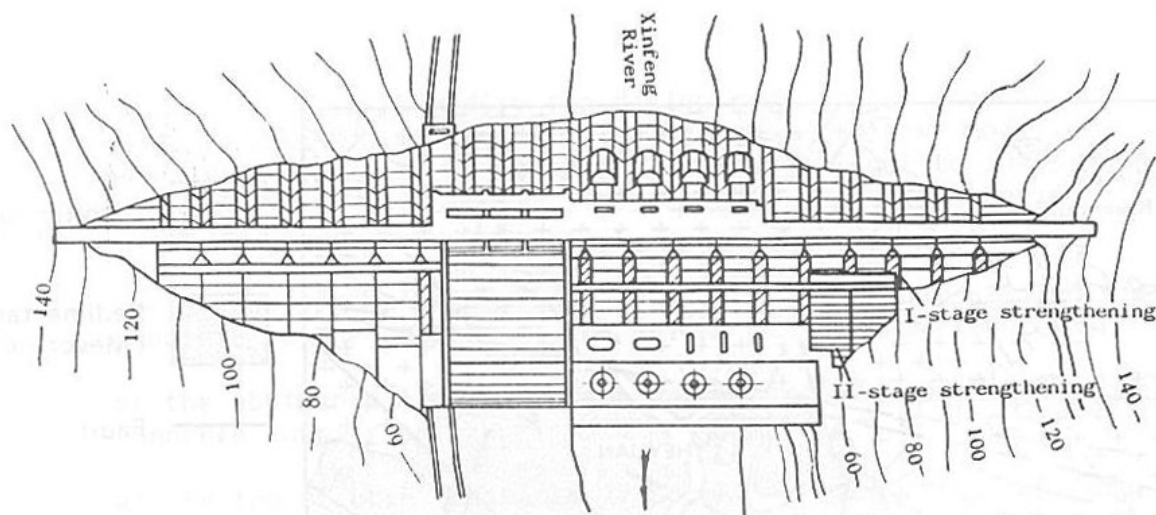
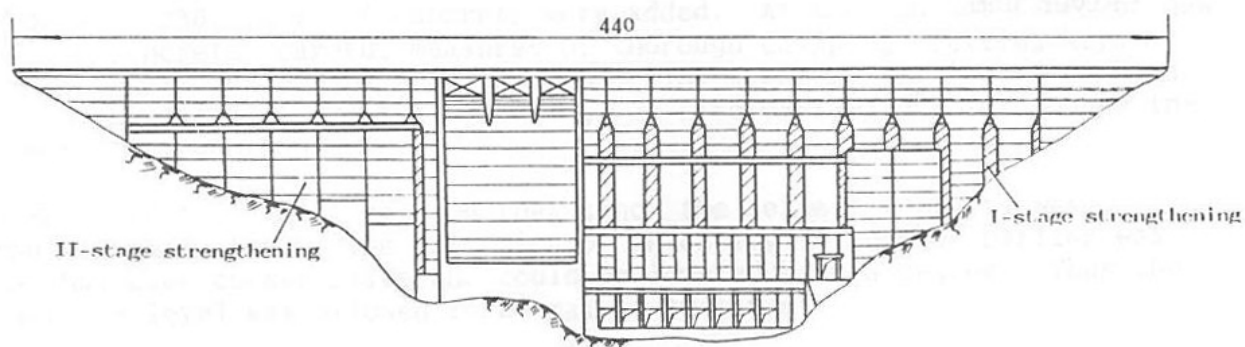


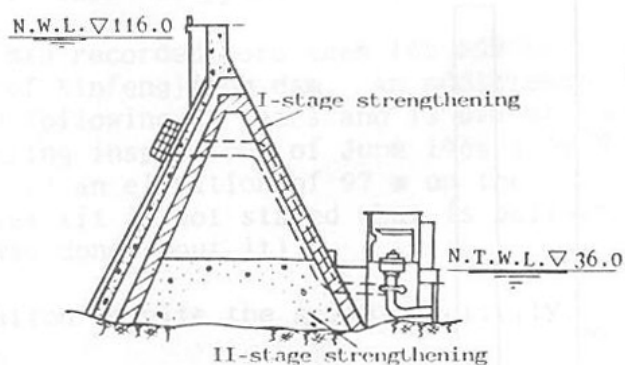
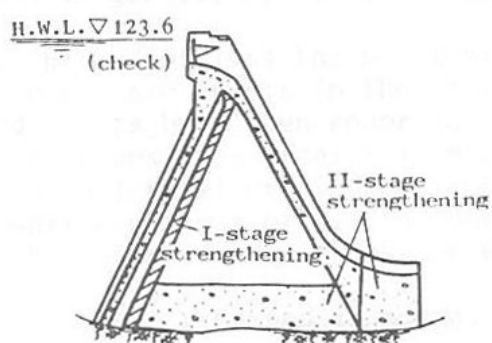
Fig. 2 Yearly earthquake frequency (including all earthquakes with M 2 except for 1960 which is for earthquakes with M 3).



