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NEWSLETTER

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Contents

GEOLOGICAL SOCIETY OF HONG KONG

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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).

Offprints: The Society does not provide authors with free offprints of items published in the Newsletter, but will obtain quotations on behalf of authors of technical articles who may wish to purchase offprints from the printer.

Cover photograph: *Broad spreads of colluvial footslopes to the south of Sunset Peak, Cheung Sha, Lantau Island. The floodplain at Pui O is in the far right.*

Geological Society of Hong Kong Newsletter, Vol. 6, pp 1-3 (1988)

Editorial comments

The editorial committee apologise for the delayed arrival of this issue. These delays have cumulated over the past three years; therefore, in order to get the Society's publications back on track both the editorial subcommittee and their products are undergoing some restructuring. Commencing from March 1989 the *Newsletter* will appear quarterly, with strict deadlines for the submission of material; the contents will therefore reflect the degree of activity of the members - so if you have any items of interest, please bring them either to the attention of a committee member, or send them to the Secretary of the Society. Items can be in either English or Chinese, but Chinese text must be submitted in camera-ready format, suitable for direct use, together with an English translation.

The *Newsletter* and the *Bulletin*

The aim of the Newsletter will be to provide a means of rapid communication with the members - the articles contained may not be subject to rigorous refereeing, but will be published as soon as possible with the aim of promoting discussion amongst members. As such, "Letters to the Editor", discussion or comments referring to published articles, or giving information on recent geological discoveries etc., will be printed in the next available issue. The Society aims to use the existing occasional publication, the *Bulletin*, as the vehicle for disseminating longer and more rigorously refereed articles. Previously, the *Bulletin* was used for the Proceedings of two Conferences and one Symposium. We anticipate that the *Bulletin* will appear approximately annually, subject, of course, to future conference schedules. When submitting articles, prospective authors are invited to state whether they would prefer their article to be used in the *Newsletter* or the *Bulletin*.

In this issue:

Bedrock structure and granitic corestones

We commence this issue with an insight into the differential effects of weathering on the development of granitic corestones on either side of faults. Mr Whiteside's paper demonstrates the usefulness of field observations when applied to engineering - this is precisely the type of article which the Newsletter and the Bulletin should be disseminating.

Use of Allen & Stephens' igneous rock classification

Following Mr Whiteside's paper, three articles are included on broadly classificatory aspects of the granitoid rocks of Hong Kong. Zircons feature in papers by Nau & Yim (pp. 11-14), and Nau (pp. 15-21), describing fission track dating and heavy mineral studies respectively. Chan (pp 22-26) has used the property of magnetic susceptibility to attempt to differentiate between Cheung Chau and Hong Kong Granites, as defined by Allen & Stephens (1971).

These papers refer to properties of the rocks and their constituent minerals which might throw some light on the problem of distinguishing between different intrusions, in time or space. Each paper makes reference to the Allen & Stephens (1971) classification of the granites as the existing basis for such a discussion, a classification itself broadly generalized and widely used, capable of being tested and accepted, modified or rejected. All three papers are preliminary in nature; they do no more than offer certain pointers but the authors have found the work of Allen & Stephens to be a convenient point of reference for their discussions.

In the new geological survey of Hong Kong currently in progress, the Allen & Stephens classification is not being used, either in its original form or modified, for reasons given elsewhere (Strange, 1985; Addison, 1986; Strange & Shaw, 1986). Mr Paul Strange, the author of the first published explanation of the classification system used for the present remapping (Strange, 1985) and now the current leader of the Geological Survey Section of the Geotechnical Control Office, has provided the following as qualifying comments on the continued usage of Allen & Stephens' igneous rock classification:

> 'The classification of the granitoid rocks by Allen & Stephens (1971) has been widely used in Hong Kong, as shown by these three articles. The revised geological survey being undertaken by the Geotechnical Control Office, has divided these rocks simply on the basis of composition (e.g. granite, granodiorite and syenite) with grain size and rock texture as qualifying descriptors (e.g. megacrystic fine-grained granite). It was considered that, from the local geology viewpoint, such a classification could readily be adopted by geologists and non-geologists alike and would allow for reasonably accurate descriptions of the rocks encountered, for example in a site investigation. A major problem with Allen & Stephens' classification has not been with the overall division of the rocks, but has been due to the misuse of the classification. For example, a borehole describing 'Needle Hill Granite' provides no rock description and in most cases would have been identified by looking at the location on the Allen & Stephens geological maps.
>
> 'In 1984 I suggested that, until most of the granitoid igneous rocks of the Territory had been remapped, it would be inadvisable to apply such names as Cheung Chau Granite. With the survey of the majority of these rocks now complete, the Geological Survey is in the position to propose a revised lithostratigraphic division of the granites. The identification of a complex series of pluton emplacements has resulted from very detailed field mapping, whole rock and trace element geochemistry and petrographical techniques. Recent advances in world-wide granite classification (Cobbing et al, 1986) has introduced new ideas, notably that of modification of a granitoid body by subsequent later intrusions. This process has been recognised in Hong Kong (Strange & Shaw, 1986), producing a complex series of "overprinting" of one granitoid on another.'

Mr Strange further notes that a summary of the proposed lithostratigraphy is under preparation, and that details of a new sequence of pluton emplacement will be revealed in the *Newsletter* and *Bulletin* during the forthcoming year.

GCO Publications: *Geoguide 3, Guide to Soil and Rock Description*, and Geotechnical Area Studies Programme Reports

The igneous rock classification used in the geological resurvey has the aim of simplifying rock description, highlighting the dominant elements of composition, grain size and texture. The use of these identifiers is exemplified by the recommended schemes given in the *Guide to Rock and Soil Description, Geoguide 3* (Geotechnical Control Office, 1988). An announcement on the publication of this guide is contained at p. 39.

Publication of the series of regional terrain evaluation reports, within the Geotechnical Area Studies Programme (GASP) series is nearly complete. Eleven regional studies are now available - further details are given on p. 40.

Contacts with other geological organisations

This Society is keen to establish, maintain, and improve our contacts with other geological societies and organisations, locally within Southeast Asia, and world-wide. Other than through personal contacts, we benefit through assistance with overseas field excursions. Two excursion reports are contained within this issue, to western Guangdong (pp 42-50), and to the Daya Bay Peninsula (p. 52). In addition, Mr K.L. Siu has visited Guilin, for the inauguration of their Geological Society (p. 41)

In a similar vein, Wyss Yim has provided a copy of the report which he presented to the 1st Asian Regional Meeting of the International Geological Correlation Programme on activities in Hong Kong. These activities are important, because they provide a framework within which our local knowledge can be fitted. The report helps to summarise the directions in which the local geological fraternity are progressing.

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Structural control in the development of granitic corestones

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(now with Geotechnical Control Office, Hong Kong)

SUMMARY During deep excavations for a basement and caisson foundations in Hong Kong, detailed observations were made of the weathering profile of the decomposed granite. A fault zone, dipping at 60°, passes through the middle of the site. The pattern of jointing appears to predate the faulting and is similar on either side of the fault, in terms of both orientation and spacing. However, the joints on the foot-wall side of the fault are very tight, while those on the hanging-wall side are open and the rock mass is very loose. On the foot-wall side of the fault, there is a distinct weathering front across which completely decomposed granite gives way to slightly decomposed granite over a short vertical distance. In contrast, on the hanging-wall side of the fault there is extensive development of corestones in varing stages of decomposition, and an overall profile similar to that described by Ruxton & Berry (1957). The development of these very different profiles is attributed to the difference in joint tightness which in turn is related to the fault. Similar looseness of strata associated with the hanging-wall of faults has been observed elsewhere in Hong Kong. Such contrasting weathering profiles may therefore be expected in other faulted locations.

Introduction

Figure 1 Plan showing location of the study area

During foundation and basement construction for the new Caritas Medical Centre in Sham Shui Po, Hong Kong (Figure 1), over one hundred hand excavated caissons were dug in order to carry structural loading to sound bedrock. In the course of these excavations, detailed records were kept, with particular attention being paid to the nature of the deep weathering of the granite.

In addition to the caissons, deep open excavations were necessary for construction of pile caps and basements, and these temporary exposures of the ground afforded a further opportunity to examine the weathering profile across the site.

General geology of the area

The original, natural ground at the site sloped about 30° to the south and was incised by a small stream.

The area has recently been geologically remapped as part of the 1:20 000 Sheet 11 of the Hong Kong Geological Survey (Geotechnical Control Office, 1986). Detailed explanatory descriptions of the geology are presented in the accompanying Memoir (Strange & Shaw, 1986).

The bedrock in the area is predominantly medium-grained equigranular, biotite granite with minor developments of fine-grained, occasionally pegmatitic, granite.

The results of a joint survey carried out in the caissons and in the open excavations, is shown in Figure 2. The jointing pattern is predominantly orientated at 60°/070° with a subordinate set at 72°/340°. Fairly flat-lying "sheeting" joints are also present. They tend to be undulating, fairly persistent, but few in number. The main, sub-vertical jointing was recorded as medium spaced (British Standards Institution, 1981), i.e. an average spacing of about 400mm and generally beween 200 and 600mm.

Figure 2 also shows the poles of a series of minor faults which cross the site. These faults are concentrated in the centre of the site, where they constitute a distinct fault zone which dips at about 60° to the east. They cross-cut and dip obliquely to the main joint set, and they commonly have 100mm or more of pale green clay fault gouge.

The granite in the area of the fault zone is hydrothermally altered and mineralised with iron and probably manganese. As a result of the alteration, the alkali feldspars are pink or orange coloured while the plagioclase tends to be bright green. These effects, which are more obvious at depth, are much more widespread on the hanging-wall side of the fault zone.

The presence of this fault zone is presumed to have dictated the position of the incised stream which originally crossed the site in the same place. The central, slightly lower part of the site was covered by up to 6m of colluvium.

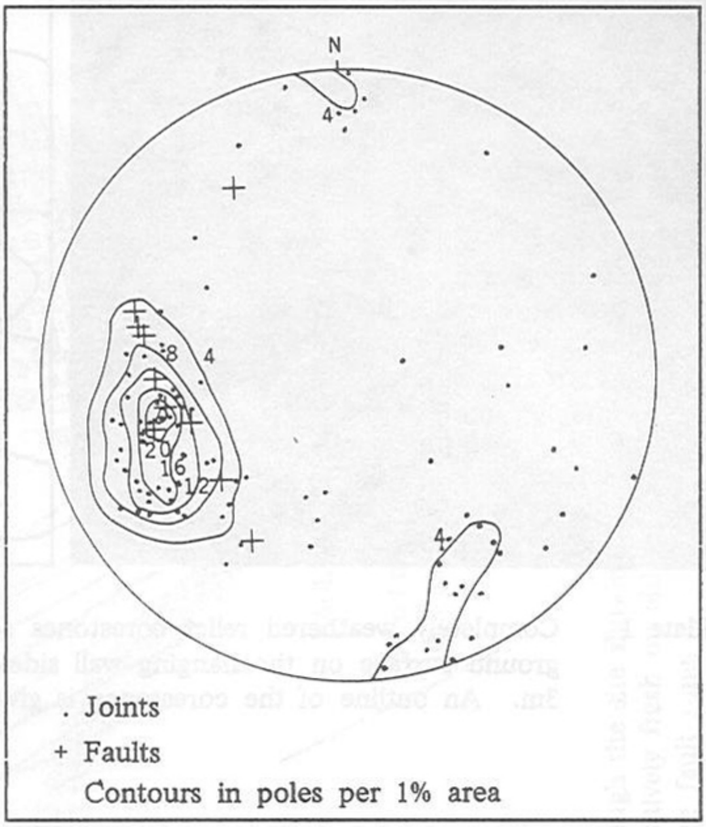

Figure 2 Contoured equal-area density plot of joint poles. Fault Poles are also shown.

Weathering profile

Three distinct weathering profiles are present within the decomposed granite. On the hanging-wall side of the fault zone, approximately 20m of decomposed granite with corestones is present, while on the foot-wall side about 12m of fairly uniformly decomposed granite is present. Figure 3 is an idealised cross-section through the site.

On the hanging-wall side, weathering is clearly centred along joints and the pattern of corestones developed exemplifies the profile described by Ruxton & Berry (1957). In the completely weathered upper portion, a regular pattern of relict corestones is still clear (Plate 1). Down the profile, these corestones become progressively less weathered (Plate 2), until almost the entire rock mass consists of essentially fresh blocks separated by weathered joints (Plate 3). This relatively fresh rock mass is however very loose, the joints being open and very permeable. It was not unusual, during excavation of the caissons, for adjacent caissons to become unintentionally linked by an open joint.

On the foot-wall side, however, there were no relict corestones observed in the completely decomposed material, suggesting that weathering had progressed through the rock mass as an overall weathering front rather than being concentrated in more permeable joints. Occasional linear features of a different colour were evident, which were thought to be relict joints. The development of this weathering front also resulted in the zone of moderately weathered rock being relatively thin; in fact there is generally a transition zone of only 1 to 2 m between completely decomposed granite and the underlying, relatively fresh bedrock. The joints in the relatively fresh bedrock are of similar orientation, spacing and persistence as those on the hanging-wall side of the fault zone but, unlike the hanging-wall side, they are very tight.

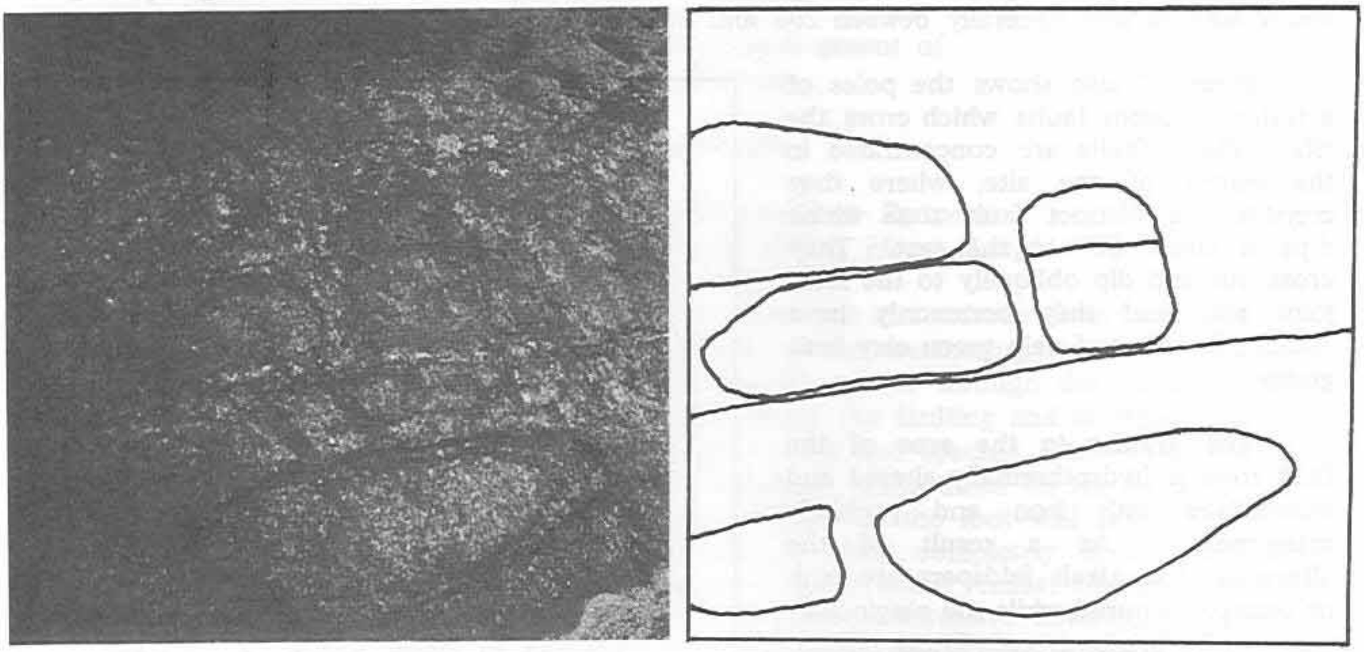

Plate 1 Completely weathered relict corestones seen in the side of an excavation at the ground surface on the hanging-wall side of the fault. The field of view is about 3m. An outline of the corestones is given in the adjacent sketch.

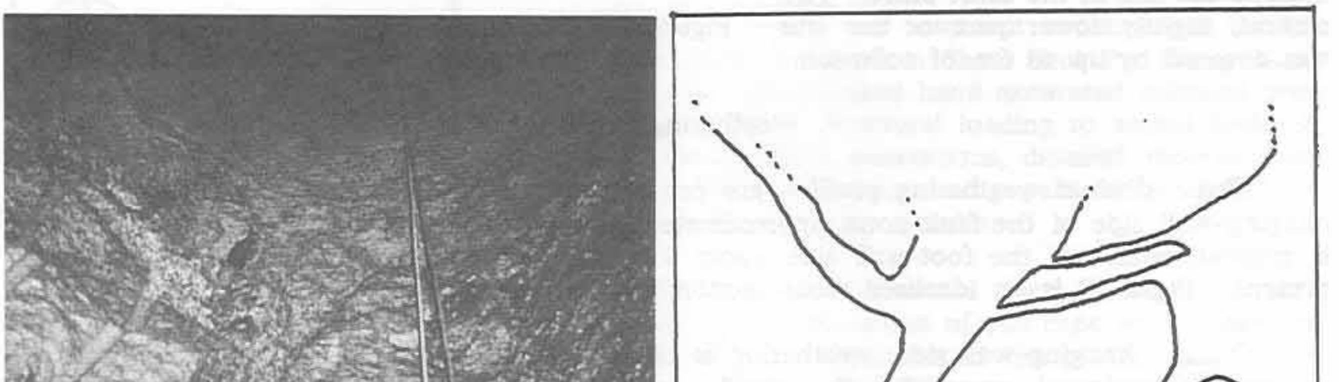

Plate 2 Corestones of fresh granite separated by bands of highly weathered granite along relict joint lines. This Plate shows the view looking up a 1.5m diameter caisson. An outline of the corestones is given in the adjacent sketch.

