THE PETROGRAPHY OF THE ROCKS OF HONG KONG

by

Newton Fraser Gordon Davis

A Thesis submitted for the Degree of

MASTER OF ARTS

in the Department

of

Geology

R. W. Brock

The University of British Columbia

April, 1926.

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INTRODUCTION

Purpose.

"The materials dealt with in this thesis were supplied by the Geological Department of the University and were for the most part collected in the field by Dr. S.J.Schofield, while engaged on a Geological Survey of Hong Kong and the Leased Territories. This survey is being made for the Hong Kong Government by Dr. R.W.Brock with the assistnace of members of the staff of the Geological Department of the University. Dr. Brock made the preliminary arrangements including a reconnaissance of the area to be covered. He was followed by Dr. Schofield who spent a field season of about six months on the general geology and areal mapping. Dr. Williams spent the last session on the work, principally on the sedimentary rocks of the area, and Dr. Uglow is at present in the field."

This thesis is an attempt at a petrographical description and classification of the various rock types represented in the area, based upon the examinatinn of the thin sectinns.

Acknowledgements.

The above explanation of the work carried on in China has been kindly contributed by Dean R.W.Brock. The work of this thesis has been prepared under the particular supervision of Dr. S.J.Schofield who has greatly assisted the writer. The quotations regarding field description are all from Dr. Schofield's "Summary of the Geology of the Crown Colony of Hong Kong". For convenience they have been made without reference. Dr. E.M.Burwash of the Geological Department has always been willing to give suggestions regarding the microscopic work. The

microphotographs were taken with the assistance and cooperation of Mr. F.L.Fournier of the staff of the Geological Department.

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THE PETROGRAPHY OF THE ROCKS OF HONG KONG

CHAPTER ONE

GEOGRAPHY

General Geography.

The continent of Asia can be divided into four great physiographic areas. Shelving gradually upward from the low plains of Siberia the general continental level rises to a great central water-shed or divide, which stretches from the Black Sea to Behring Strait. This divide is not always marked by well defined ranges running in alignment with the general northeast-southwest direction. There are areas where the strike of the ranges is transverse to the water parting. Here lacustrine regions are found. The ranges are not high, seldom over 5000 feet elevation.

South of the divide the level drops to the central depression of the Gobi Desert, where the average elevatinn is probably less than 2000 feet above sea level. This depression extends westward from the eastern edge of the Gobi desert to Chinese Turkestan where it is limited by the great elevation of the Pamir.

South of this enclosed depression are the highly elevated table lands of Tibet, from 15,000 to 16,000 feet in altitude. These vast Tibetan highlands are bounded on the north by the Altyn-tagh and Kuen-lun mountain ranges and on the south by the Himalayas.

This whole vast mountainous area stretching from the Amur River to the Caspian Sea forms the northern boundary of the lowlands of the Arabian, Indian, Siamese and Chinese peninsulas. Bordering the low plains of the Amur and of China are the shallows of the Yellow Sea and the islands of Japan and Formosa, once integral parts of the

continent.

Between the vast central highlands and the coast of southeastern China are a series of smaller mountain chains with a general northeast-southwest trend of which the Coast Range of China is one.

This coastal area has been depressed so that the lower parts of the main valleys have been entered by the sea, giving a fiord-like appearance to the coast line. This also accounts for the numerous islands which fringe the coast line and dot the entrances to the mouths of the great rivers.

Local Geography.

"The Crown Colony of Hong Kong is situated on the southeastern coast of China in the mouth of the Canton River near its northern shore. It includes the large islands of Lan Tao with an area of 60 square miles and an area of 376 square miles on the mainland as well as the island of Hong Kong itself.

"The fine harbour of Hong Kong lies between theisland of Hong Kong on the south and the leased territory on the mainland to the north. The passage inwards from the east is through Lyee Mun pass and the western portal of the harbour opens into the Canton River.

"The islands of Hongkong and Lan Tao are simply two mountainous ridges rising out of the sea to the heights of 1850 and 3000 feet respectively. The general trend of these two islands is northeast-southwest, conforming in general to the structural direction of the whole region. The city of Victoria is built on the lower slopes of the north flank of the island and faces the harbour. Across the harbour on a narrow promontory lies the city of Kowloon, lying at the foot of the

Kowloon hills of the mainland, 1800 feet above the sea."