Plan of Xinfeng River dam



Downstream elevation of the Xinfeng River dam



Sections of the Xinfeng River dam a) at the spillway,
b) at the powerhouse

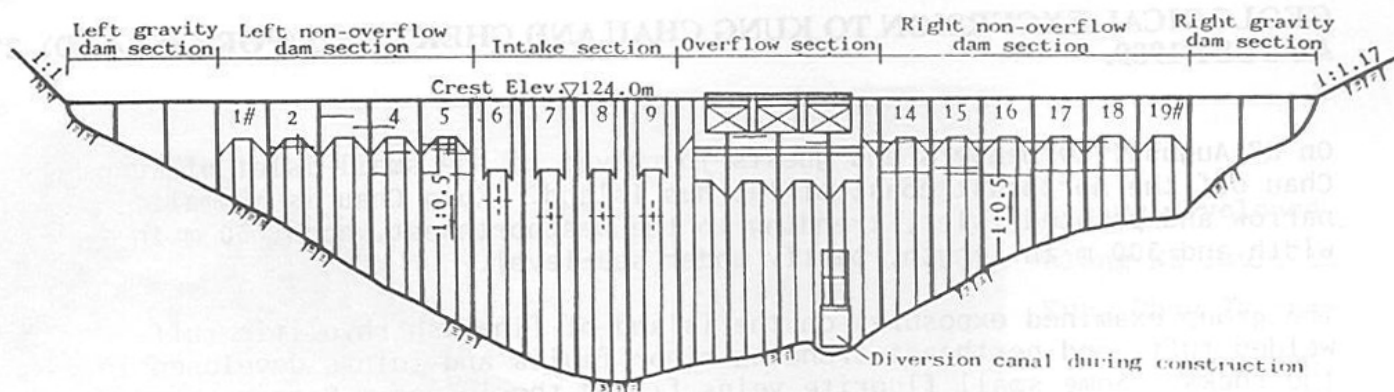


Fig. 4 Upstream elevation of the dam, showing position of cracks

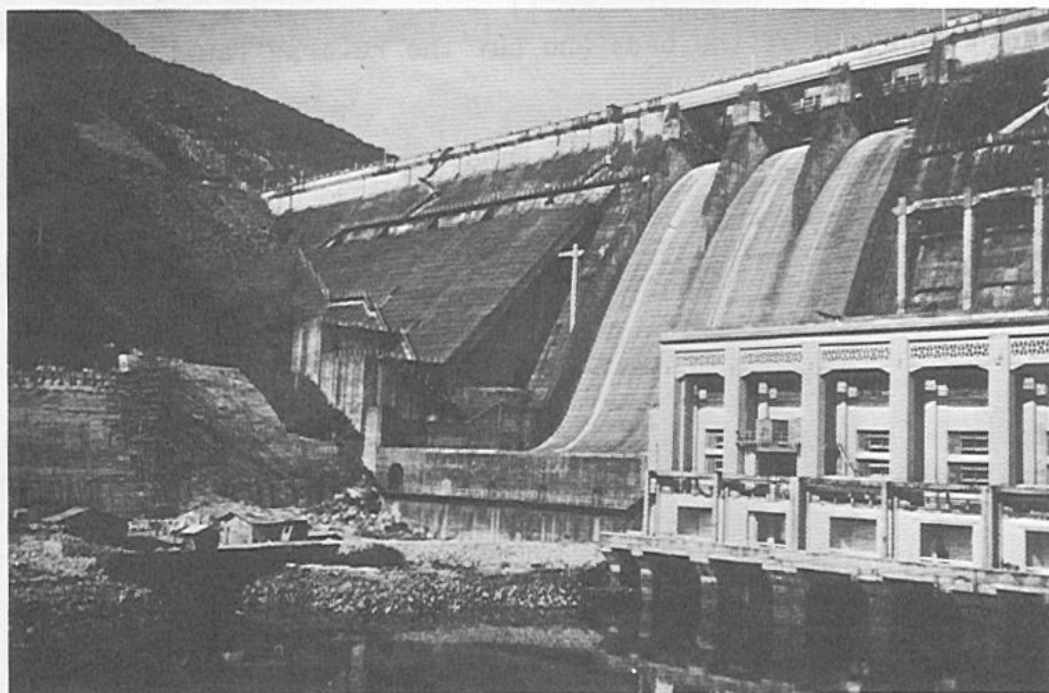


Fig. 5 View of the downstream face of the dam, showing the powerhouse and spillway.

GEOLOGICAL EXCURSION TO KUNG CHAU AND CHEK CHAU (PORT ISLAND), 27 AUGUST 1989.