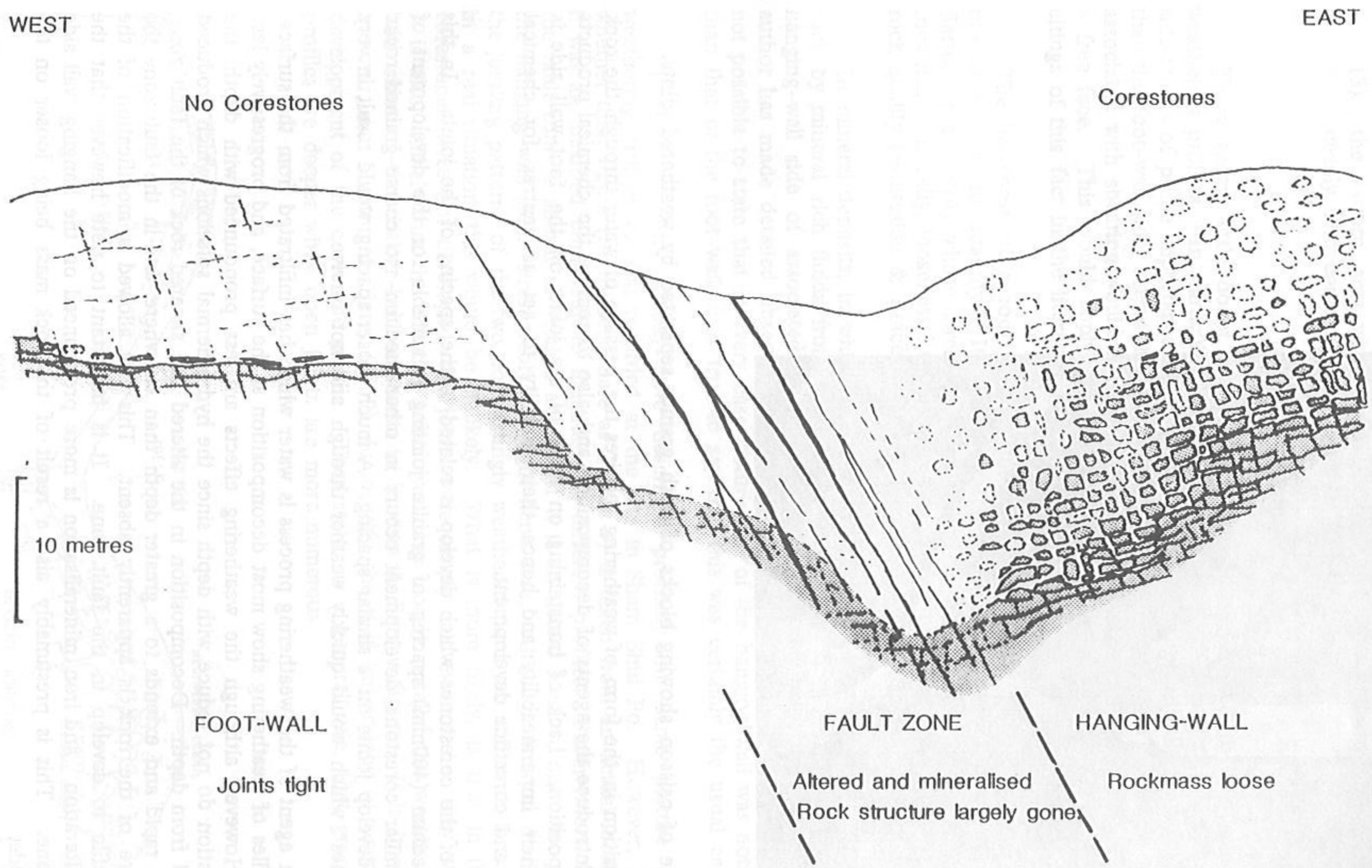

Figure 3 **Idealised, natural scale cross-section through the site showing contrasting weathering profiles. The rock shown shaded is relatively fresh on either side of the fault but moderately to slightly decomposed in the fault zone.**

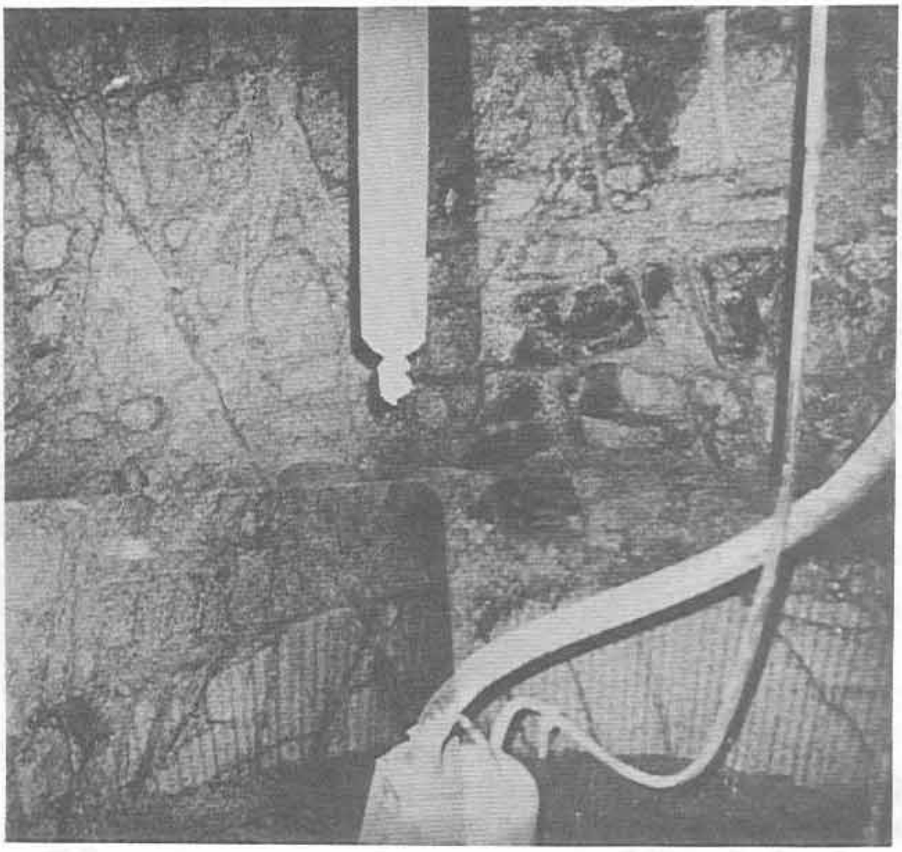

Plate 3 Base of caisson showing blocks of fresh granite separated by weathered joints.

Decomposition in the form of weathering requires the passage of water through the rock mass, both to introduce the agents of decomposition and also to remove the chemical products of that decomposition. Lack of ironstaining on most of the joints on the foot-wall side is indicative of their impermeability and hence their inability to act as centres for chemical decomposition and corestone development.

The size of the corestones which develop is related to the spacing of the joints. In this respect, the medium (400mm) spacing of granite jointing is suitable for the development of corestones. Similar corestone development occurs in other medium- to coarse-grained rocks which tend to develop joints on a similar spacing. A much closer spacing would result in very small "corestones" which would quickly weather through and not survive.

The main agent of the weathering process is water which has infiltrated from the surface. Therefore, profiles of weathering show most decomposition at the surface, and progressively less with depth. However, although the weathering effects are less pronounced with depth, the effects of alteration do not reduce with depth since the hydrothermal solutions which produced them emanated from depth. Decomposition in the altered and sheared rock of the fault zone, has been more rapid and extends to a greater depth than elsewhere, and in the fault zone the jointed structure of the rock is apparently absent. This has allowed a modification of the weathering profile to develop in the fault zone. It is important to note however that the hydrothermal alteration and iron mineralisation is more pronounced on the hanging-wall side of the fault zone. This is presumably also a result of the rock mass being looser on the hanging-wall side.

Across the site there are therefore three distinct weathering profiles:

(1) the western area with no corestones and a sharp transition from very weathered rock to relatively fresh rock,

(2) the central area where the fault zone has resulted in a structureless, more deeply decomposed profile, and

(3) the eastern area where open jointing has allowed weathering to penetrate deeply, and corestones to develop.

Discussion

There seems little doubt that the fault zone has dictated the pattern of contrasting weathering profiles. In particular, it is the looseness of the rock mass on the hanging-wall side that is of prime importance. That this side should be tectonically more disturbed (looser) than the foot-wall side, seems intuitively correct simply because any dilatancy and disturbance associated with shearing would more easily be accommodated by movement on the side with a free face. This would apply for normal, reverse or strike-slip faults. However, specific citings of this fact in the literature are difficult to find.

The looseness of a rock mass is undoubtedly an identifiable characteristic, albeit one that is difficult to quantify. Its importance in underground excavations was recognised by Barton et al (1974) whose stress reduction factor is closely related to the looseness of the rock mass. Locally, looseness has been used as one of the factors in determining underground rock quality (Whiteside & Bracegirdle, 1984).

In mineral deposits, in which mineralisation took place by invasion of fractured country rock by mineral rich fluids from depth, it is common to find greater mineralisation on the hanging-wall side of associated fractures. In many tunnel exposures in Hong Kong, the author has made detailed observations of fault zones in jointed rock masses, and, while it is not possible to state that in every case disturbance of the hanging-wall was noticeably greater than that of the foot-wall, it is true to say that this was certainly the usual case.

Ruxton & Berry (1959) have described precisely the same picture of contrasting weathering profiles as that recorded at the site in Sham Shui Po. However, it is not clear whether their figure (reproduced here as Figure 4) is taken from an actual locality or whether it was an idealised composite to illustrate the different profiles. Furthermore, in their figure, the fault zone is shown as vertical and so, if it is an actual locality, one cannot tell which is the hanging-wall side. Presumably the right hand side. Although Ruxton & Berry state that the jointing patterns of the two contrastingly weathered parts are different, it would seem that in a real situation this would be unlikely. What is more likely, is that in the area where corestones were not developed, the joints were simply not evident, i.e. they were very tight. It is also unlikely that the sheeting joints would so closely parallel the weathering surface on both sides of the shatter belt as shown in Ruxton & Berry's figure. It is important to note however, that Ruxton & Berry (1959) do identify the vital importance of open joints in the development of the corestone profile. They state, as a general rule, that granitic weathering profiles are deeper when open joints are more numerous.

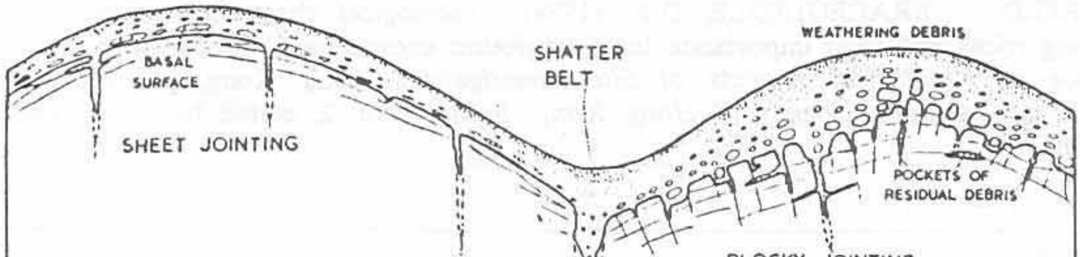

Figure 4 Contrasting weathering patterns. Taken from Ruxton & Berry (1959).

Conclusions

Where jointed rock masses are subsequently cut by faulting, the hanging-wall side of the fault is usually noticeably more disturbed than the foot-wall side. The joints on the hanging-wall side tend to be open and the rock mass loose, while those on the foot-wall side are closed and the rock mass tight.

Granite corestones develop when a loosely jointed rock mass with moderately spaced joints, weathers. In a very tightly jointed rock mass there are no preferential paths for percolating water to penetrate and so a sharp weathering front develops.

In granitic areas which are traversed by faults, corestones are more likely to form on the hanging-wall side of the fault than on the foot-wall side. This could have implications for many construction sites in Hong Kong.

Acknowledgements

The observations and conclusions in this paper were made while the Author was working for Scott Wilson Kirkpatrick & Partners on a project for Caritas Hong Kong. The permission of Caritas Hong Kong, to publish details of the site is gratefully acknowledged.

The Author would like to thank Dr L.J. Endicott for very useful site discussions on the relationship between the jointing pattern and the corestone development.

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Geological Society of Hong Kong Newsletter, Vol. 6, pp 11-14 (1988)

Fission track dating of zircons from granitoid rocks of Hong Kong

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Introduction

Radiometric age determinations using conventional K:Ar and Rb:Sr methods on a number of granitoid rocks in Hong Kong was first carried out by Chandy & Snelling (in Allen & Stephens, 1971). Based on the results obtained, the granitoid rocks of Hong Kong were attributed to five phases of intrusive activity by Allen & Stephens (1971, Table 1). The aim of this short note is to report the results of fission track age determinations of zircons separated from selected granitoid rocks of Hong Kong and to examine briefly their significance.

Table 1 Summary of geochronological data of granitoid rocks in Hong Kong

Sequence of intrusion in Hong Kong (Allen & Stephens, 1971)	Phase	Geochronological data (from Chandy & Snelling)		Fission track age (Ma)	
		Whole rock Rb:Sr age (Ma)	K:Ar age (Ma)	Melbourne University	Guiyang Institute of Geochemistry
Dolerite	5		76±2 62±2 57±2 63±6		
Needle Hill Granite	4				
Hong Kong Granite	4	140±7	117±3		41.5±5.8 42.6±4.1 57.7±6.4
Quartz Monzonite Dyke Swarm	3				
Ma On Shan Granite	2				
Cheung Chau Granite	2	163±35	134±4	89.9±6.3	68.5±6.3
Sung Kong Granite	2		130±3 134±3		88.6±6.3
Tai Po Granodiorite	1		134±2	103.1±5.7	

Sampling and method

During 1981, at the request of Professor J.F. Lovering, University of Melbourne, three samples of fresh granitoid rocks were collected by P.S. Nau, from the Hong Kong Granite, Cheung Chau Granite and Tai Po Granodiorite of Allen & Stephens (1971). Although all three samples were sent to Professor Lovering, zircon crystals were separated only from the two latter samples for fission track dating, while the first sample was not zircon-bearing. The two dated samples are a medium-grained Cheung Chau Granite (sample FT2, Grid Reference KV12455870) (Figure 1). Fission track dating was carried out by the external detector method (EDM).

In 1985, zircon concentrates were separated from insitu highly to completely weathered granitic rocks from the localities FT3, FT4, FT5 and FT6 (Figure 1). Laboratory techniques used in the concentration of zircon include panning, heavy liquid and electromagnetic separations. The latter was carried out with a Frantz Separator, using a side and forward slope of 25° and 15° respectively, and a current setting of 1.5 amps. Five zircon concentrates (Table 2) consisting of euhedral and transparent zircon were sent to the Guiyang Institute of Geochemistry, Academia Sinica, for fission track age determinations by EDM.

Details on the theory and application of fission track dating have not been included here but may be found in Fleischer et al. (1975).

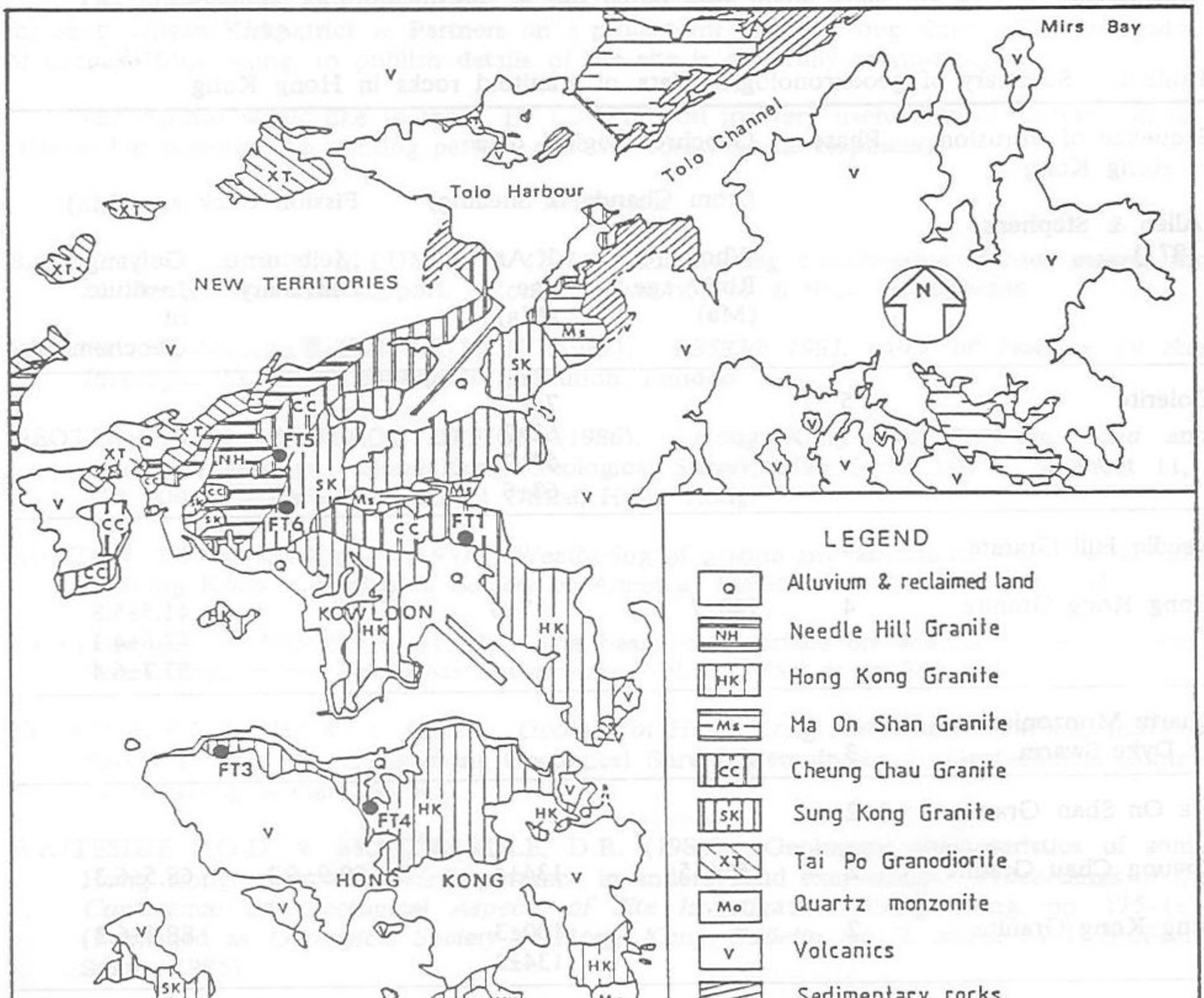

Figure 1 Simplified geological map (after Allen & Stephens, 1971), showing sample localities.

Fission track dating results

The fission track age of zircons obtained for the Cheung Chau Granite and the Tai Po Granodiorite are 89.9±6.3 Ma and 103.1±5.7 Ma respectively (Table 1). However, the age of the former is unreliable because the small number of zircons obtained was considered to be unsuitable (J.F. Lovering, personal communication). Unfortunately, other analytical details are not available.

Table 2 shows the results of the zircon samples separated from the residual soil of granitoid rocks. For the three samples of Hong Kong Granite, the ages range between 41.5±5.8 Ma and 57.7±6.4 Ma with a mean apparent age of Ca. 47.3 Ma. The sample of Cheung Chau Granite (FT 5) gave an older age of 68.5±6.3 Ma while the sample of Sung Kong Granite (FT 6) gave the oldest age of 88.6±6.3 Ma.

Table 2 Fission track dating results of zircon samples separated from residual soil of granitoids in Hong Kong

Sample No.	Rock type and grid reference	Spontaneous tracks		Induced tracks		Neutron flux	Age (Ma)
		Number counted	Density (t/cm^2)	Number counted	Density (t/cm^2)	Φ (n/cm^2)	
FT3a	Medium-grained Hong Kong Granite	485	1.5×10^6	528	3.26×10^6	1.38×10^{15}	41.5±5.8
FT3b	KV04766710	225	1.52×10^6	625	8.46×10^6	3.62×10^{15}	42.6±4.1
FT4	Medium-grained Hong Kong Granite KV09006535	1257	4.39×10^6	918	6.42×10^6	1.38×10^{15}	57.7±6.3
FT5	Medium-grained Cheung Chau Granite KV06457645	1747	5.15×10^6	3054	17.82×10^6	3.62×10^{15}	68.5±6.3
KT6	Coarse-grained Sung Kong Granite KV06677465	1772	3.37×10^6	879	3.44×10^6	1.38×10^{15}	88.6±9.5

Discussion

The zircon ages obtained are likely to provide an indication of the timing of initial post-intrusion cooling of the granitoids. In the present study, no evidence of ages exceeding 103.1 Ma have been found. The oldest age in sample FT2 is regarded as a confident age relating to the time of cooling of the parent magma through about 200°C (J.F. Lovering, personal communication).

Previous radiometric age determinations of granitoids in Hong Kong by Chandy & Snelling (in Allen & Stephens, 1971) are summarized in Table 1. These authors suggested that the cooling of the granitic rocks, as indicated by K:Ar ages on biotite, occurred at about 135 Ma. Therefore there is great discordance between fission track ages and the K:Ar and Rb:Sr ages. The time of cooling for the Hong Kong Granite, the Cheung Chau Granite and the Sung Kong Granite as indicated by the mean apparent zircon ages is 65, 40 and 34% respectively too young. On the other hand, the time of cooling for the Tai Po Granodiorite is indicated by the single zircon date to be closest to the K:Ar age of 135 Ma, even though it is still 24% younger.

When discordance exists between fission track ages and those obtained by radiometric methods, the fission track ages are in most cases younger (Fleischer & Price, 1964a and 1964b; Nagpaul & Mehta, 1975). This is accounted for by track fading due to thermal annealing. Laboratory experiments have shown that zircon will lose all fission tracks when heated to 720°C for a hour or to 380°C for 1 million years (Fleischer et al., 1965).

The young zircon results found in the present study may be explained by subsequent heating events of late intrusive activities causing the fission tracks in zircon of the older intrusion to be partially lost. Consequently, the zircon age of the older intrusion is reset, becoming younger than the real age. Therefore, it is possible that the times of cooling of the granitoid rocks as indicated by zircon ages are younger in comparison to the K:Ar ages.

Conclusions

The two main conclusions drawn are:

(1) Discordance exists between fission track ages and ages obtained by other methods used by Chandy & Snelling (in Allen & Stephens, 1971). In order to determine whether the zircon dates are reset by late intrusive events, further fission track dating on sphene and apatite as well as zircon should be carried out.

(2) In spite of the younger absolute ages obtained by the fission track method, the sequence is in general agreement with that of Allen & Stephens (1971). Zircon ages also indicate that the Tai Po Granodiorite cooled first, followed by the Sung Kong Granite, the Cheung Chau Granite and the Hong Kong Granite.

Acknowledgements

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Heavy mineral assemblages of some granitoid rocks in Hong Kong

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Introduction

Plutonic granitoid rocks (mainly granite and granodiorite) in Hong Kong constitute a large part of the Upper Jurassic terrain. Allen & Stephens (1971) have reported the accessory minerals of the granitoid rocks to include zircon, iron, apatite, epidote, orthite, pyrite and carbonate.

The aim of this study is to examine the heavy accessory minerals in weathered granitoid rocks in Hong Kong. The heavy accessory minerals of the Specific Gravity (SG) >3.3 fraction in the weathered granitoid rocks have been found to include magnetite, ilmenite, zircon, monazite, xenotime, sphene, cassiterite, wolframite, thorite, pyrite and limonite. Apatite, epidote and orthite reported by Allen & Stephens were not detected in this study. Zircon and probably magnetite and ilmenite are ubiquitous minerals. Other heavy minerals are less abundant or rare. Cassiterite is in high content in the named Needle Hill Granite.

Rock description

Igneous activities in Hong Kong have been named geographically by Allen & Stephens (1971). In this study, the named granitoid rocks concerned include the Tai Po Granodiorite, Sung Kung Granite, Cheung Chau Granite, Hong Kong Granite and Needle Hill Granite.

The coarse- to medium-grained granodiorite is composed of plagioclase, K-feldspar, hornblende, biotite and quartz. All the named granitic rocks are similar in lithology, with the main constituents composed of K-feldspar, plagioclase, quartz and biotite. Grain size of the granitic rocks range from fine to coarse. The Sung Kong Granite is coarse-grained. The Cheung Chau and Hong Kong Granites are medium-grained. The Needle Hill and part of the Hong Kong Granite are porphyritic fine-grained (Allen & Stephens, 1971).

However, as there are no great differences between the named granitic rocks, the above-named nomenclature of the granitoid rocks has not been adopted recently, and instead, a revised classification scheme for the granitoid rocks based simply on grain composition and size has been used (Addison, 1986; Strange, 1985; Strange & Shaw, 1986).

Field and laboratory procedures

Altogether, ten samples were collected from the localities shown in Figure 1. Five were collected from the Hong Kong Granite, two from the Needle Hill Granite, and one from each of the Cheung Chau and Sung Kong Granites and the Tai Po Granodiorite.

Hand samples were collected from highly to completely weathered granitoid rocks, in which the texture of the original rock was preserved, for ease of crumbling. In the sampling, mineral veins were avoided. After crumbling by hand, the heavy accessory minerals of the sample were pre-concentrated by means of panning.

In the laboratory, the pre-concentrated heavy minerals were passed through a permanent magnet to separate the ferromagnetic grains. The remainder was then passed through a Frantz isodynamic separator with the forward and side slopes of the vibrating chute set at 15 and 25° respectively. The field currents were set at 0.5, 1.0, and 1.5 amps to obtain different heavy mineral fractions with corresponding electro-magnetic properties. Heavy liquid separation using methylene iodide with a specific gravity of 3.30 was applied to separate minerals with S.G. of less than 3.30 (which were found to be mainly quartz and mica). Heavy minerals obtained were examined microscopically. For the confirmation of cassiterite, the zinc dish test was employed. Each fraction with a mixture of heavy minerals was finally treated by picking out particular mineral grains under the microscope to obtain a pure portion of that mineral, which was weighed using a chemical balance.

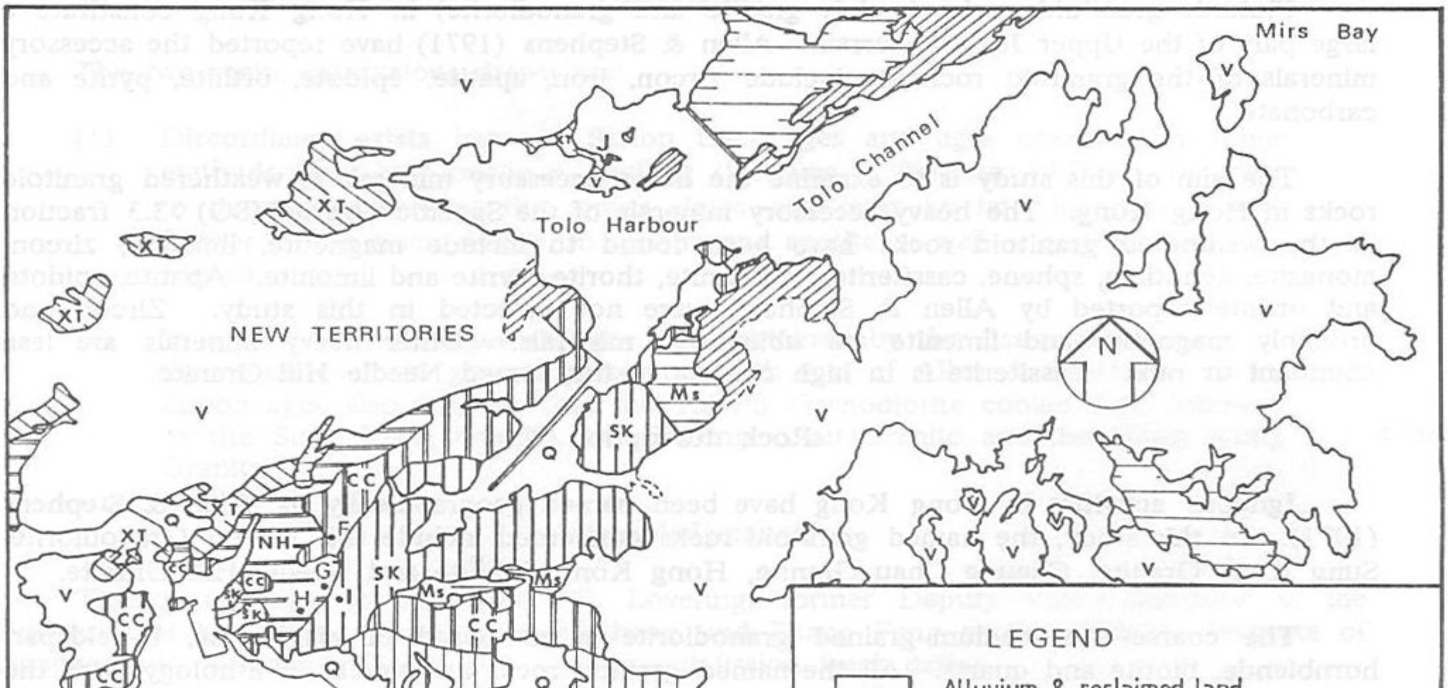

Figure 1 Simplified geological map (after Allen & Stephens, 1971), showing lithology and sample localities

Table 1 Percentages (by weight) of heavy accessory minerals of the S G >3.3 fraction

Description of sample	Sample	Magnetite	Ilmenite	Zircon	Monazite	Xenotime	Sphene	Cassiterite	Wolframite	Thorite	Limonite	Pyrite	Total weight (in grams)
Medium-grained Hong Kong Granite	A	93.30	0.310	0.440	5.820	0.008	0.110		0.0176		0.0044		4.5430
	B	96.65	0.703	0.380	1.940	0.065				0.25			0.9238
Porphyritic fine-grained Hong Kong Granite	C	93.24	6.160	0.171	0.428		trace						0.2339
	D	11.17	46.810	3.190	31.380	5.320	1.600		0.5320				0.0188
	E	56.56	24.300	0.860	17.850					0.43			0.0465
Medium-grained Cheung Chau Granite	F	36.39	14.800	48.520	0.135	0.135		trace					0.0742
Porphyritic fine-grained Needle Hill Granite	G			30.600				61.22	8.1600				0.0049
	H	5.13	0.860	11.960		0.860		41.88	25.6400	3.42	10.250		0.0117
Coarse-grained Sung Kong Granite	I	74.12	21.080	4.790	trace							trace	0.0313
Porphyritic coarse-grained Tai Po Granodiorite	J	71.85	5.390	20.960	1.200	0.600							0.0167

Results

Heavy mineral assemblages of the ten samples and weight percentages of the heavy minerals in the assemblages are given in Table 1. Distributions of the heavy minerals are far from uniform between samples.

Magnetite -occurs abundantly in samples A, B and C, with weight percentages over 90%. In other samples it is less abundant. Samples G and H contain little or no magnetite.

Ilmenite -occurs as irregular fragments or flattened octahedra, ranging in size from 0.1 to 0.5mm. Usually there is much less illmenite than magnetite. However, ilmenite is 4 times more abundant than magnetite in sample D, but it is absent from sample G.

Zircon -has been detected in all the samples and occurs in mainly three types:

(i) transparent colourless,

(ii) transparent to semi-transparent to semi-transparent buff (sometimes with an orange tint), and

(iii) translucent orange-yellow.

The former two are dominant in most of the samples, but in samples G and H, the translucent variety is dominant - about 3 times more than the other two. Most of the zircons are sharp euhedra. Some are fragmented. A few grains in samples D and H are slightly rounded-prismatic. Simple dipyramidal crystals are common. Crystals showing complex terminations were also detected in the samples A, E, F and J. Average length/breadth (L/B) ratio of zircon in the ten samples ranges from 1.8 to 2.8 (Table 2). It is evident that the zircon in granite has an average L/B ratio around 2.0, while the L/B ratio of zircon in granodiorite approaches 3.0. Zircon contents of the samples vary greatly, from less than 1% (samples A, B, C and E) to about 50% (sample F).

Monazite -occurs in most of the samples, but not in samples G and H. It is brownish to reddish yellow and orange-brown, semi-transparent to translucent. Average grain size of euhedral and fragmented monazite is around 0.4mm.

Table 2 Elongation of euhedral zircon in granitoid rocks

Sample	A	B	C	D	E	F	G	H	I	J
Average length	0.147	0.130	0.071	0.101	0.065	0.210	0.148	0.100	0.16	0.30
Average breadth (mm)	0.069	0.059	0.032	0.054	0.037	0.084	0.078	0.050	0.09	0.11
Average length/breadth ratio	2.070	2.400	2.180	1.980	2.210	2.620	2.060	2.090	1.80	2.80
No. of zircons measured	53	59	1	42	26	50	20	51	30	50

Xenotime	-The transparent to semi-transparent xenotime is brownish yellow, orange-yellow or yellow in colour. It occurs in the forms of pseudo-octahedron and tetragonal-bipyramid. The latter form is similar to that of zircon. However, xenotime separates in the electro-magnetic fraction and zircon in the non-magnetic fraction. Weight percentages of xenotime in the samples are commonly less than 1%.
Sphene	-transparent and yellow in colour, sphene is rare in the samples. It was only observed in a few samples in small amounts.
Cassiterite	-a pneumatolytic mineral, occurs abundantly in samples G and H (Table 1), where it is deep brown to dark brown. Cassiterite is also present in sample F, but is reddish brown in colour, similar to the cassiterite detected from the beach sediment at Pak Nai, Castle Peak (Yim & Nau, 1981). All cassiterite grains are translucent, fragmented or subhedral. Average grain size is around 0.4mm.
Wolframite	-a pneumatolytic mineral present in the 0.5 amp fraction, is black in colour with translucent thin edges showing red. The wolframite grains, displaying tabular or wedge forms with striated prisms, are mostly subhedral and partly fragmented. The average grain size is around 0.15 by 0.25mm. Wolframite was detected in only four samples. In samples G and H containing abundant cassiterite, a high content of wolframite was present. In samples A and D, which contained no cassiterite, wolframite was present in small amounts.
Thorite	-rarely found in the samples. The fragmented and subhedral tetragonal thorite grains are translucent and orange to orange-red in colour.
Pyrite	-only one grain of pyrite was observed, in sample I.
Limonite	-Limonite is a weathering product which might be derived from the iron-bearing minerals. It was found in only two samples with its proportion having a considerable range.

Discussion

The study of heavy accessory minerals along cannot furnish conclusive evidence for correlating igneous rocks (Reed & Guilluly, 1932; Spotts, 1962). However although the heavy mineral assemblages may be affected by many factors (contamination, volatile content .... etc.), comagmatic igneous rocks should possess heavy mineral assemblages with many points in common, for example colour, shape, grain size, inclusions, proportion .... etc. (Groves, 1930). So, to say the least, heavy mineral studies may provide some useful clues for classification of igneous rocks.

In this study, the heavy accessory minerals examined include magnetite, ilmenite, zircon, monazite, xenotime, sphene, thorite, cassiterite, wolframite, pyrite and limonite. The first seven of these minerals are primary stable or rather stable heavy minerals which crystalise from magma at an early stage of cooling. The next three minerals are pneumatolytic minerals which are believed to be formed from magma at a later stage of cooling. Limonite is a weathering product caused by surficial weathering. However, although the samples were collected from weathered granitoid rocks, no more secondary minerals were detected, and the assemblages themselves may represent the unweathered granitoid rocks.

Zircon, magnetite and ilmenite are almost ubiquitous, notwithstanding that the latter two only occur in nine of the ten samples. Monazite and xenotime, although not ubiquitous, are fairly common. The other minerals are rare or absent from most of the samples.

Samples, A, B and F were collected from medium-grained granites. Samples A and B are remarkable for the similar development of the heavy minerals (magnetite, ilmenite, zircon, monazite and xenotime) in proportion. Outstanding characteristics of these two samples are the high contents of magnetite (over 90% by weight). Sample F may be distinguished from samples A and B by its high zircon content, which approaches 50% by weight, and more ilmenite, but less abundant magnetite and monazite. It also contains scarce cassiterite, which was not found in samples A and B. For the reasons mentioned above, it is suspected that the named Hong Kong Granite represented by samples A and B, and the named Cheung Chau Granite represented by the sample F, are not closely correlated. However, the heavy mineral data of a few samples are not conclusive.

Five samples, C, D, E, G and H were collected from fine-grained porphyritic granite. Obviously, samples G and H have similar heavy mineral assemblages. Both samples are characterised by the presence of cassiterite and wolframite in high or rather high percentages by weight, and by the presence of low magnetite contents (ranging from zero to around 5%) in contrast with all other samples. Three samples, C, D and E, contain little or no cassiterite or wolframite (except that sample D contains a small amount of wolframite), and also low zircon contents (ranging from less than 1% to around 3%) in contrast with samples G and H. On the other hand, in samples G and H, there is about 3 times more translucent zircon than transparent to semi-transparent zircon. On the contrary, in most samples (samples A, B, C, D, E, F, I and J) containing no or scarce cassiterite and wolframite, the transparent to semi-transparent zircon is predominant. Besides, a few grains of slightly rounded-prismatic zircon were detected from the sample H. Based on the above mineral data, the fine-grained porphyritic rock with abundant cassiterite, named Needle Hill Granite and represented by the samples G and H, is not comagmatic with the fine-grained porphyritic rocks represented by the samples,C, D and E, or with the medium- or coarse-grained granitoid rocks as mentioned above (see Table 1). It is possible to postulate that the named Needle Hill Granite was formed during a later intrusive phase.

The proportions of the corresponding heavy minerals of samples C, D and E are not similar when compared with one another.

Sample C, on the basis of similar magnetite and zircon contents is likely to be grouped with the samples A and B and placed in the named Hong Kong Granite although the contents of ilmenite and monazite differ slightly in contrast to samples A and B. But for samples D and E, the heavy minerals magnetite, ilmenite and monazite differ greatly in weight percentages when compared with samples A, B and G (Table 1). Besides, slightly rounded-prismatic zircons were found in sample D. It is suspected that the fine-grained porphyritic rocks represented by sample D and E are not, genetically, closely correlated with samples A and B representing the named Hong Kong Granite, although they were collected from the same igneous body, based on Allen & Stephens' geological map (1971). However, many factors may affect the mineral assemblages, and it is stressed that the mineral data are not conclusive.

Sample I gives the heavy mineral assemblage of a coarse-grained rock named Sung Kong Granite. The assemblage includes magnetite, ilmenite, zircon, and two scarce minerals monazite and pyrite. The mineral data shows no close similarity with those of other samples (Table 1).

Sample J displays the heavy mineral assemblage of the named Tai Po Granodiorite. There is no difficulty in identifying granite and granodiorite lithologically and the assemblage does not closely resemble the other assemblages listed in Table 1. However, the proportion of magnetite in this sample is similar to that of magnetite in sample I. Zircon grains in the granodiorite are somewhat larger than the zircon grains in granitic rocks (Table 2).

Conclusions

This heavy mineral study leads to the following conclusions :

(i) General similarities in heavy mineral assemblages of most of the samples are tenuous. However, stronger similarities in heavy mineral assemblages were found to occur between samples A and B and also between samples G and H.

(ii) Hong Kong Granite, as represented by samples A and B, is rich in magnetite which constitutes over 90% of the heavy minerals by weight. Needle Hill Granite represented by samples G and H, is poor in magnetite, ranging from zero to around 5% of the heavy minerals by weight. The samples of Sung Kong Granite and Tai Po Granodiorite have a magnetite content around 70% of the heavy minerals by weight respectively, and are therefore moderately rich in magnetite.

(iii) Cassiterite occurs in the Needle Hill Granite and the Cheung Chau Granite. The Neddle Hill Granite is considered to be "tin mineralised" while Cheung Chau Granite is not, as the heavy mineral assemblage of the former contains considerable amounts (around 40% to 60% by weight) of cassiterite while cassiterite is scarce in the later. "Tin mineralisation" of the Needle Hill Granite is suspected to be endogranitic. On the basis of the mineral data, it is believed that the Needle Hill Granite is non-comagmatic with the other named granitoid rocks. Although the Cheung Chau Granite contains cassiterite as well, it is clearly not to be grouped with the Needle Hill Granite, simply because there are differences in lithology, in heavy mineral assemblage and in the amount and colour of cassiterite.

Acknowledgements

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Possible use of magnetic susceptibility for differentiating between Hong Kong Granite and Cheung Chau Granite

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Among the different bodies of granite in Hong Kong distinguished by Allen & Stephens (1971), the Hong Kong Granite and Cheung Chau Granite are the two most widespread. They represent about 70% of all the granitic rocks exposed in the Territory. Lithologically, the Cheung Chau Granite is very similar to a particular phase of Hong Kong Granite; they are both phaneritic, light-coloured, non-porphyritic, equigranular granites containing about 30% to 40% quartz and carrying microperthite as the principal potash feldspar. Due to the similarities in lithological characteristics, it is virtually impossible to distinguish the two granites in hand specimens. In a geological survey conducted by Allen & Stephens (1971), the identification of two igneous units was based on one criterion: the Cheung Chau Granite contains quartz porphyry dykes and the Hong Kong Granite does not. Whatever its applicability in field mapping, this distinction is not useful for identifying hand specimens or small outcrops, since a positive identification of Cheung Chau Granite must be based on the exposure of porphyry dykes while, on the other hand, absence of such dykes in an outcrop cannot automatically imply the Hong Kong Granite.

Taking a different approach to the classification of granite rocks in Hong Kong, Strange (1984) suggested a classification of granitic rocks which is based on the composition, overall size and size range of constituent grains. Clearly, this may place granitic intrusions of different phases and different ages into the same categories. It will bring out zonation within a given pluton but will not show intrusive relationships among different plutons of similar texture. From a geologist's point of view, a classification of intrusive rocks which is based on time and space relationships between the intrusive bodies must be the ultimate objective of mapping, as a means of unravelling the history of the igneous activity.

The author has studied the possibility of using rock magnetism in differentiating between the so-called Hong Kong and Cheung Chau Granites. As part of a palaeomagnetic study of Hong Kong, the author has conducted natural remnant magnetism and magnetic susceptibility measurements on 34 samples collected from outcrops of Hong Kong Granite and Cheung Chau Granite. Each sample represents an individual site where a specimen was collected. The samples were about 10cm x 10cm x 5cm, and three to five cylindrical cores of 2.4cm diameter by 2.4cm length were prepared from each sample. The magnetic experiments were conducted at the University of Minnesota. The experimental procedures involved measuring natural remnant magnetism with a cryogenic magnetometer, which has a resolution of 10^{-8} emu/cm^3, and magnetic susceptibility with a Bartington Susceptibility Bridge. The main objective of the experiments was to compare the magnetic properties of the two different granites and to determine if the magnetic properties are useful indicators for the igneous units.

The usefulness of magnetic properties for differentiating the two granites depends on whether they exhibit fundamental differences in their magnetic mineralogy. The natural remnant magnetism (NRM) of a specimen refers to the strength, or intensity, of the magnetism in the specimen. The magnetic susceptibility represents the ability of the specimen to acquire a magnetism in an applied magnetic field. Both NRM and magnetic susceptibility depend on the nature of the magnetic carriers in the rocks, which are mainly titanomagnetites in both granites, concentration of magnetic materials, grain size of the magnetic carriers, as well as domain structure of the magnetic minerals. Differences in the magnetic properties reflect fundamental differences in the titanomagnetites in the two granites.