On 27 August, 29 members and guests journeyed to the small islet of Kung Chau off the northeast coast of Tap Mun Island. Kung Chau is a small, narrow and pointed islet, trending to the westnorthwest, about 50 m in width and 300 m in length, partly under sea-level.

The group examined exposures on the island of fine ash rhyolitic tuff, welded tuff, and northeast-trending minor faults and joints developed in the rocks. Some small fluorite veins filled the joints. Some members were interested in collecting fluorite mineral specimens.

Red pebbles of "Port Island" sedimentary rocks were seen in a cave which is developed along a northeast-trending fault eroded by sea waves.

In the afternoon we landed on Port Island to look at the unconformity between the Repulse Bay Volcanic Group which forms the western half of the island and the overlying red conglomerates and sandstones which form the eastern half. The Port Island Formation forms a conspicuous dip slope on the eastern side. A reverse fault trending northnortheast parallel to the strike occurs on the east coast. Small normal dip faults have locally displaced the outcrop of the beds and cut the reverse fault.

C.M. Lee



Plate 1

Collecting Fluorite
mineral specimens in
Kung Chau Island

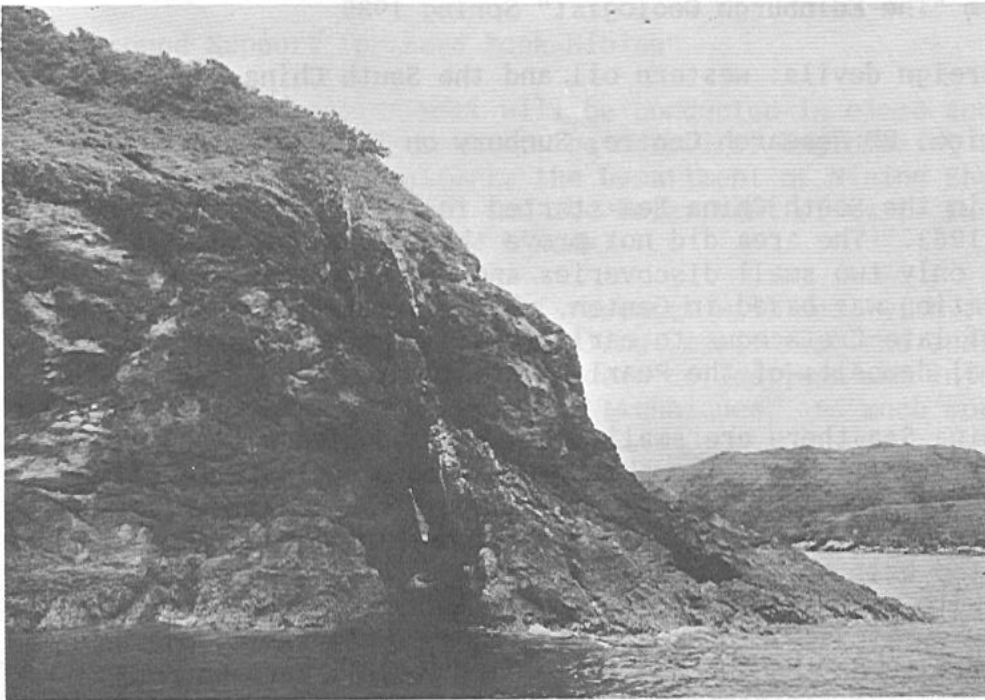


Plate 2

A cave developed along NE fault in Kung Chau Island



Plate 3

A NNE reverse fault occurred on the east side of Port Island, dipping toward WNW.

CONGLOMERATE

fragments from various sources

From "The Edinburgh Geologist" Spring 1989

Last of the foreign devils: western oil and the South China Sea

Dr I Price, BP Research Centre, Sunbury on Thames

Seismic exploration in the South China Sea started in 1979 and the first well was drilled in 1983. The area did not prove the bonanza which was originally expected, only two small discoveries and one commercial field being found. Exploration was based in Canton, which is situated in a region where hills of late-Cretaceous to early-Tertiary granites are surrounded by alluvial deposits of the Pearl River basin.

Beneath the South China Sea there are small ocean basins which are now dormant. These are rift-related half-grabens in Palaeozoic strata (mostly limestone) with late-Tertiary infills. It was thought that organic-rich lake sediments could provide an oil-source, with reservoirs in peripheral or central highs in the half grabens. These are characterised by listric faults and two sags with central doming. As the lake sediments are generally overlain by cyclic sandstones and mudstones transgressing over the continental shelf, it was thought that prospects for oil were good. However, in general the lake sediments are too coarse-grained to be potential oil sources.