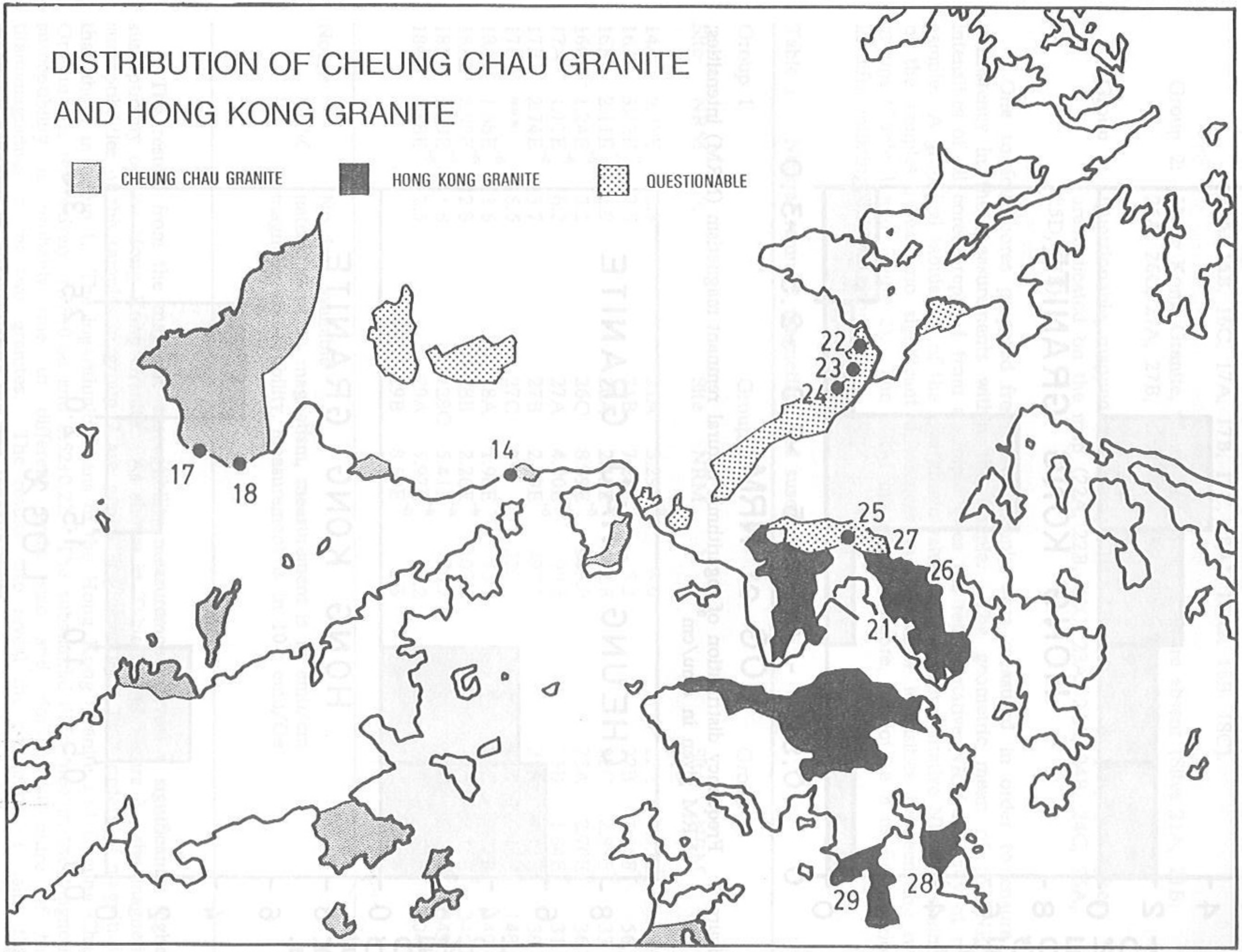

Figure 1 Locations of sampling sites (simplified geology based on Allen & Stephens, 1971)

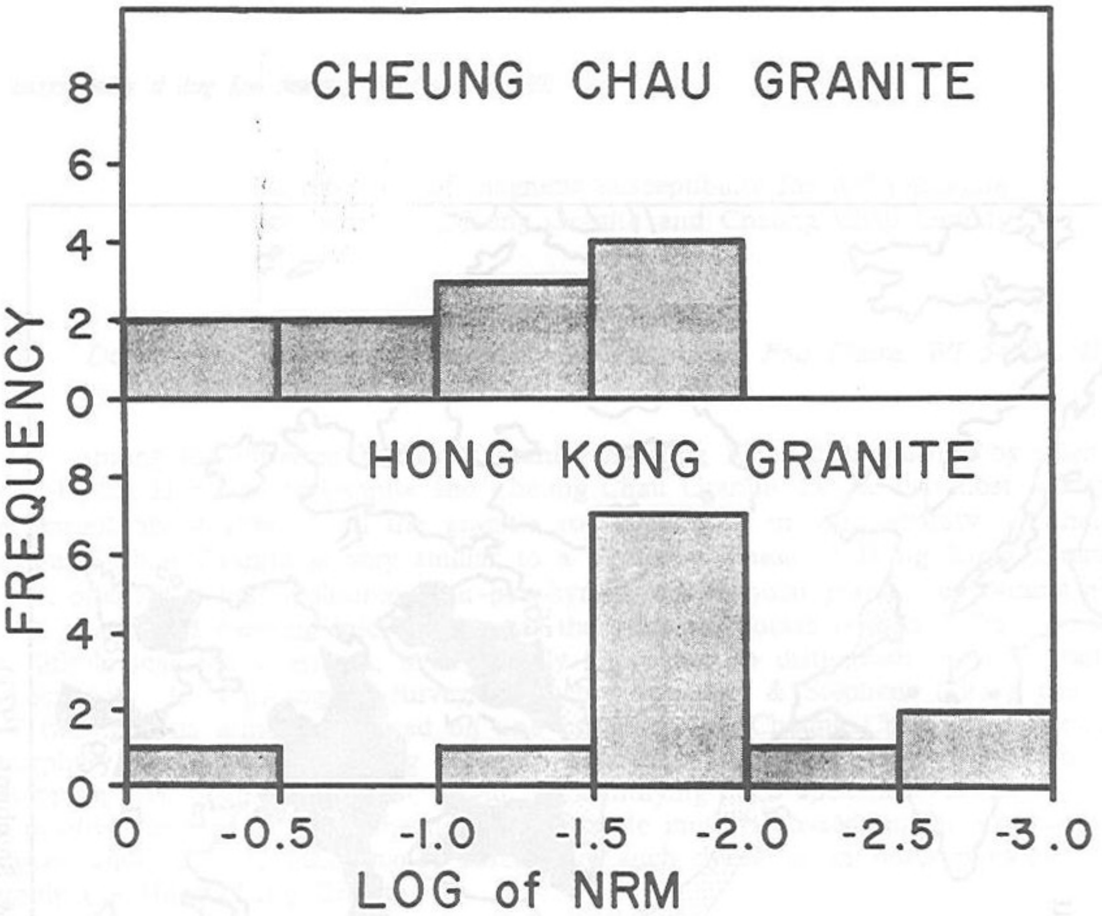

Figure 2 Frequency distribution of logarithmic natural remnant magnetism (NRM) intensities; NRM given in emu/cm^3

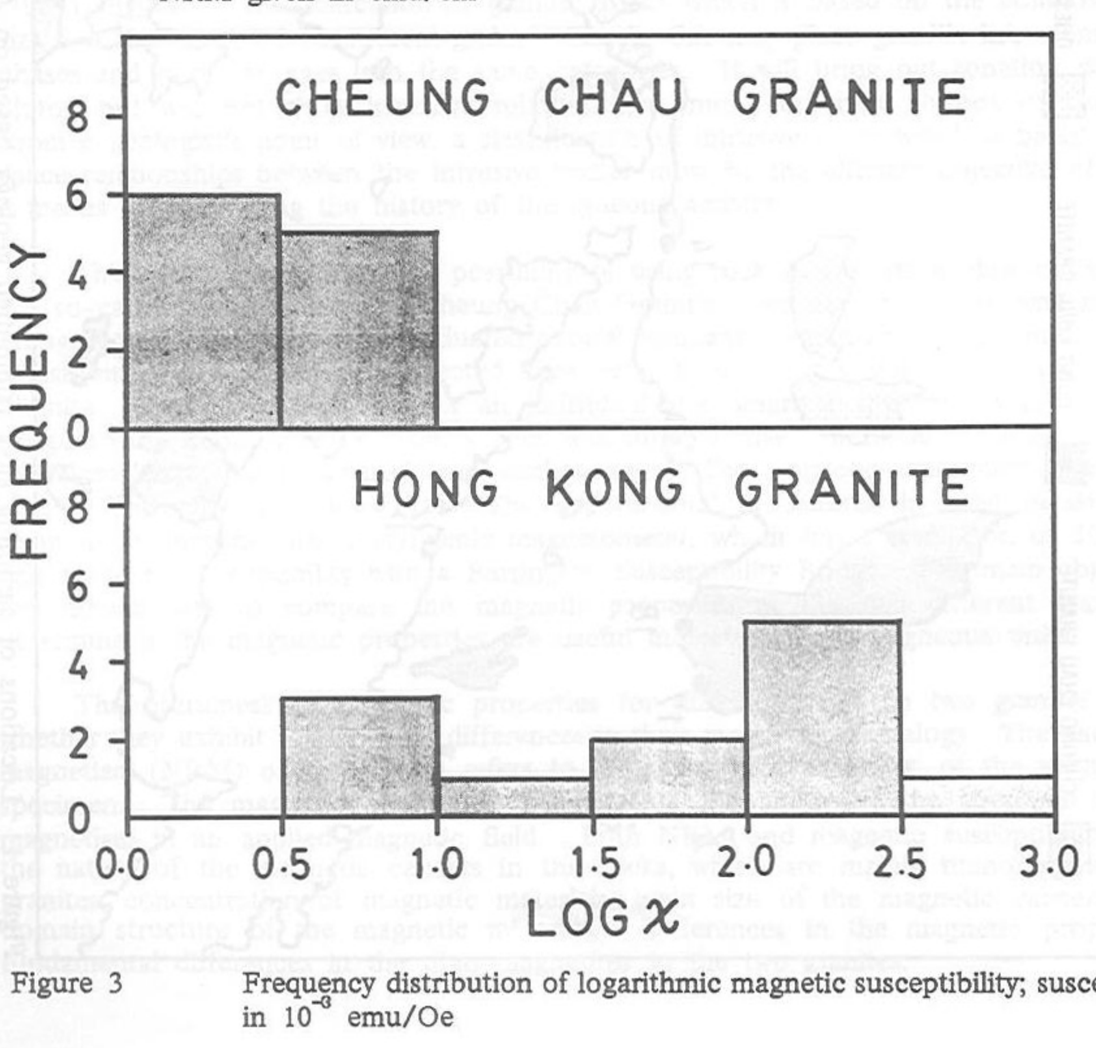

Figure 3 Frequency distribution of logarithmic magnetic susceptibility; susceptibility given in 10^{-3} emu/Oe

The rocks samples are divided into three groups (Figure 1), based on the geological map published by Allen & Stephens (1971).

Group 1: Cheung Chau Granite, where porphyry dykes are present (Sites 14A, 16A, 16B, 16C, 17A, 17B, 17C, 18A1, 18A2, 18B, 18C).

Group 2: Hong Kong Granite, where porphyry dykes are absent (Sites 21A, 21B, 26A, 26C, 27A, 27B, 27C, 28A, 28B, 28C, 29A, 29B).

Group 3: Questionable, mapped as Cheung Chau Granite but no porphyry dykes are indicated on the map (22A, 22B, 22C, 23A, 24A, 24B, 24C, 25A, 25D, 25E).

One to four cores prepared from each sample were measured in order to ensure a consistency in the measurements within the sample. The geometric mean of the NRM intensities of all cores prepared from a sample gives the representative NRM intensity of the sample. A graphical tabulation of the logarithmic values of the representative NRM intensities of the samples reveals no significant differences in the NRM intensities between the two groups (Table 1 and Figure 2). The NRM intensity, therefore, cannot be a useful criterion in differentiating the two granites.

Table 1 Natural remnant magnetism and susceptibility data

Group 1			Group 2			Group 3		
Site	NRM	X	Site	NRM	X	Site	NRM	X
14A	$5.38E^{-7}$	2.3	21A	$3.29E^{-6}$	8.0	22A	$9.55E^{-8}$	2.3
16A	$3.42E^{-6}$	7.5	21B	$7.28E^{-6}$	5.2	22B	$3.85E^{-6}$	56.8
16B	$2.11E^{-7}$	2.9	26A	$2.13E^{-6}$	172.8	22C	$2.88E^{-5}$	33.5
16C	$1.24E^{-6}$	3.2	26C	$8.99E^{-6}$	209.0	23A	$2.70E^{-4}$	36.3
17A	$1.11E^{-6}$	6.2	27A	$4.00E^{-5}$	99.5	23B	$1.84E^{-4}$	31.9
17B	$2.74E^{-6}$	3.7	27B	$2.39E^{-5}$	497.7	24A	$4.73E^{-5}$	38.1
17C	***	6.5	27C	***	220.1	24B	$6.46E^{-6}$	148.6
18A1	$1.68E^{-6}$	1.6	28A	$1.98E^{-5}$	73.3	24C	$9.27E^{-6}$	340.0
18A2	$2.02E^{-6}$	2.8	28B	$2.26E^{-6}$	109.0	25A	$2.24E^{-3}$	346.0
18B	$1.89E^{-7}$	1.8	128C	$5.41E^{-6}$	36.7	35D	$6.69E^{-5}$	349.3
18C	$1.88E^{-6}$	2.5	29A	$5.97E^{-6}$	14.2	25E	$2.63E^{-5}$	204.2
			29B	$8.59E^{-5}$	8.3			

Notes: *** No data available
NRM natural remnant magnetism, measurement is in emu/cm^3
X magnetic susceptibility, measurement is in 10^{-6} emu/Oe

The results from the magnetic susceptibility measurements reveal a significantly higher susceptibility of the Hong Kong Granite. As shown in Table 1 and Figure 3, the magnetic susceptibilities of the samples in group 2 are generally greater by 1 to 2 orders of magnitude than those in group 1. The logarithmic means of the Hong Kong Granite and Cheung Chau Granite are, respectively, 1.73±0.66 and 0.52±0.22. The substantial difference in the magnetic susceptibility is probably due to different grain size and domain structure of the titanomagnetites in the two granites. The results also reveal the possibility of using this magnetic property in differentiating the two igneous units.

The difference in the magnetic susceptibility of the two granites is probably due to a difference in titanomagnetite grain size in the rocks. The author has examined 25 petrographic thin sections prepared from samples 14B, 17B, 18B, 18C, 21A, 26, 27B, and 29C. The result reveals a difference in the maximum magnetite grain size between the two groups of granites. In general, all the samples examined contain about 1 to 2% of fine-grained magnetites 1 to 2µm in diameter. The largest magnetites observed in samples 14B, 17B, and 18C (Cheung Chau Granite) are about 0.04 to 0.06mm while those in samples 21A, 26, and 27B (Hong Kong Granite) exceed 0.4mm in diameter. Not only does the latter group contain larger magnetities, its magnetite abundance is also greater. Such differences in the magnetite grain size and abundance may explain the observed difference in the magnetic susceptibility of the two phases.

The author has attempted to apply this method to determine the igneous units of the sites included in group 3. As shown in Table 1, the magnetic susceptibilities of the samples from sites 22 to 24, which are collected from the granitic pluton exposed near the Chinese University in Shatin, show substantial variations in susceptibility. The logarithmic mean of the measurements of the sites yields a value intermediate between the characteristic susceptibilities of the two granites. In this case, the use of susceptibility to determine the intrusive phase of the sites is inconclusive. Sites 25A to E are located at Diamond Hill in Kowloon. The magnetic susceptibilities of these sites show consistently high values, similar to those of the Hong Kong Granite (Table 1). Therefore, the rocks at these locations are probably part of the Hong Kong Granite and may have been misidentified as Cheung Chau Granite by Allen & Stephens (1971).

It must be pointed out in conclusion that variations of magnetic susceptibility within the plutons and the effect of weathering on the magnetic properties have not been fully evaluated. The validity of the method is still pending corroboration from further measurements and confirmation of the present results. Also, it should be noted that the method may not identify confidently the rock unit of a specimen that shows an intermediate susceptibility value, as exemplified by the case of sites 22 to 24 above. Although the method may be useful in the present case for distinguishing between the two named granites, the Hong Kong Granite and the Cheung Chau Granite, it may not be applicable to other igneous units. Despite these limitations, the measurement of magnetic susceptibility is a relatively quick and easy procedure compared to the preparation of petrographic thin sections and elemental analysis.

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ALLEN, P.M. & STEPHENS, E.A. (1971). *Report on the Geological Survey of Hong Kong, 1967-1969*, Hong Kong Government Press, 116p, plus 2 maps.

STRANGE, P.J. (1984). Towards a simpler classification of the Hong Kong granites. *Proceedings of the Conference on Geological Aspects of Site Investigation*, Hong Kong, pp 99-103. (Published as *Geological Society of Hong Kong, Bulletin* No. 2, edited by I. McFeat-Smith, 1985).

Geological Society of Hong Kong Newsletter, Vol. 6, pp 27-32 (1988)

Future Sea-level Rise and Coastal Development

Report on the Joint Meeting: Geotechnical Division of the Hong Kong Institute of Engineers and the Geological Society of Hong Kong

16th April 1988

Report by W.W.-S. Yim and G.W. Lovegrove

Speakers

S. Jelgersma	President, Commission on Quaternary Shorelines, International Union of Quaternary Research,
M.J. Tooley	Reader, Department of Geography, University of Durham,
W.W.-S. Yim	Lecturer, Department of Geography and Geology, University of Hong Kong,
T.-S. Cheng	Senior Scientific Officer, Royal Observatory
M.L. Chalmers	Associate, Scott Wilson Kirkpatrick and Partners

Introduction

This meeting, attended by over 80 registrants, was held at the University of Hong Kong on 16th April, 1988. The meeting was divided into two sessions which were chaired by R.J. Osborne, Partner in Scott Wilson Kirkpatrick and Partners, and G.W. Lovegrove, Divisional Director of Mott Hay and Anderson Hong Kong Ltd, respectively.

R.J. Osborne welcomed the registrants and introduced the aims of the meeting. Stating that the meeting was well timed in view of major coastal developments planned for Hong Kong, it was fortunate to have two leading international experts in the field of sea-level changes and impacts, from the Netherlands and the U.K. He drew attention to the need to avoid creating infrastructure which might be subject to unacceptable flooding risks within a few generations. The importance of a scientific database was stressed, as was the need to alert politicians, town planners and administrators to the risks of future sea-level changes. Reference was made to the Harbour Area and Reclamation Growth Study (SHRUG) in Hong Kong.

Paper 1
A future sea-level rise: its impact on coastal lowlands

Dr S. Jelgersma

A review of the environment, landuse and sea-level of the world's coastal lowlands was presented with reference to the effects of a future sea-level rise and to the necessary response. Tide gauge measurements in many parts of the world have indicated a relative rise in sea-level of approximately 20cm during the last century. This is higher than the rate of rise predicted from the derived sea-level curves obtained from the investigation of many coastal areas. Recent observations suggest that this figure may even be exceeded in places. It is estimated that global warming of the earth due to the increase in carbon dioxide and other greenhouse gasses may cause a rise in sea-level of between 60 and 200cm during the next century.

A case study of the impact of a future sea-level rise of 1m in the next century on the coastal lowlands of the Netherlands was given. The recommendations for all the coastal lowlands include:

1. Observe and analyse tide gauge measurements; if gauges are absent, they should be constructed.

2. Control land reclamation and coastal defense.

3. Control man-induced subsidence caused by groundwater extraction and drainage.

4. Determine the amount of coastal erosion and aggradation by mapping.

5. Calculate the sediment budget of the coast.

6. Calculate the sediment supplied by rivers to the coast.

7. Publish 'coastal hazard' maps, indicating the areas of extreme, high and moderate risk of future sea-level rise, which take into account changes in storminess. An example of this type of map is given at Figure 1.

8. Persuade decision makers with these maps and other pertinent data.

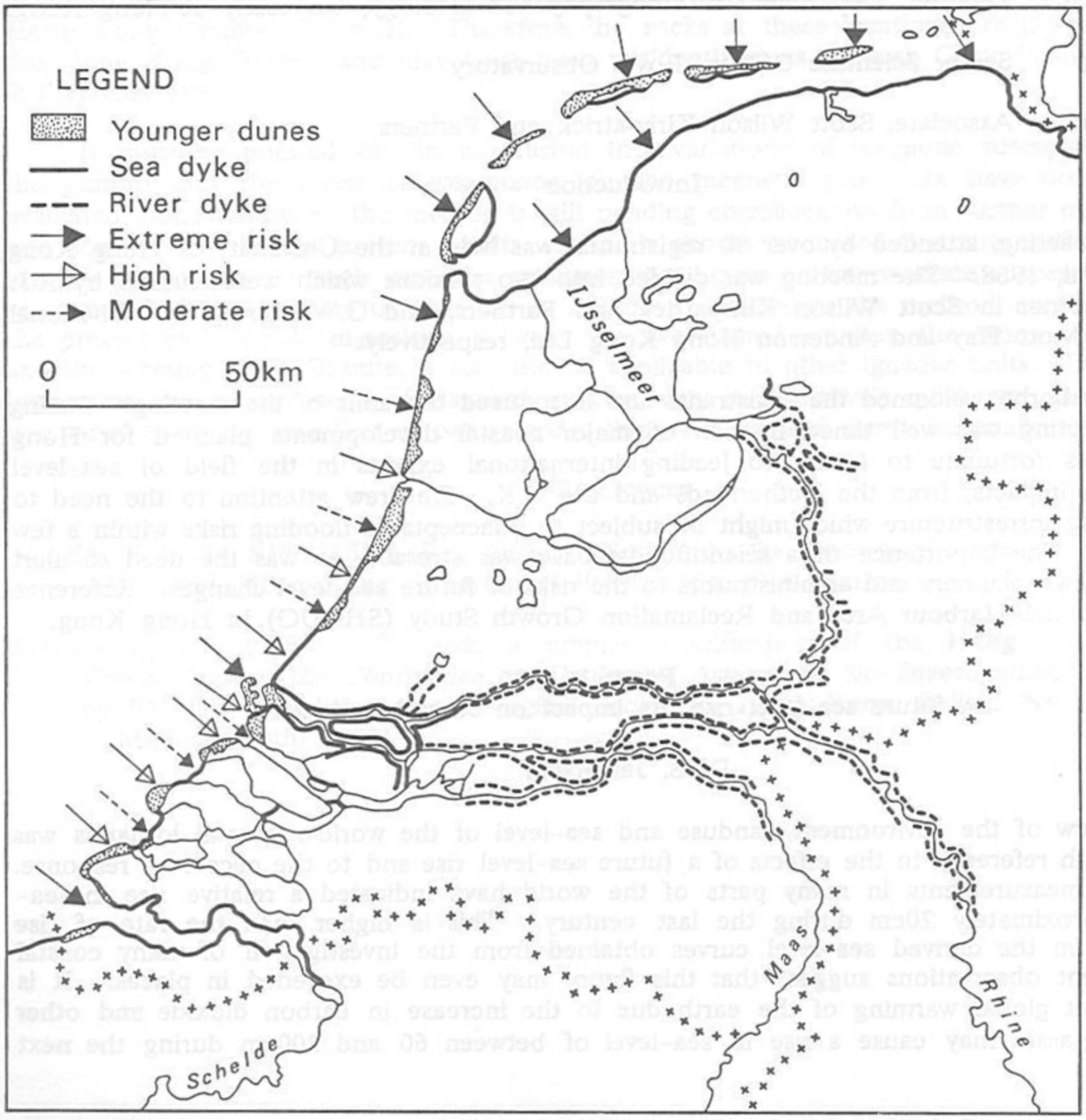

Figure 1 Coastal hazard map of the Netherlands, indicating areas of extreme, high and moderate risk for future sea-level rise.

Paper 2

The impact of projected sea-level changes in the United Kingdom

Dr M.J. Tooley

The sea-level rise scenarios of the U.K. Environmental Protection Agency to AD 2100 were considered in relation to consequential changes in the geoid, hydroisostacy, palaeotides, density/temperature changes and sediment consolidation. The thinning of both the Antarctic and Greenland ice sheets will result in both a rise and fall in sea-level at different latitudes, because of regional variability over the earth's crust.

A case study of sea-level changes in Britain, with particular reference to coastal lowlands in southern, southeastern, eastern and northwestern England was presented. A geographic information system applied to the Tees estuary (Figure 2) was used to illustrate the management impact of sea-level rise.

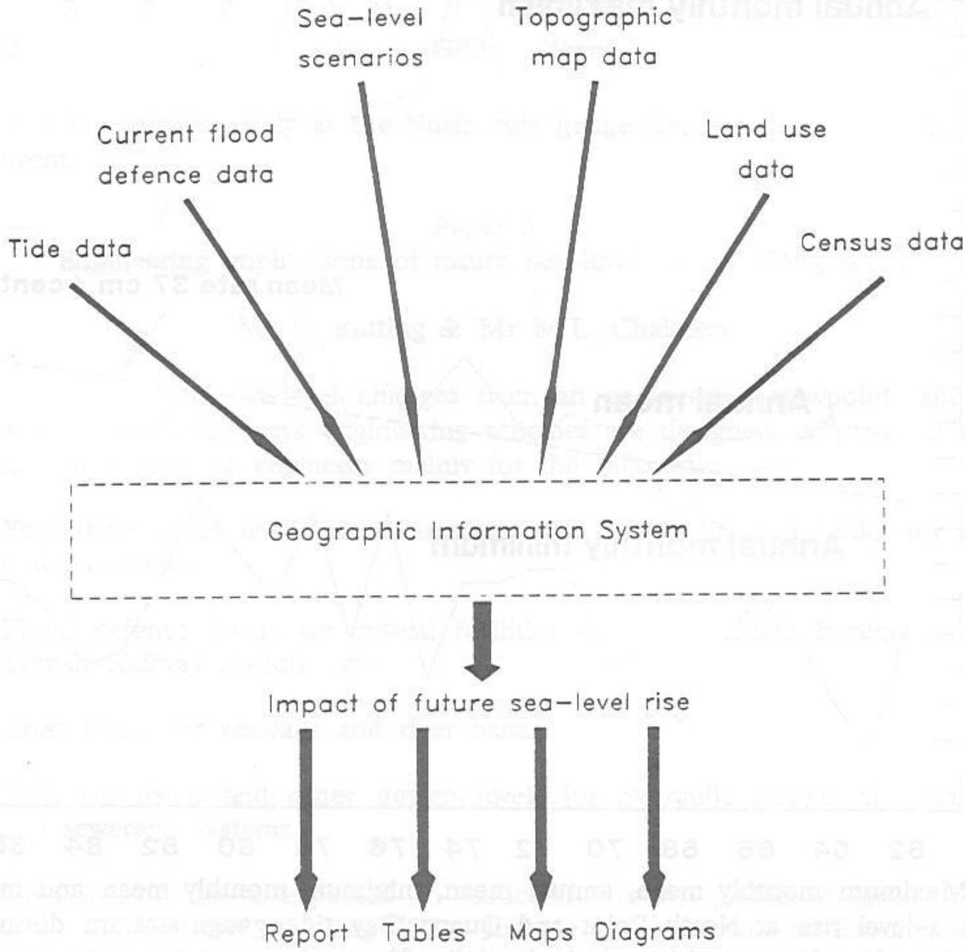

Figure 2 A geographic information system used to provide data for future management of the impact of sea-level rise in the Tees estuary (from Shennan & Tooley, 1987).

Paper 3

An analysis of tide gauge and storm surge data in Hong Kong

Mr W.W.-S. Yim

A maximum rate of future sea-level rise of ca. 37cm/century is predicted from an analysis of tide gauge data obtained over the past 26 years from the North Point (1962-1985) and Quarry Bay (1986-1987) stations in Hong Kong (Figure 3). However, if long term ground surface settlement of both stations, estimated from surveying data of the Port Works Division, Civil Engineering Services Department, Hong Kong Government, is taken into account, the future rate of sea-level rise is virtually nil. A possible explanation for this discrepancy between Hong Kong and the global rate of future sea-level rise predicted by many workers (see Warrick, 1986) is the regional subsidence of the Pearl River Mouth caused by isostatic responses of sedimentation due to the southerly migration of the Pearl River delta. It is therefore recommended that long term monitoring of ground surface settlement of all major reclamations, as well as all operational tide gauge stations in Hong Kong be carried out.

Storm surges had only a minimal effect on Hong Kong during the 1982-83 and 1986-87 El-Nino events. However, a return of typhoon activity with associated storm surges is expected during non-El-Nino years.

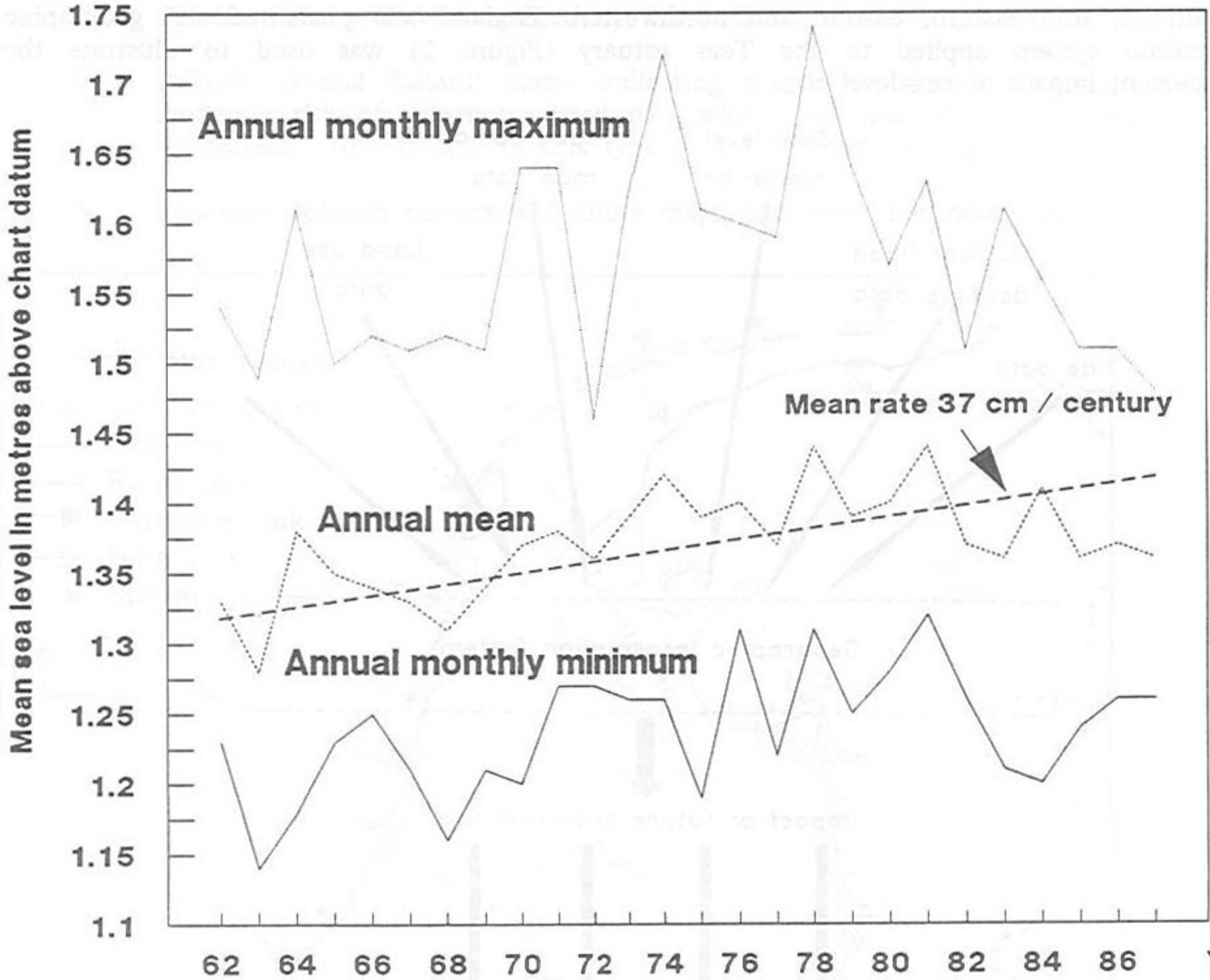

Figure 3 Maximum monthly mean, annual mean, minimum monthly mean and mean rate of sea-level rise at North Point and Quarry Bay tide gauge stations during 1962-87. Note that the mean rate of sea-level rise shown does not take into account ground surface settlement at the tide gauge stations.

Paper 4

El-Nino and sea-level changes

Mr T.-S. Cheng

El-Nino years are associates with climatic changes in many parts of the world. During the 1982-83 El-Nino event which is the strongest in the era of instrumented records, the devastation to people and their economy in some countries was unprecedented. In Hong Kong, there is a tendency for a relative decline in sea-levels during El-Nino events. Between 1982-83, the sea-level anomaly recorded at the North Point tide gauge station was found to exceed 20cm below the normal sea-level (Figure 4).

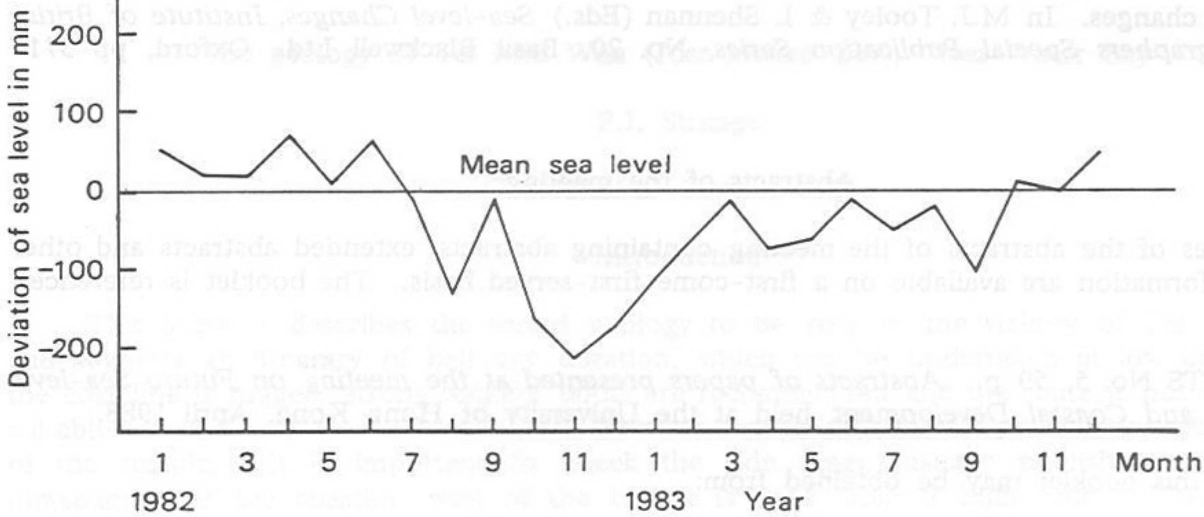

Figure 4 **The sea-level anomaly at the North tide gauge station during the 1982–83 El-Nino event.**

Paper 5

Engineering implications of future sea-level rise in Hong Kong

Mr S. Butting & Mr M.L. Chalmers

This paper examined sea-level changes from an engineering viewpoint, and considered them in perspective with the ways engineering schemes are designed, constructed and behave. Sea-level data are needed by engineers mainly for the following:

1. Formation levels for land reclamations and hence finished levels for streets and pavements.

2. Flood defence levels for critical facilities such as building basements, Mass Transit Railway stations, etc.

3. Crest levels for seawalls and river banks.

4. Tailwater levels and other design levels for hydraulic design of stormwater and sewerage systems.

A future sea-level rise is expected to reduce the return period of given high sea-level events. Possible implications to Hong Kong include a higher risk of flooding in low-lying coastal areas, and overtopping of seawalls due to the combined action of waves and high water levels.

Close of meeting

All five papers were discussed after each presentation. This was followed by an open forum in which numerous questions were raised from the floor. Answers were enhanced by contributions from the two overseas experts. From the chair, G.W. Lovegrove drew the meeting to a close well into lunch time by proposing a vote of thanks to all the speakers for their fine presentations.

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Warrick, R.A. (1986). Climatic change and sea-level rise. *Climatic Monitor*, Vol. 15, pp 39–44.

Shennan, I. & Tooley, M.J. (1987). Conspectus of fundamental and strategic research on sea-level changes. In M.J. Tooley & I. Shennan (Eds.) *Sea-level Changes, Institute of British Geographers Special Publication Series*, No. 20, Basil Blackwell Ltd., Oxford, pp 371-390.

Abstracts of the meeting

Copies of the abstracts of the meeting containing abstracts, extended abstracts and other relevant information are available on a first-come-first-served basis. The booklet is referenced as:

ABSTRACTS No. 5, 59 p. *Abstracts of papers presented at the meeting on Future Sea-level Rise and Coastal Development*, held at the University of Hong Kong, April 1988.

Copies of this booklet may be obtained from:

The Secretary, Geological Society of Hong Kong, c/o Dept of Geography and Geology, University of Hong Kong, Hong Kong.

The cost is HK$20, for members of GSHK or Geotechnical Division of the HKIE, and HK$25 for non-members. All payments should be made by crossed cheque made payable to the Geological Society of Hong Kong.

In addition to abstracts or extended abstracts of the papers summarised above, this volume contains 9 pages of general information, and:

Englefield, G.J.H. (1988). Computer-aided techniques for analysing coastal sedimentary sequences related to sea-level changes, pp 35-37.

Van De Plassche, O. (1988). IGCP project proposal on Quaternary coastline evolution, pp 38-46.

Yim, W.W.-S. (1988). A bibliography on future sea-level rise and coastal development, pp 47-53.

Announcements:

IGCP Board Assessment of Project No. 200 'Late Quaternary Sea-level Changes: Measurement, Correlation and Future Applications', p 54.

INQUA Commission on Quaternary Shorelines Working Group II, East and Southeast Asia, p. 55.

Participation in IGCP Project No. 274 'Quaternary Coastal Evolution: Case Studies, Models and Regional Patterns', p. 59.

Geological Society of Hong Kong Newsletter, Vol. 6, pp 33-38 (1988)

The geology of Tai Miu Wan (Joss House Bay), Clear Water Bay

P.J. Strange

Geotechnical Control Office

Introduction

This account describes the varied geology to be seen in the vicinity of Tai Miu Wan, and suggests an itinerary of half day duration, which can be undertaken at low tide. Since the coastline is rugged, strong walking boots are recommended and the route is not considered suitable for small children. Families can however remain on the sandy beach immediately east of the temple. It is important to check the tide times (usually published in the daily newspapers) as the coastline west of the temple is impassable at high water. There are car parking spaces near the Clear Water Bay Country Club gate house (location 12 on the map), but there is no public transport. The KMB No. 91 bus operates from the Choi Hung MTR station as far as the Clear Water Bay Main beach, some 2km to the north.

Outline of Geology

The oldest rocks of the Repulse Bay Volcanic Group present in this area are fine ash vitric tuffs of the Ap Lei Chau Formation. These outcrop extensively in Junk Bay (Strange & Shaw, 1986), and underlie the Silverstrand Formation in the southern part of the Clear Water Bay Peninsula. The Silverstrand Formation is a thick welded fine ash tuff sequence with a prominent eutaxitic fabric throughout (for a detailed description of eutaxitic fabric, see Workman, 1985). This is in turn overlain by the Mang Kung Uk Formation which is dominated by well-bedded tuffite, siltstone and sandstone layers. Flow-banded trachyandesite lava (Tai Miu Wan Member) of the Clear Water Bay Formation rest unconformably on the Mang Kung Uk tuffites and sedimentary rocks. Within the Tai Miu Wan Member, a tuffite layer appears to separate individual lava flows. The highest unit in the volcanic succession of the district is the High Island Formation. This consists of massive, very uniform fine ash welded tuff. In places, this formation oversteps the Clear Water Bay lavas to rest on the Silverstrand tuffs and appears to infill former topographic hollows within the older volcanics. The east-west striking fissure vents cut the volcanics, and are usually found in association with quartz syenite intrusions (Figure 2).

Quartz syenite is found both as small plutonic bodies and also an east-west striking dykes. The latter contain enclaves or pods of coarse-grained granite. Numerous small basalt dykes of presumed Tertiary age are seen cutting the volcanics.

These volcanic units will be described in detail in the forthcoming GCO publication, *Geology of Sai Kung and Clear Water Bay*, Hong Kong Geological Survey Memoir No. 4.

Field excursion itinerary

The notes below refer to the numbered localities shown on the accompanying 1:10 000 scale geological map (Figure 1).

Locality Number	Decription
1	After descending the path, we turn left at the temple and walk along the eastern side of the bay. Here, we see tuffs and tuffites which apparently lie between lava flows of the Tai Miu Wan Member. Along this part of the beach the flow-banded lava is not seen and the tuffs and tuffites are in contact with syenitic intrusions. The tuffites are finely laminated in part and this banding is often contorted.