(Sent in by A W Malone)

From "The British Geologist" Autumn 1989

Quote from a contribution to Regional News by the Hong Kong Group of the Institution of Geologists

"It is now virtually impossible to recruit a Hong Kong geologist in Hong Kong"

Palaeogeography of South China altered

M J Atherton

Recent discoveries of Lower Devonian rocks of marine origin in Hong Kong by the palaeontological team from the Nanjing Institute of Geology and Palaeontology, Hong Kong Polytechnic, the Hong Kong Geological Survey and Hong Kong University are likely to have far reaching effects on palaeogeographic maps of China.

The discoveries show that the boundaries of the South China Sea at that time (395 million years ago) must be extended at least 200 km eastwards to include Hong Kong. It was previously thought that the eastern shore line of this sea was to the west of Guangdong Province, and that Guangdong and Hunan provinces were mountainous at that time.

INVITATION TO JOIN
GRADUATE STUDIES IN
ROCK MECHANICS, GROUND CONTROL, MINE DESIGN

The Canadian Mining Industry has recently decide to fund a major three year research project on:

"Ground Support for Hard Rock Mining"

The related research work will be conducted in close cooperation with the Mining Research Directorate, the School of Engineering at Laurentian University (Dr P K Kaiser), the Department of Mining Engineering at Queen's University (Dr W Bawden) and the Department of Civil Engineering at the University of Toronto (Dr E Hoek).

Approximately 50 man-years of research will deal with various aspects of ground support, numerical modelling, monitoring and analysis of at least three case studies, geological data collection and interpretation for support design, special support techniques, and much more.

Special funds are alloctaed to support highly qualified graduate students up to C\$ 18 000 a year to work under the supervision of the three principal researchers at the three research centres listed below. Since research will be initiated in January 1989, those interested in pursuing graduate studies in Civil Engineering, Mining Engineering or Geological Engineering should immediately contact one of the principal investigators and submit an application to the appropriate Faculty of Graduate Studies. Students will conduct their research at one of the three centres in Kingston, Sudbury or Toronto. A strong background in geology or geological engineering, continuum mechanis, computer programming, geotechnical engineering, rock mechanics or mining is an asset but not a condition for acceptance.

For more information and application forms please contact preferably in writing with CV:

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香港早侏羅世海相化石新產地——白角山南岸

黎權偉

(土力工程處地質組)

89年6月16日土力工程處地質調查組在赤門海峽進行野外地質測量時，在白角山南岸當地漁民稱為白角仔(50803915)的潮間帶(圖1和2)發現了早侏羅世海相的菊石和瓣鳃類化石

赤門海峽北岸主要地層有：

泥盆系黃竹角組，主要是由灰白色砂岩夾礫岩和紫紅色粉砂岩形成與海岸平行的北東向山脊。

下侏羅統赤門海峽組，主要為含黃鐵礦結核的黑色泥岩夾灰白色砂岩。該地層以前只發現出露鳳凰笏南岸，全長375米，(Allen & Stephens 1971)現發現此地層分佈要廣得多，全長可達3公里，由南面的往灣仔(4845 3775)往北經鳳凰笏，直達白角仔，(5090 3925)主要分佈在山脚、浪蝕平台和潮間帶，闊30—80米。

上侏羅統淺水灣羣火山岩系，主要為灰色至灰綠色、含火山角礫粗火山灰岩晶屑凝灰岩，沿斷裂噴出地面。在鳳凰笏可見覆蓋於含菊石的黑色泥岩上。

赤門海峽北岸，出現一系列北東60°的斷裂，傾向北西，傾角85°。黃竹角組和赤門海峽組之間、和赤門海峽組和淺水灣羣凝灰岩之間均為斷層接觸，斷層走向均平行海岸方向。

海相化石發現在赤門海峽組黑色泥岩中，主要為菊石和瓣鳃類化石，亦有少量植物化石。

菊石經南京地質古生物研究所何國雄先生鑑定，為*Coroniceras* sp. (圖3F.G.H)和? *Sulciferites* sp. (圖3E)後者與香港菊石為同屬異名。瓣鳃類經南京地質古生物研究所陳金華先生鑑定為松本擬疊瓦蛤*Parainoceras matsumotoi* Hayami (圖3 A.B.C.D)。由這些化石的形成年代，說明赤門海峽組應形成於早侏羅世的Sinemurian期相當2.06—2億年前的產物。

本文承蒙正在香港理工學院進行香港古生物研究的中國科學院南京地質古生物研究所的何國雄先生和陳金華先生協助鑑定化石，麥振朝先生共同進行野外工作、採集化石和繪製插圖，並承蒙土木工程署署長批准發表本文，在此謹向他們致以衷心感謝。

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(註：所有插圖，請參閱本期英文版。)

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Cover Photograph: Carious weathering in medium-grained granite,
Southeast Cheung Chau (2223E 0745N).
Courtesy of R.L. Langford.

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