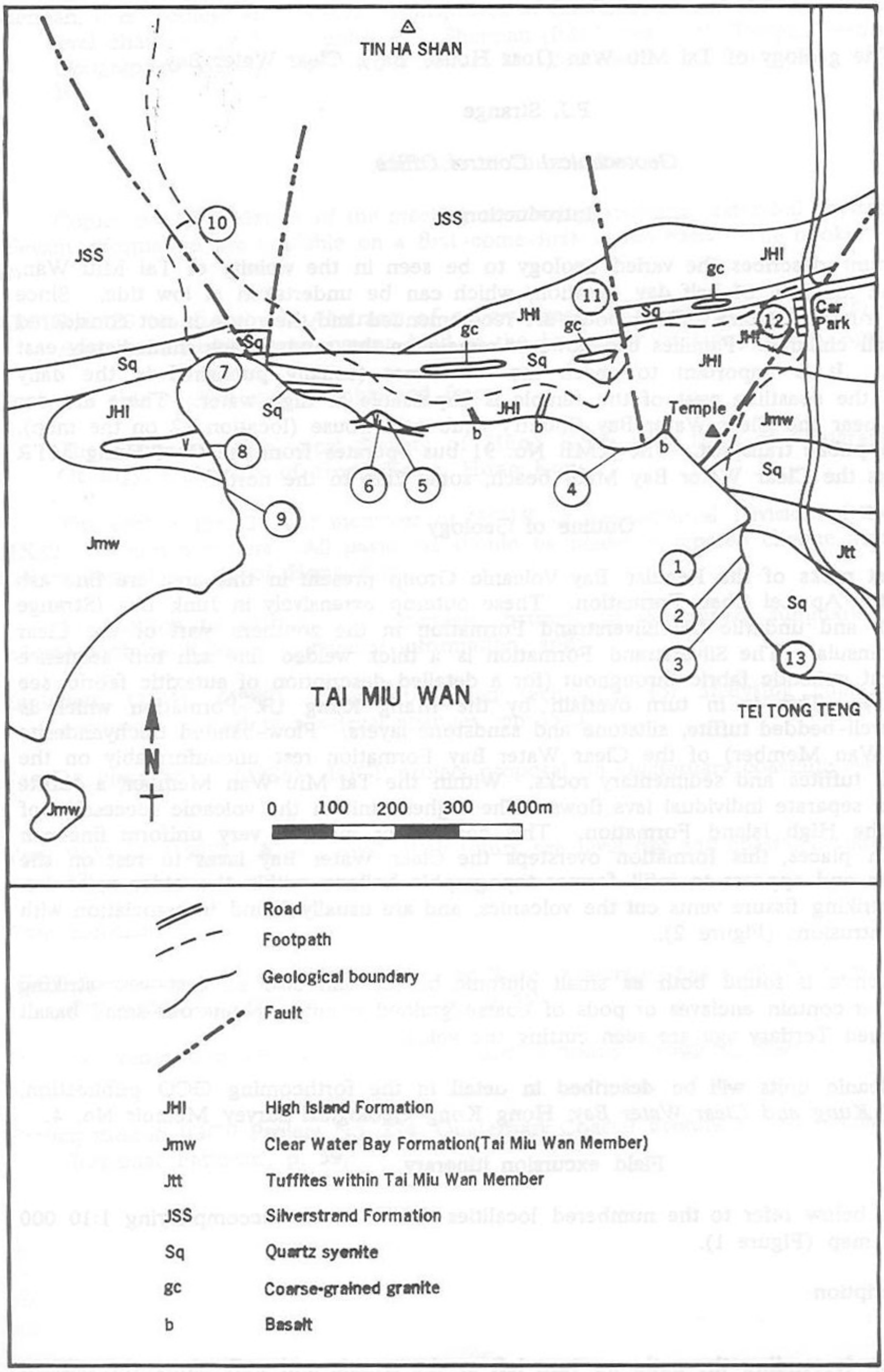

Figure 1 Geological sketch map of Tai Miu Wan, scale 1:10 000

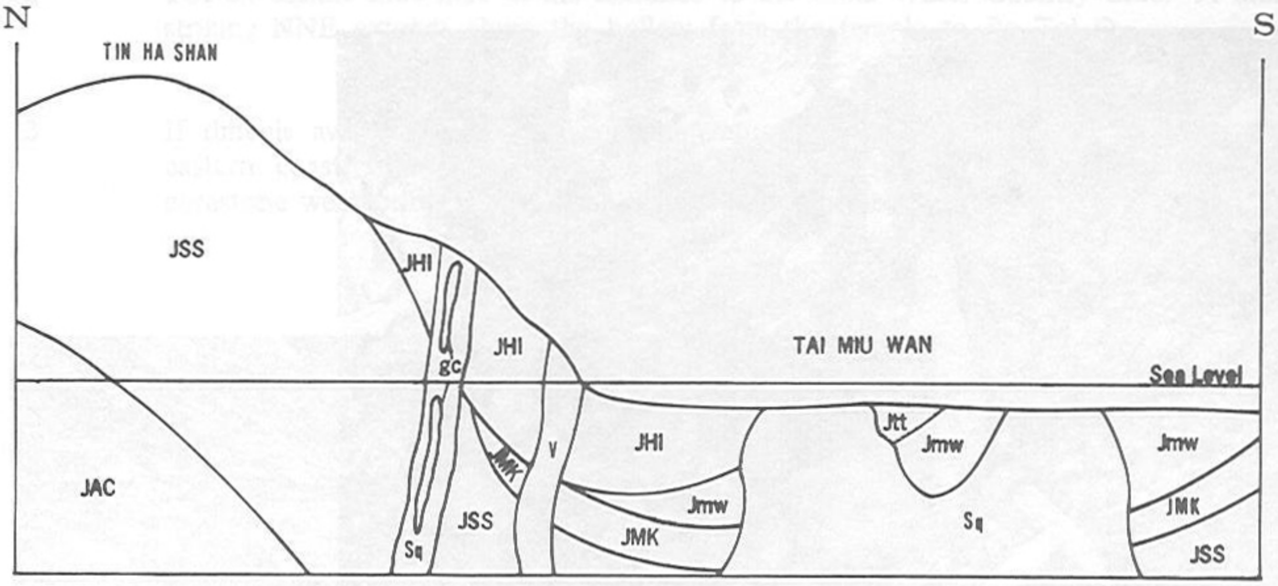

Figure 2 Generalised geological cross-section of Tai Miu Wan

Locality	Description
2	The intrusive contact is steeply dipping and there is a wide chilled margin of the syenite intrusion. The groundmass is very fine-grained and alkali feldspar megacrysts are common. This very fine-grained equivalent of the quartz syenite is termed quartz trachyte (Strange, 1987).
3	The main part of the small pluton comprises fine-grained quartz syenite with distinctive alkali feldspar megacrysts. These are often aligned in a trachytoid texture. The rock weathers in a similar way to granite (note large rounded boulders and blocks offshore), but the weathered material has a much higher clay content than the typical granite.
4	Typical fine ash tuffs of the High Island Formation are found along the coastline westwards from the temple. These welded tuffs are remarkably uniform, and were formerly considered to be rhyolite lavas (Allen & Stephens, 1971). Detailed examination of the rock with a hand lens, particularly on rock surfaces which are slightly weathered, often reveals a faint eutaxitic fabric with small wispy fiamme. These are more conspicuous as we proceed westwards. Small syenite intrusions and a number of basalt dykes are seen cutting the tuffs. Mapping evidence has shown the High Island Formation tuffs to be infilling what was probably a topographic hollow (striking roughly east-west) at the time of deposition.
5	A spectacular fissure vent cuts the High Island tuffs (Plate 1). This vent strikes roughly east-west paralleling the coast, but several offshoots penetrate into the country rock. The vent is filled with very variable material including sandstones and tuffaceous rocks, possibly derived from the underlying Mang Kung Uk Formation tuffites and sedimentary rocks. Syenite has infiltrated the vent matrix producing a distinctive banded pattern on the rock.
6	Eutaxite (of the Silverstrand Formation) is present here and may represent a very large clast within the vent. Note the large scale fiamme, particularly well seen on slightly weathered surfaces.

Plate 1 Fissure vent material, at Locality 5

Locality	Description
7	After crossing several quartz syenite dykes, we come to the beach at the western end of Tai Mui Wan. A large dyke of quartz syenite forms the low rounded hill immediately behind the beach and the rock can be seen outcropping on the beach. Close by, a mass of haematite mineralization can be seen near the high water mark.
8	Vent material is again seen here, very similar in appearance to locality 5. Syenite patches are also common.
9	Another 50m along the coast, the High Island tuffs are seen alongside the flow-banded lavas of the Tai Mui Wan Member. Although not very clear at this locality, it is assumed that the younger tuffs of the High Island Formation were deposited against a steep slope or cliff of the older lavas. The Tai Mui Wan Member is the lowest major lava unit within the Clear Water Bay Formation and is of trachyandesite composition. Note the flow-banding visible in these lavas (Plate 2).
10	We now retrace our steps to the east side of the west bay, and near the haematite mineralization, we climb inland. On reaching the main footpath (part of the High Junk Peak Trail), we turn eastwards. Note the large blocks of eutaxite fallen from the slopes of Tin Ha Shan. Further along blocks of coarse-grained granite are found lying close to the path. This granite occurs as enclaves or screens forming elongate bodies up to 100m in length but only a few metres wide, within the large syenite dyke.
11	At the helicopter landing site, the syenite dyke has 'bulged' and forms the conspicuous low flat-topped hill. Again, blocks of coarse-grained granite are found within the syenite dyke.

Locality	Description
12	The excursion ends here at the entrance to the Clear Water Country Club. A fault striking NNE extends along the hollow from the temple to Po Toi O.
13	If time is available, you may consider returning to the temple and following the eastern coast to examine the syenite pluton at Locality 13. Here, excellent corestone weathering is displayed in the cliffs (Plate 3).

Plate 2 Flow-banded trachyandesite lava, at Locality 9

Plate 3 Corestone weathering of quartz syenite, at Locality 13

Acknowledgements

The author is grateful to Dr R. Addison and Dr A. Reedman (British Geological Survey) for their valued observations on the geology of the area, and to Mr K.O. Lam for drafting the figures. This paper is published with the permission of the Director of Civil Engineering Services of the Hong Kong Government.

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ALLEN, P.M. & STEPHENS, E.A. (1971). *Report on the Geological Survey of Hong Kong, 1967-1969.* Hong Kong Government Press, 116 p, plus 2 maps.

STRANGE, P.J. & SHAW, R. (1986). *Geology of Hong Kong Island and Kowloon, 1:20 000 Sheets 11 and 15.* Hong Kong Geological Survey Memoir No. 2, Geotechnical Control Office, Hong Kong, 134 p.

STRANGE, P.J. (1987). Petrological aspects of the Hong Kong quartz syenites. *Geological Society of Hong Kong, Newsletter* Vol.5, No.2, pp 3-8.

WORKMAN, D.R. (1985). An exposure of welded tuff at Mount Kellett. *Geological Society of Hong Kong, Newsletter* Vol. 3, No. 4, pp 1-7.

Publication Notices: The Society has received two Publication Notices from the Geotechnical Control Office. The first is particularly relevant to the fields of egineering geology and geotechnical engineering; however, teachers and society members in general may find this guide to be of use when describing field exposures, as it will aid consistency in feature reporting, and will help to make sure that all relevant details are identified and noted.

Geoguide 3:
Guide to Rock and Soil Descriptions

The third of a series of Geoguides relating to geotechnical engineering in Hong Kong is now available.

The *Guide to Rock and Soil Descriptions (Geoguide 3)*, which has been produced by the Geotechnical Control Office (GCO), presents a recommended standard of good practice for the description of Hong Kong rocks and soils for engineering purposes. It has been produced after wide consultation throughout the public and private sectors of the industry. Emphasis has been given to the many rock and soil types that could be encountered in engineering works in Hong Kong.

The Geoguide is intended to be used in conjunction with the companion document, *Guide to Site Investigation (Geoguide 2)*, and will be invaluable to engineers, geologists and architects involved with the planning, execution and supervision of site investigations for engineering projects and building works. It will also be of interest to teachers and academics.

Accurate and detailed descriptions of rocks and soils are essential for high quality ground investigations, and these are fundamental to sound geotechnical engineering practice. Considerable debate has always existed over the use of 'standardised' methods and terminology for the description of rocks and soils. The descriptive scheme recommended in the Geoguide is one which has been developed specifically for Hong Kong. However, many different schemes exist, and it is recognized that the practitioner may wish to use alternative methods to those recommended. Whatever scheme is employed, the important principle is that all descriptive terms should be defined clearly and used consistently. Therefore, while the Geoguide presents much useful guidance on good descriptive practice, its recommendations are not mandatory.

The 189-page Geoguide, which includes a useful checklist on descriptions for field and laboratory use, is available from:

Government Publications Centre,
General Post Office Building,
Ground Floor,
Connaught Place,
Hong Kong.

Overseas orders should be placed with:

Publications (Sales) Office,
Information Services Department,
1, Battery Path,
Central,
Hong Kong.

Price in Hong Kong : HK$40

Overseas orders : US$9 (including surface postage)

ISBN 962-02-0073-X

2. Following the announcement in Vol. 4, No. 3 of this Newsletter, reporting the publication of the first of the GASP Reports for Hong Kong and Kowloon (GASP I), the Geotechnical Control Office has notified the Society of the publication of the rest of the series of Regional GASP Reports:

Geotechnical Area Studies Programme
Publication of Reports II to XI

The Government has announced the release of Geotechnical Area Studies Programme Reports for the following areas:

GASP II - Central New Territories	GASP VII - Clear Water Bay
GASP III - West New Territories	GASP VIII - North East New Territories
GASP IV - North West New Territories	GASP IX - East New Territories
GASP V - North New Territories	GASP X - Islands
GASP VI - North Lantau	GASP XI - South Lantau

With the publication of the first eleven Reports, the Geotechnical Control Office has now completed Terrain Classification Mapping of the Territory at a scale of 1:20 000. Each of the series of twelve Reports contains regional geotechnical information for planning purposes. The first of these Reports, for Hong Kong and Kowloon, was released late in July 1987; it is expected that the last Report in the series - GASP XII - Territory of Hong Kong, which is a summary of the entire Territory, will be available soon.

Dr E.W. Brand, Principal Government Geotechnical Engineer, explained that the GASP studies were designed specifically to assist planning and land management within the Territory. In addition, the publication of the GASP Reports is an example of Government's on-going policy of providing information to assist the public wherever possible.

Pointing out that the studies were based on terrain classification techniques which use aerial photographs, field reconnaissance and existing site investigation records, Dr Brand added that they also contain a wealth of factual information. This includes aerial photographs, fold-out colour maps, a number of plates and large maps which present a general geotechnical assessment of each area.

The Reports published to date complete coverage at 1:20 000 scale of the Territory and contain information invaluable to those involved with planning, land development, environmental assessment and engineering feasibility studies. The Maps and Reports will also be of interest to teachers and academics, because they provide a comprehensive inventory of the land resources of the Territory. These Reports are now available from the Government Publications Sales Centre at the General Post Office and at Map Sales Outlets of the Buildings and Lands Department.

The GASP Reports and Maps form an important element in the Geotechnical Control Office's integrated approach toward the assessment of the land resources of the Territory. Dr Brand added that they compliment the new series of fifteen 1:20 000 scale Geological Maps and six accompanying Memoirs which are currently being produced by the GCO.

For further information on either the Geoguides or the GASP Reports, please contact:

Principal Government Geotechnical Engineer,
Geotechnical Control Office,
Civil Engineering Services Department,
6th Floor, Empire Centre,
68, Mody Road,
Tsim Sha Tsui East,
Hong Kong.

Creation of the Geological Society of Guilin
Report of Visit

K.L. Siu

On 10 May 1988, the Geological Society of Guilin was officially established in the City of Guilin, Guangxi, China. The ceremony took place at the Guilin College of Geology. It was attended by some 100 delegates from different geological organizations of Guilin City and Province of Guangxi. Delegates from geological societies of the adjacent Province and of the Geological Society of Hong Kong were also present. The ceremony was held from 9.30am to 5.00pm and included speeches by government officials and delegates of professional societies, election of committee members, lectures on geology and mineral resources and discussions of the draft society constitution and possible activities (such as conferences) in future. The Society will comprise four groups namely, Stratigraphy and Palaeontology; Karst Hydrogeology and Environmental Engineering Science; Mining and Investigation; and Geology and Mineral Resources. Mr Yuan Kuirong, President of Guilin College of Geology, was elected as the first Chairman of the Geological Society of Guilin.

A meeting was hold in the morning of the following day, also at the College of Geology. At the meeting, delegates of different geological societies exchanged their experience and news about the activities of GSHK in the past few years, for GSHK is a small and newly established society, in comparison with many of the others.

In the afternoon, I visited the Department of Engineering Geology and Hydrogeology at Guilin College. I was impressed by the sizes of the soil and rock testing laboratories (which must exceed 2 000m² floor area in total) and the quantity of equipment (i.e. more than 50 direct shear boxes) the Department is currently performing research on soil dynamics and rock strength, the latter involving triaxial testing of rock using a 500 Tonne Universal Testing Machine. There is an exchange programme of students and teachers between the College and several Australian Universities.

Following this, I visited the exhibition hall of the Institute of Karst Geology, Ministry of Geology and Mineral Resources. The hall has a good display of rock samples and photographs collected from other parts of China, as well as those from the Guangxi Province and the City of Guilin. The hall and the exhibition are of international standard.

For the third day, the hosts arranged a boat tour along the River Li where the beauty of the karst topography was not completely obscured by rain. Home sickness gave me a strong desire to return to Hong Kong and I eventually came home at 1am on the fourth day, after the flight was delayed for 3 hours. Fortunately, there wasn't another hijacking that day.

Contact Addresses:

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c/o Guilin College of Geology
Ministry of Geology and Guilin,
Guangxi

Mineral Resources of China
People's Republic of China
Guida Road,
Guilin,
Guangxi
(Telex : 48462 GLGEO CN) (Cable : 3310 Guilin)

Geological Society of Hong Kong Newsletter, Vol. 6, pp 42-50 (1988)

A Geological Field Trip to Western Guangdong

C.M. Lee & K.H. Liu

Twenty-eight members of the Geological Society of Hong Kong joined a geological field trip to Western Guangdong organised by the Fushan City Urban Geological Society and the Geological Society of Hong Kong, during 24th to 31st December 1987. The climax of the trip was the visit to Maoming oil shale, Shilu copper mine and the tektite deposit of Longton Village in Donghai Island, Zhanjiang City. Figure 1 provides a map of the route.

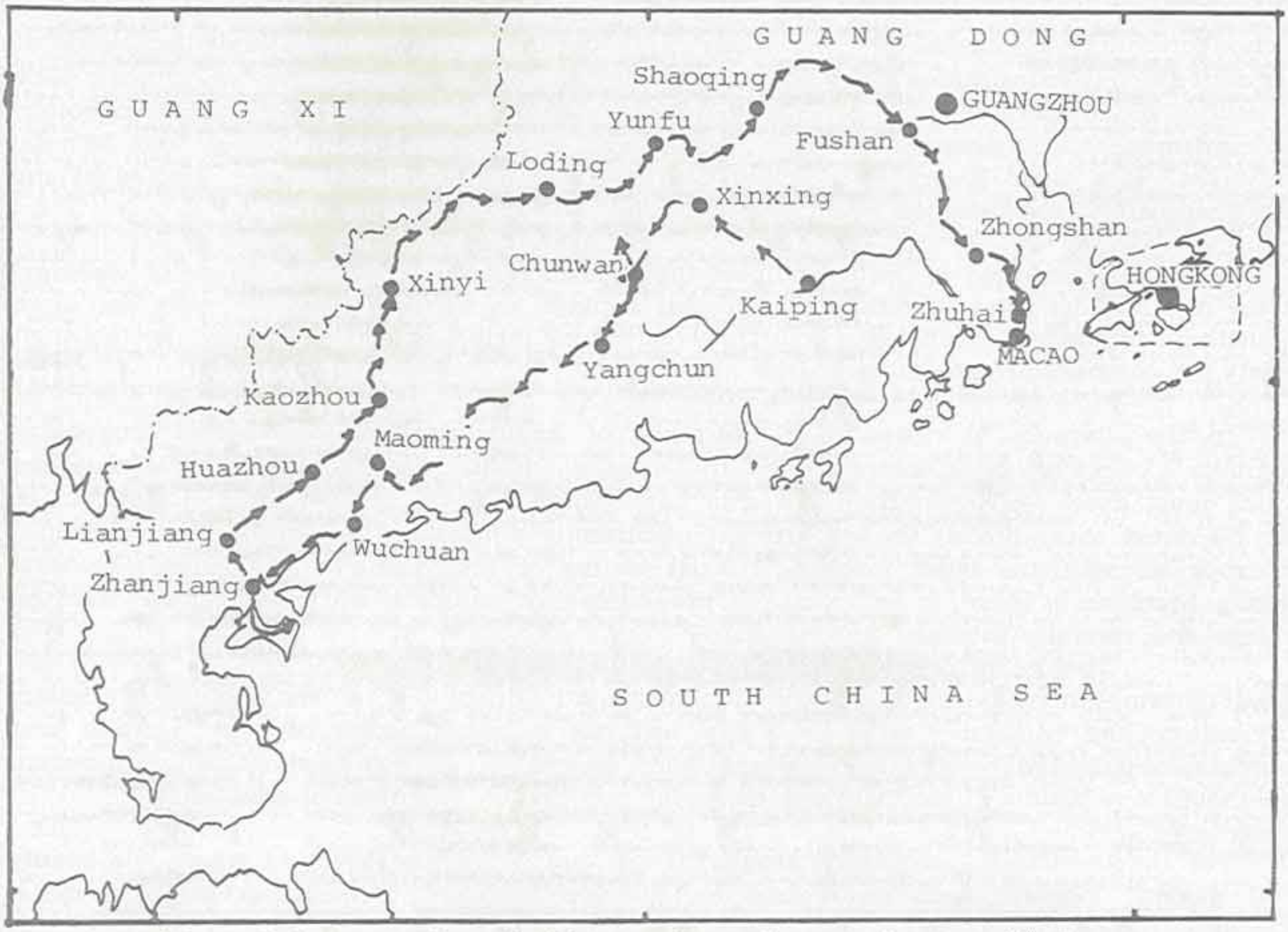

Figure 1 Map of the route through Western Guangdong, and areas visited

Seismic ground fissure and landslide, Mashi Village, Hetou District, Xinxing County

Xinxing County is in the north-west of Kaiping County. There is an elongated ground fissure by the side of a main road about 100m south of Mashi Village in Hetou District. The fissure is about 100m long and 1m wide. The landslide which accompanied the appearance of the fissure created a large volume of debris which blocked the road and caused the river channel to be shifted eastward.

The fissure was formed on 28 January 1986, about six months before the Yangjiang earthquake, and is located within the same structural fault zone. Therefore, there may be a close relationship between the fissure and the earthquake, in that it is believed that the fissure was a product of increasing stress in the Yangjiang District prior to the Yangjiang earthquake. The landslide is shown on Plate 1.

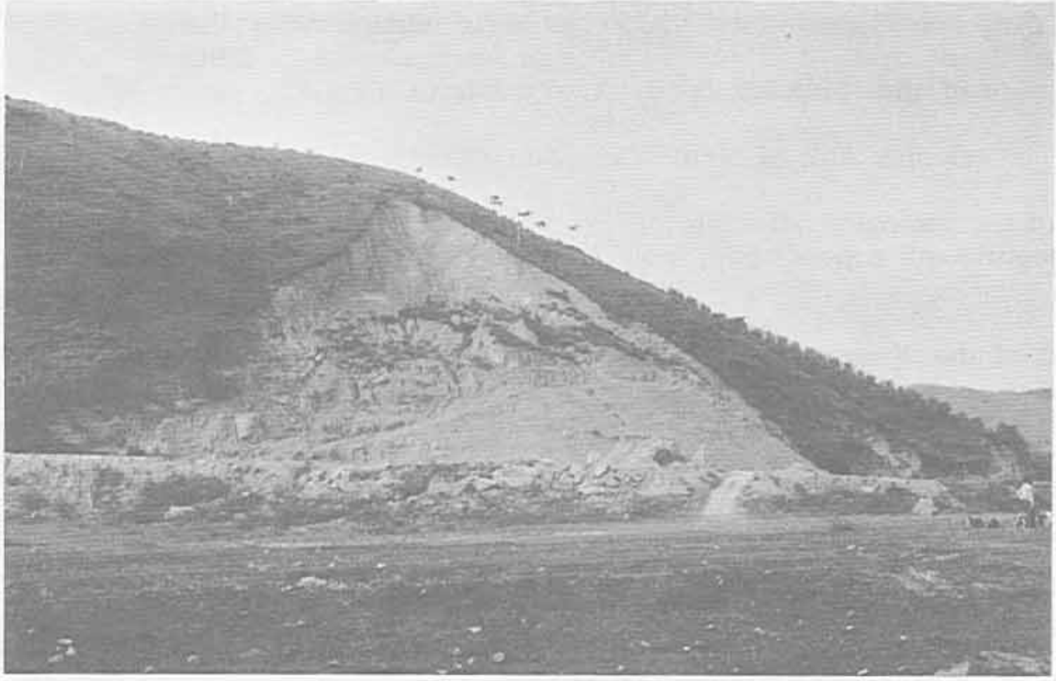

Plate 1 The landslide in Xinxing County caused by the ground fissure

Ling Shao Cave and Hong Dong Cave of Yangchun

There are several famous limestone caves in Yangchun County. Ling Shao Cave is about 29km to the north of Chunwan Town. The cave is developed along inclined bedding within Early Carboniferous limestone. The total area of the cave is about 30 000m^2. The cave is divided into three parts: the main part, the eastern part and the western part, which are at four different levels. The lowest level was formed by the erosion of underground water. Carbonation is still active in shaping the cave. Various shapes of stalactites, stalagmites and limestone pillars are found everywhere in the cave, some of which are shown in Plate 2.

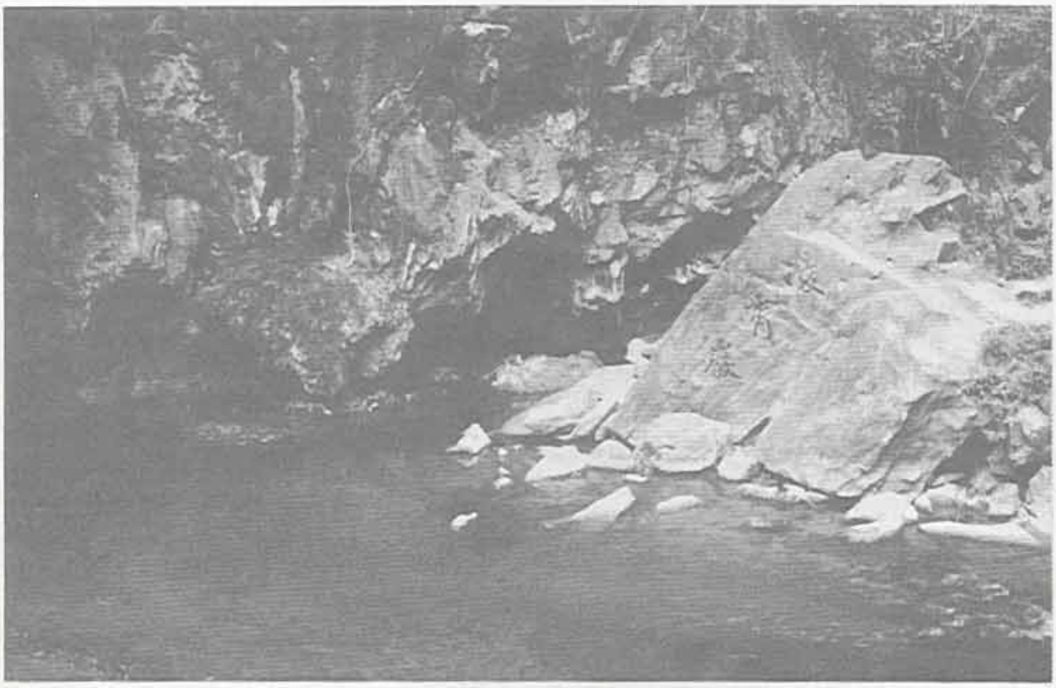

Plate 2 The sign at Ling Shao Yan Cave

Hong Dong Cave (which, in Chinese, means 'hollow' limestone cave) is located about 4km to the west of Yangchun County City. Although it is much smaller than Ling Shao Cave (which means 'very high' cave), it is one of the four famous caves in China. This cave is formed in the limestone of the Middle to Upper Carboniferous Period.

Copper Ore of Shilu, Yangchun County

The complexity of the geological structure of Yangchun enables it to be a very important mining area. Rich deposits of copper, iron, coal, tin, wolframite and pyrite can be found there.

Towards the west of the Yangchun synclinal axis, the main ore deposits lie under a flat plain. Mining here is an integrated operation including mining, sorting and refining.

The Shilu copper ore is a concealed ore body. The land surface above the ore is covered by rice fields. The ore mined is not the primary copper ore; it is only the secondary malachite which has formed several metres beneath the land surface that is worth mining for its industrial value. Plate 3 shows the opencast mining operation.

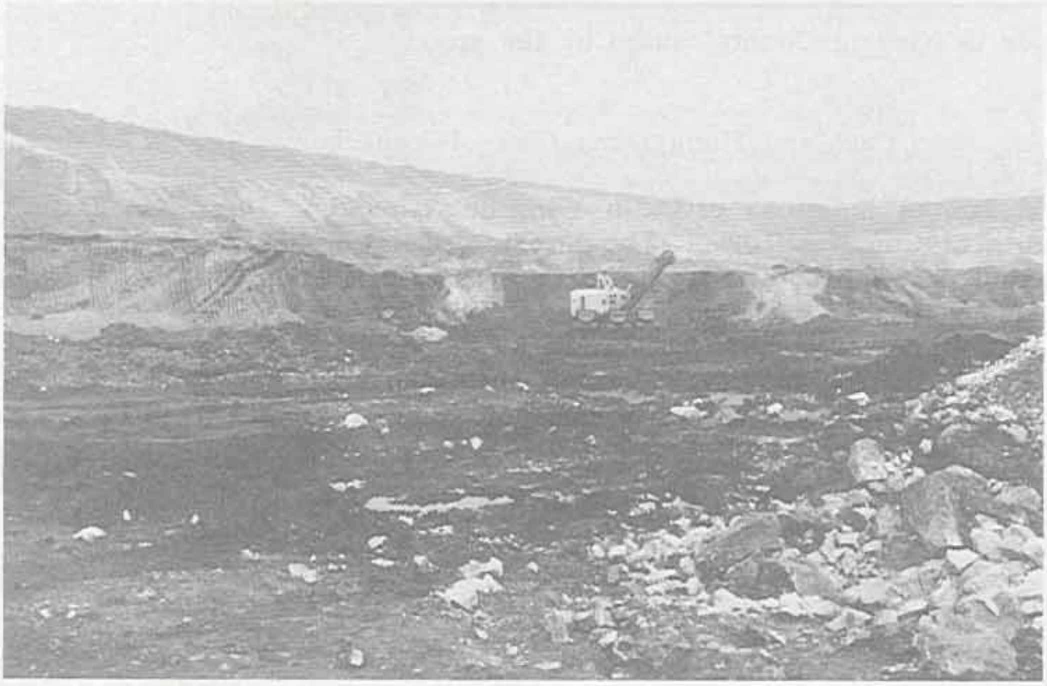

Plate 3 The opencast mining of Shilu Copper Ore

The chemical composition of malachite is dehydro copper carbonate with a copper content of 57.5%. Shilu copper ore is the largest malachite deposit in China, and as a result, Guangdong has become an important copper refining area.

Malachite can be used for copper refining and as a colouring material. When it is of dense texture and good quality, malachite can be used as gem material for ornaments and jewellery making. The columnar, fibrous, stalagmitic and botryoidal aggregations of malachite are good for artistic carving. Some malachite can also show the chatoyancy effect.

Maoming Oil Shale

This oil shale deposit is to the west of Maoming City. It extends north-west for several hundreds of kilometres. Now dipping towards the north-east, the oil shales was formed in the Eocene Series of Lower Tertiary Period. The famous Maoming tortoise fossils (Plate 4) were found within these oil shale strata.

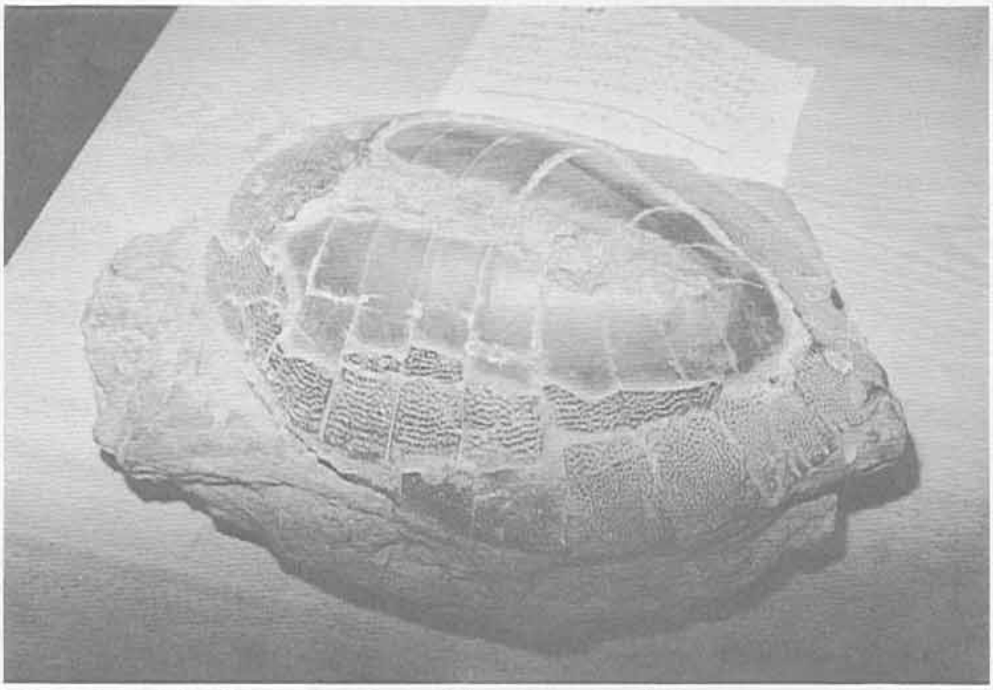

Plate 4 Fossil tortoise from Maoming oil shales

The oil shale is of high ash content and contains inflammable organic matter. Petroleum and other chemical materials are refined from these oil shales. The mine is an important oil production area in Guangdong and is operated by open-cast mining.

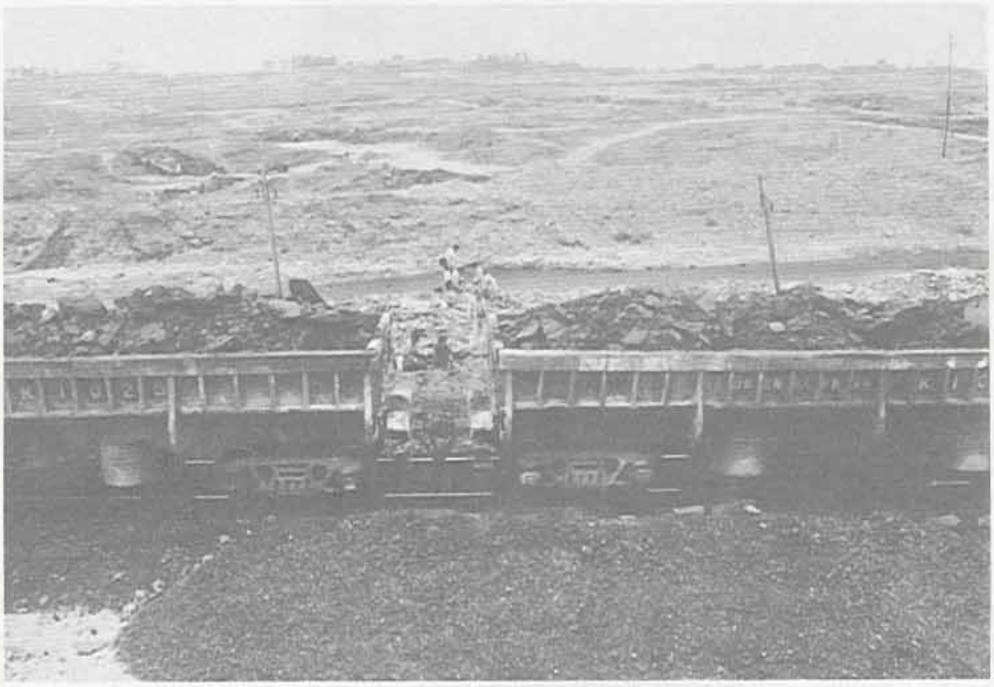

Plate 5. The transport of Maoming Oil Shale by train

A visit was also made to the Western South China Sea Petroleum Company. A brief introduction about the petroleum geology and oil prospecting in the South China Sea were given by experts from the company.

Huguangyan Park and Quaternary Basalt of Zhanjiang City

After visiting the sub-tropical Botanical Plantation, the study group went to Huguangyan Park. It is one of the eight famous scenic spots in Guangdong and is about 20 km from Xiashan in the southwest suburb of Zhanjiang City.

Huguangyan Park is surrounded by undulating small hills. The highest peak is in the eastern part of the park and is about 100m high. The total includes 2.4km^2 of waterbodies, reaching 28m depth. This park surrounds a natural lake formed from a caldera filled with water about six hundred thousand years ago in a volcanic eruption. The small hills around are of pyroclastic rock formed in Huguangyan member of the Late Pleistocene. The rock strata dip to all directions. The main rock types are basaltic laminated tuffaceous volcanic breccia, volcanic breccia, laminated volcanic breccia, tuff, lava, tuffite and cinder volcanic breccia. Seven sedimentation series of can be seen to have resulted from this volcanic eruption can be seen, some of which are shown in Plate 6.

Plate 6 Basaltic tuffite of Huguangyan Park

Quaternary Fault of the Jiaoyi Range, Zhanjiang City

A volcanic cone of pyroclastic rock, formed during the Quaternary, is located about 1 km to the northwest of Huguangyan Park. This site is now a quarry. The underlying fault plane can be clearly seen. The rocks here display laminated sedimentation characteristics. Faults are intensively arranged in these Quaternary volcanic breccia. All are normal faults and the fault planes dip to the northwest or southeast. Fault gouge and shatter zones are well displayed, therefore it is an excellent place to study neotectonic movements (Plate 7).

Wave-cut platform of Donghai Island

Rocks of the Beihai Formation of the Early Pleistocene and the Zhanjiang Formation of the Middle Pleistocene are widely distributed from the southwest of Zhanjiang City to the wave-cut platform of the Leizhou Peninsula.

Extending widely along the coast, the steep and irregular cliff above the wave-cut platform is about 20 to 30m high. The lower part of the cliff is formed of a grey clay layer and sandy gravel layer of the Zhanjiang Formation. The upper part consists of brownish yellow sandy gravel and sands of the Beihai Formation. The boundary of these two formations is easily identified.

Plant fossils can be found in the clay rock of Zhanjiang Formation while some eroded tektite can be found in the weathered material of the Beihai Formation (Plate 8).

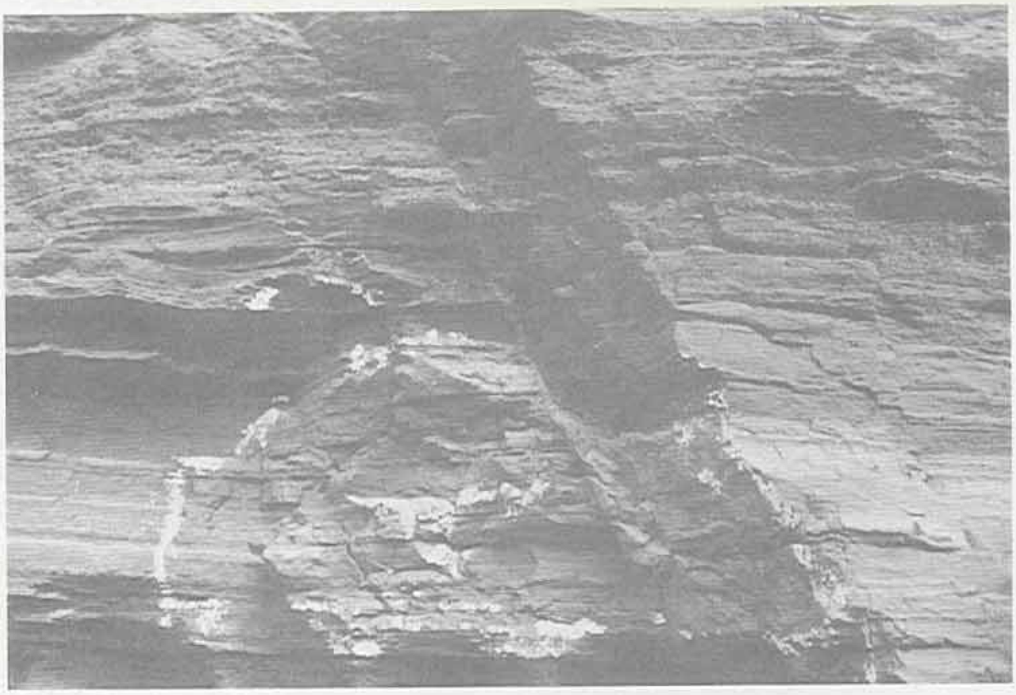

Plate 7 The Quaternary Fault of Jiaoyi Range near Zhanjiang City

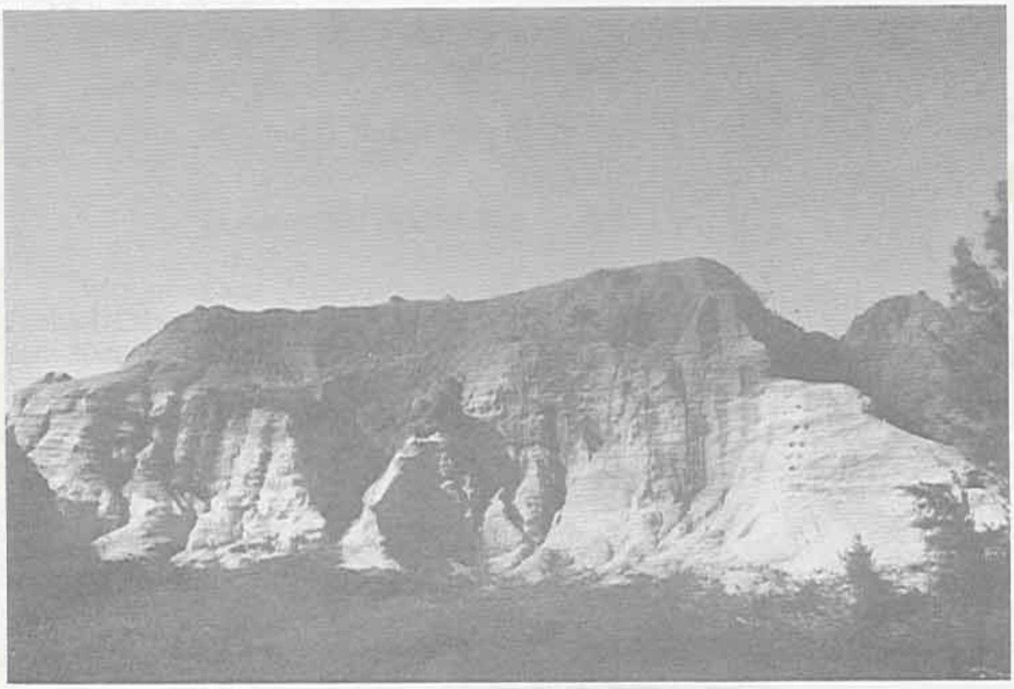

Plate 8 The Badlands of Dongjingwan Bay

Tektite in Longton Village of Donghai Island

Special arrangements were made to view the tektite collection (Plate 9) in the Longtou Village within the Dongshan District in Donghai Island was made. The wave-cut platform and cliffs of Longtou Village is also formed of strata of Zhanjiang and Beihai Formations. Many tektites are easily found in the regolith which is deposited at the base of these cliffs. Local people call these tektites "the ink of the Thunder God," or "the drops of the Thunder God."

The tektites are widely distributed. Taking the Leizhou Peninsula as the centre, tektites can be found for a radius of 200km, including Hainan Island, and may be linked with Malaysia and Australia to form the Austra-Asia Scatter Region.

A tektite is small in size and light in weight. It is a kind of glassy meteorite. Typically weighing less than 200gms, tektites are dark in colour, being mostly black or dark brown. They are very hard (hardness of 7 on Moh's scale), with a glassy lustre and conchoidal fracture (Plate 10), and may occur in various shapes, e.g. elongated, lenticular, etc. They may have a linear or viscous texture, or may possess a large head and small tail.

Plate 9 Tektite-bearing Conglomerate on shore of Donghai Island (Photo by Andy Sze)

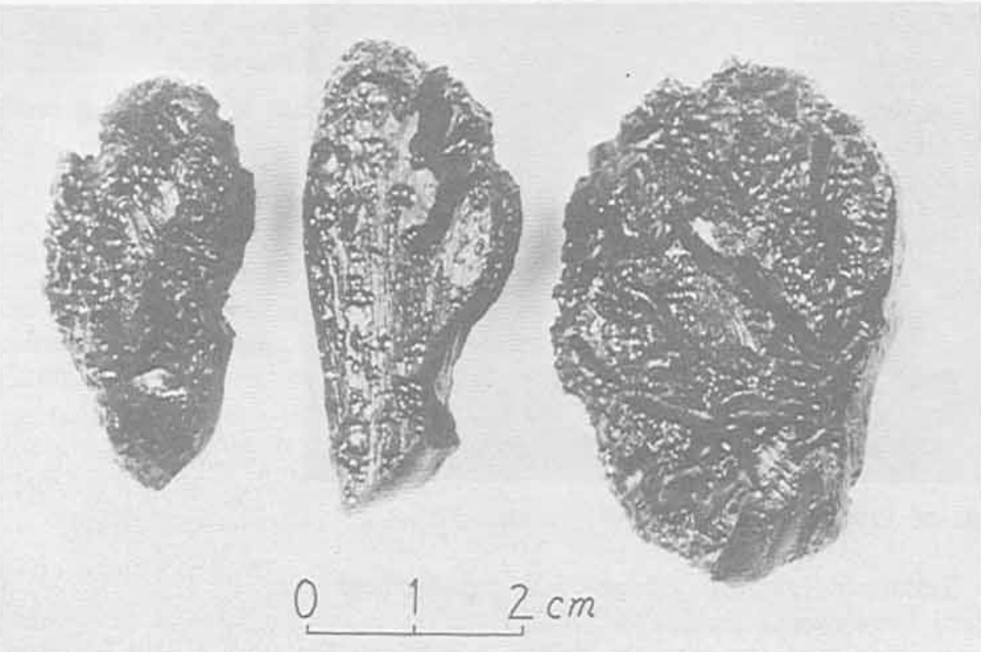

Plate 10 Texture of Tektites from Donghai Island

Surface textures of tektites can be very complicated, but may be classified into corrasion and abrasion forms. The former show surface textures of rounded pits, troughs, viscous and flow strips and the latter shows a smooth surface texture. Internally, tektites are composed of a homogeneous glassy material without any crystal grains, as has been proved by X-ray diffractography.

The main chemical composition is SiO_2 (72.85 - 75.25%) and Al_2O_3 (11.52 12.26%). Dating by the fission track method has provided an age of about 700 000 years, during the Middle Pleistocene. This is consistent with distribution of the tektites in the basal level of the Beihai Formation, which has an equivalent age. There are several explanations as to the source of the tektites. However, the most convincing is that they come from the moon. Meteorite impacts are very common on the moon's surface. Molten debris from the meteorite impact may escape the moon's gravity, and some may fall to the earth's surface, creating a limited distribution. Tektites in China are very similar to those in Australia, all being glassy meteorites.

The shape of most tektites is similar to that of a volcanic bomb or volcanic bean. The corrasion forms may be caused by the chemical corrasion of heated gases during the meteorite shock on the moon. The abrasion forms are caused by the friction of the air when the meteorites fall through the earth's atmosphere.

Visit to Fushan City

On the way to Fushan City, a visit was made to a processing factory in Xinyi County where nephrite and serpentine are used for artistic carving.

We were welcomed by the leaders of the Fushan City Urban Geology Society, although we arrived very late at night.

On the next day, we visited the Regional Geology Surveying Team of Guangdong Province, and the Fushan City Urban Geology Society.

Established about 1 300 years ago, Fushan City maintains a prominent position in the South china region. It is located 17km southwest of Guangzhou City, and has an area of about $15km^2$. The population of the city is 210 000, largely from recent rapid development.

Quaternary Basalt and Columnar Jointing in Wangzhegang Hill

Wangzhegang Hill rock mass of Fushan City is located in the southern suburbs of Fushan City. It is about 8 km from the urban area. This rock mass is more than 50m high and 30m in diameter, forming a dune-shaped small hillock.

Formed from diabase-porphyrite and basalt of the hypabyssal to ultra-hypabyssal phase, the rock mass is small and was covered by a sedimentary layer. The rocks are dark green in colour and are compact and hard with porphyritic and diabasic textures. The phenocrysts are made up of basic plagioclase, pyroxene and a little olivene and sizes can be 5-6 x 2-3 mm. The chemical composition of the rock is SiO_2 (46.3%), Al_2O_3 (17.68%), Fe (17.78%) K_2O + Na_2O_4H or K_2O + Na_2O_4 (4.43%).

The hexagonal and five-sided polygonal columnar jointing formed by basic eruptions is clearly seen in the cut slope. The intensive concentration of vertical columnar joints may denote the vent position of the past volcanic eruption. Even hollows from lava flows can be found on the exposed profile, Plate 11.

Seminar

A seminar was organized by the Fushan City Science Association and was joined by Fushan City Urban Geology Society, Fushan City Geography Society and Fushan City Pottery Society. Views on the work of an urban geologist were exchanged in the Seminar.

Later, a night visit was made to the Zumeao Temple which was built during the Sung Dynasty and is now very famous within Guangdong.

Plate 11 Columnar jointing of Basalt in Fushan

Dr Sun's Homeland

On the last day of the trip, we left Fushan City very early and went southwards to Zhongshan City. Cuihang Village of Zhongshan City is the homeland of the famous revolutionary pioneer of China, Dr. Sun Yat-Sen, called by the people "Father of the Nation". The trip ended when we left the China Town Park of Zhuhai City.

We would especially like to thank Mr. Hui Yik-Man and Mr. Chow Chun-lam for their great help during the journey and also the Fushan City Urban Geology Society for their excellent arrangement of the tour.

Geologists in the news:

Chinese Palaeontologists studying Hong Kong

Three palaeontologists from the Nanjing Institute of Geology and Palaeontology, Academia Sinica, arrived in Hong Kong on 21st November 1988, on a 6 month research project into the stratigraphy of Hong Kong. The project is funded by Hong Kong Polytechnic, and is under the direction of M.J. Atherton and C.M. Lee of the Department of Civil and Structural Engineering. They will be searching for, collecting, and identifying fossils from Hong Kong's sedimentary rocks and researching into the local stratigraphy. On their very first field trip to Nai Chung, N.T., they found 2 fossil ammonites and a large number of bivalves.

The visiting palaeontologists are:

Mr He Guo-xiong, who has a particular interest in ammonites and marine stratigraphy. He is the author of 17 published papers on Mesozoic ammonites and the stratigraphy of South China and Tibet.

Mr Chen Jin-hua, who has a particular interest in bivalves and is the author of 37 published papers on the stratigraphy and palaeontology of South China.

Mrs Wu Shu-qing, who has a particular interest in fossil plants and is the author of 10 published papers on the palaeontology of the coal series of the Northwest and South China.

Plate 1 At work in Nai Chung, N.T.

Report of a field trip to Daya Bay, 20th November 1988

M.J. Atherton

On 20th November 1988, a field trip to Daya Bay in China was organised by Mr C.M. Lee, to see the construction of the nuclear power station, a model of the reactor and the southern Daibeng Peninsula.

The trip proved to be very popular, and 88 members and their friends left Kowloon Station around 7:45am, by train for Lo Wu. Unfortunately, there was a last minute hitch in arrangements when we were told that permission to visit the power station could not be given to passport holders and civil servants, so the party divided into groups, visitors and non-visitors to the nuclear power station.

Visitors to the power station were treated to a talk and guided tour of the site, before being taken to a lookout point overlooking the power station. The non-visitors found a lookout point just outside the fence surrounding the site, and enjoyed a similar view.

An excellent lunch was served at the Nuclear Power Station Restaurant, which was enjoyed by all.

Both parties visited Xichung Bay in the south of the Daibeng Peninsula. This beautiful bay is scheduled to house an oil refinery. A major north-south fault runs down the west side of the bay faulting granite against Devonian sandstones. A new lithospheric-dynamic map of China and its surroundings (1986) suggests that this fault is an active one. The coastline shows signs of recent uplift, as much of the bay is an old lagoon separated by extensive sand bars about 5 m above sea level.

The non-visitors to the power station also visited the charming old walled town of Dai Beng and stopped to take photographs of the village of Shark River, before both partied returned to Hong Kong via Lo Wu. Only an hour was required to negotiate immigration. So ended a perfectly enjoyable day in fine weather.

Plate 1 The raised beach at Xichung Bay

Geological Society of Hong Kong Newsletter, Vol. 6, pp 53-60 (1988)

Report on International Geological Correlation Programme-related activities in Hong Kong

W.Y.-S. Yim

Department of Geography and Geology, University of Hong Kong

This report was prepared for the 1st Northeast Asian Regional Meeting of the International Geological Correlation Programme, held during 3rd-5th September 1988, at Tianjin, China.

Introduction

Hong Kong has undergone a phase of rapid expansion of interests in the field of geology since the 1970's. Although it is difficult to single out a single cause as the most influential, the following factors have all contributed:

(1) Increasing awareness of landslide hazards especially after the 1966, 1972 and 1976 disasters,

(2) The establishment of the Geotechnical Control Office by the Hong Kong Government in July 1977, leading to the recruitment of large numbers of geotechnical engineers, engineering geologists and geologists from overseas as well as locally.

(3) The establishment of the Geotechnical Group within the Hong Kong Institution of Engineers in 1980.

(4) The establishment of the Geological Society of Hong Kong during 1982 followed by a proliferation of geological activities.

(5) The decision by the Hong Kong Government to undertake a new geological survey of Hong Kong aiming at the publication of geological maps at a scale of 1:20 000.

(6) The decision by the Hong Kong Government to undertake programmes for offshore sand search.

International Conferences held in Hong Kong

The growth in interest in earth science is reflected by a succession of local, regional and international conferences, meetings and seminars held in Hong Kong since 1982. A chronological list is given below:

1982 7th Southeast Asian Geotechnical Conference, Hong Kong Institution of Engineers,

1983 Meeting on Geology of Surficial Deposits in Hong Kong, Geological Society of Hong Kong and University of Hong Kong,

1983 1st International Conference on the Palaeoenvironment of East Asia from the Mid-Tertiary, University of Hong Kong,

1984 Conference on Geological Aspects of Site Investigation, Geological Society of Hong Kong and University of Hong Kong, 1985 Seminar on Marine Geology of Hong Kong and the Pearl River Mouth, Marine Studies Group of the Geological Society of Hong Kong,

1983 1st International Conference on Rock Engineering and Excavation in an Urban Environment, Institution of Mining and Metallurgy, London,

1984 Meeting on Sea-Level Changes in Hong Kong During the Last 48 000 Years, Geological Society of Hong Kong and University of Hong Kong,

1984 Symposium on Role of Geology in Urban Development - Landplan III, Association of Geoscientists for International Development, Geological Society of Hong Kong and University of Hong Kong,

1987 2nd International Conference on Palaeoenvironment of East Asia from the Mid-Tertiary, University of Hong Kong,

1987 Seminar on Marine Sand and Gravel Resources of Hong Kong, Marine Studies Group of the Geological Society of Hong Kong,

1988 Meeting on Future Sea-Level Rise and Coastal Development, Geological Society of Hong Kong and University of Hong Kong,

1988 3rd International Symposium on Marine Biogeography and Evolution in the Pacific, Western Society of Naturalists and University of Hong Kong.

Currently, the official local contact for International Geological Correlation Programme (IGCP) matters is Dr David Workman. The local contact for Project 274 on Quaternary Coastal Evolution in which there are two participants is Wyss Yim. The correspondence address for both contacts is the Department of Geography and Geology, University of Hong Kong, Hong Kong.

Geological organisations in Hong Kong

Institutions and learned societies with an interest in earth science are given below together with details on some of their relevant activities:

(1) Geotechnical Division, Hong Kong Institution of Engineers

A division which was initially established as a group in 1980 within the professional institution for engineers. Currently this has about 400 subscribers. Main area of interest is in geotechnical engineering and engineering geology. Responsible recently for introducing a professional vetting system of individuals wishing to practice in the field.

(2) Hong Kong Geographical Association

A learned society established during 1974 with about 300 members consisting mainly of geography teachers. This association is responsible for publishing the journal *Asian Geographer*.

(3) Geological Society of Hong Kong

A learned society founded in 1982 with about 300 members. This society publishes a newsletter regularly and has two specialist groups for marine studies and teachers. Since establishment, it has been instrumental in organising a number of conferences, meetings and seminars resulting in a number of proceedings and extended abstracts. A list of these publications together with ordering details is obtainable from the Secretary, Geological Society of Hong Kong, c/o Department of Geography and Geology, University of Hong Kong, Hong Kong.

(4) Institution of Mining and Metallurgy, Hong Kong Section

Current membership is over 30. Formed in 1984 by a group of local members of the parent body in the United Kingdom. Responsible for the local organisation of the 1st International Conference on Rock Engineering and Excavation in an Urban Environment during 1986.

(5) Institution of Geologists, Hong Kong Group

Formed by a group of professional geologists affiliated to the United Kingdom parent body. Current membership is about 20.

(6) Geotechnical Control Office, Civil Engineering Services Department, Hong Kong Government

The largest employer of geotechnical engineers, engineering geologists and geologists in Hong Kong. Currently has more than 100 professional posts including a geological survey section with programmes for offshore sand search. Responsible for the publication of regional geotechnical assessment reports as well as geological maps and memoirs.

(7) Environmental Protection Department, Hong Kong Government

Employs a number of geologists for environmental impact assessment including waste management.

(8) Department of Geography and Geology, University of Hong Kong

A department established in the 1950's currently offering courses in geology to B.A., B.Sc and B.Sc. (Eng.) students. Also awards higher degrees on the same subject at M.Ph. and Ph.D. levels. Currently employs two geologists of lectureship grade. Courses offered includes general geology, environmental geology and geochemistry, and geology for civil engineers.

(9) Department of Civil and Structural Engineering, Hong Kong Polytechnic

Currently employs two engineering geologists of lectureship grade for teaching diploma courses in civil engineering.

In addition to institutions and learned societies, there are also numerous international engineering companies operating in Hong Kong who employ geologists on a full-time basis. These include Binnie and Partners, Maunsell Consultants Asia, Scott Wilson Kirkpatrick and Partners, Freeman Fox Far East Limited, Mott Hay Anderson and Partners, Ove Arup and Partners, Wilbur Smith and Associates, Fugro Hong Kong Limited, and Charles Haswell and Partners.

Interest in current IGCP projects

Table 1 provides a summary of the current IGCP projects of interest to Hong Kong with details of their relevance.

Table 1 Current IGCP projects of relevance to Hong Kong

Project number*	Degree of interest	Number of participants	Relevance to Hong Kong
216	low	–	academic interest only
218	high	1	Quaternary palaeoenvironment studies; search for marine fill; applied engineering geology
219	low	–	academic interest only
220	high	1	both tin and tungsten deposits are present locally; participant has considerable interest on geology of tin placer deposits in southeast Asia and Australia, and has attended the International Symposium on Geology of Tin Deposits in Nanning, China
221	low	–	academic interest only
235	low	–	academic interest only
237	low	–	academic interest only
245	high	–	geological mapping and research work on non-marine Cretaceous red beds
246	moderate	–	correlation of offshore deposits
250	moderate	–	crustal stability and geological hazards in the South China region
254	low	–	academic interest only
260	moderate	–	assessment of the impact of Quaternary glaciations on local sedimentation
262	low	–	academic interest only
269	low	–	academic interest only
272	moderate	–	stratigraphic correlation
271	high	2	prediction of future sea-level rise; providing understanding on offshore sedimentary sequences; availability of data for coastal modelling; search for marine fill; applied engineering geology
276	low	–	academic interest only

* See appendix for a list of the project titles.

Report on scientific progress

Scientific progress has been made in IGCP Project numbers 200, 218, 220 and 274. Since Project 274 is a follow-up to Project 200, and both are closely related to Project 218, the progress made in these projects will be dealt with together under the same heading.

(1) Project numbers 200, 218 and 274

In the summary final report of Project 200 for Hong Kong, advances in understanding were stated to have been made in the areas of:

(a) Seismic interpretation of offshore sedimentary sequences,

(b) Logging of continuously sampled offshore boreholes,

(c) Radiocarbon dating of offshore boreholes and excavated samples below the sea bed,

(d) Micropalaeontological study including pollen and spores, foraminifera and ostracoda for palaeoenvironmental reconstruction,

(e) Location of offshore sand and gravel deposits for the building construction industry.

Since the above report was produced, the total number of radiocarbon dates obtained has reached and exceeded the landmark of one hundred. Furthermore, comparative studies of radiocarbon dating with other methods of dating are undertaken by the University of Hong Kong in collaboration with overseas institutions to determine the reliability of the last interstadial ages. These results will be of interest to Project numbers 218 and 274.

An exciting recent discovery has been made by the offshore sand search programme of the Hong Kong Government. Marine geophysical and borehole investigations have revealed the existence of large reserves of marine fill which is needed for the local building construction industry. This may permit a number of ambitious land reclamation schemes from the sea to go ahead.

A number of publications including some arising from collaborative studies with institutions in China are available. A selected list is given in the section below.

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(2) Project 220

Advances have been made in the stratigraphic control of tin placer deposits in northeastern Tasmania, Australia. With further research work, it should be possible to determine whether global events are responsible for the formation of major tin placers in Australia and southeast Asia.

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Current and future activities

A continuation of interest in Project numbers 218, 220 and 271 is expected. Currently for Project 271, a collaborative study on the palaeomagnetic dating of offshore boreholes in Hong Kong between the Institute of Oceanology, Academia Sinica, Qingdao, and the Department of Geography & Geology, University of Hong Kong, is in progress. Further collaborative studies with other institutions in China and overseas are under negotiation.

Whether geologists in Hong Kong will increase their involvement in IGCP projects in the future is dependent mainly on the local need for research. Because Hong Kong has already been through a phase of rapid expansion of employment opportunities for geologists due to civil engineering-related activities, future growth is likely to be less rapid. Much will depend on the future demands of the building construction industry, and the priority given by the Hong Kong Government to set up geology departments in universities and polytechnics.

Current topics identified to be of interest to Hong Kong include:

(1) Quaternary sedimentation patterns in deltas including areas adjacent to river mouths,

(2) Geological hazards including floods, landslides and earthquakes,

(3) Natural and man-made ground movements,

(4) Application of geological data to assist environmental modelling.

New IGCP projects dealing with these topics are likely to have the best response from Hong Kong.

Appendix - IGCP Projects

216 Global biological events in earth history

218 Quaternary processes and events in South-east Asia

219 Comparative lacustrine sedimentology through space and time

220 Correlation and resource evaluation of the tin and tungsten granites in South-east Asia and the Western Pacific region

221 Pre-Jurassic evolution of Eastern Asia

235 Metamorphism and geodynamics

237 Floras of the Gondwanic continents

245 Non-marine Cretaceous correlations

246 Pacific Neogene events in time and space

250 Regional crustal stability and geological hazards

254 Metalliferous black shales

260 Earth glacial record

262 Tethyan Cretaceous correlation

269 A global database in sedimentary petrology

272 Late Palaeozoic and early Mesozoic Circum-Pacific events

271 Coastal evolution in the Quaternary

276 Palaeozoic in the Tethys

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通　訊

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