CHAPTER TWO

GENERAL GEOLOGY.

Geology of Asia.

"An examination of the geological map of the world will show that the Canadian-Baltic Archean province forms the positive land mass to the northwest of the Asiatic-European basin of sedimentation or negative land mass. To the southeast of this basin lies a former positive land mass called Cathaysia by Grabau which at one time formed a border land to the southeast of the basin of sedimentation. Cathaysia now lies beneath the waters of the Pacific Ocean.

"Sediments from both these positive land masses were carried into this huge basin forming the extensive deposits of Proterozoic, Palaeozoic and lower Mesozoic strata which now outcrop throughout China and Europe. In places on this basin local upwarps have permitted erosion to remove some of these sediments so that patches of Archaean rocks are exposed in various parts of China.

"Great orogenic movements during the Upper Mesozoic era laid the foundation of the present continent of Asia because no marine Tertiary strata are known in China.

"These orogenic movements caused the sediment in the basin to be warped into folds which strike in a northeast-southwest direction parallel to the present coast line of China from Hong Kong to Ning Po.

"Immense batholiths of granite were intruded simultaneously with the folding of the strata and correspond in strike with the main

trend of the mountains so that the batholiths occur as narrow elongated masses. The most easterly of these batholiths stretches from Hong Kong to Ning Po, a distance of about 800 miles and is comparable in size and geological composition to the Coast range of British Columbia.

"The Cretaceous and Tertiary of China are represented by continental and marine deposits and it is in these continental Cretaceous strata that the remains of dinosaurs and their eggs have been found in the Mongolian desert.

"During the Miocene period the great mountain building forces which built the Alps of Europe and the Himalayas of Asia simply caused an uplift of the early Tertiary peneplain and renewed the activity of the agents of erosion. Hence the continent of Asia during the Cretaceous and Tertiary periods was above sea level and undergoing erosion.

"The Crown Colony of Hong Kong forms part of the eastern edge of the great Asiatic basin of sedimentation in close proximity to the down sunken land of Cathayasia. Associated with the sediments which occur in the vicinity of Hong Kong is the largest outpouring of acidic lavas in the world".

Geology of Hong Kong.

The oldest rocks found in the area of the Crown Colony of Hong Kong are sedimentary and are Lower Cretaceous in age. These are the Tolo Channel series.

"They consist of a basal group mainly of conglomerates composed of well rounded pebbles of white quartz in a matrix of white sandstone, This conglomerate group is overlain by an alternating series of white sandstone, tuffaceous sandstone and greyish black argillite, all highly weathered their original characters being now very hard to determine."

The next group of rocks are the Repulse Bay Volcanics. These could possibly be divided into two series, a lower and older series of grey flow rocks in which occur a few bands of red tuffaceous rocks which yield a north-easterly strike, and an upper division of darker flow rocks. It is considered probable that the Repulse Bay Volcanics represent merely an interruption of the processes of sedimentation which is represented by the Tolo Channel series and the Junk Bay formation.

The Junk Bay formation is the next in order. It consists of a basal conglomerate containing pebbles of the underlying volcanics with a siliceous and tuffaceous cement. Overlying this is a series of tuffaceous sandstones with a few layers of argillites. The strike of the formation is north and south with a dip of 45 degrees to the east in the vicinity of Junk Bay.

Overlying the last formation are the Rocky Harbour Volcanics which represent the southern extremity of a vast outpouring of acid lavas along the coast. They vary considerably in their lithology, ranging from light coloured flows to very dark yet ever extremely acid flows.

The Tai Mo Shan granite sill opens the plutonic activity of the region. The rock are typically dark coloured and porphyritic in structure. The linear form of the intrusive mass and its conformity to the general strike of the whole mountain mass created the impression that it is in the form of a dyke or sill which is very likely from the structure of the rock itself.

The Hong Kong granite is the next in order of intrusion and represents the main action of the area. It is the southern extension of a great batholith which extends from Hong Kong to Ning Po and the adjacent islands. The Hong Kong granite is typically light pink in colour and coarse

grained, and is a rather acid granite.

The D'Aguilar Peak granite is a later and smaller intrusive body. The colour of this granite is grey and it is usually of a porphyritic structure.

Another later granite represented in the area is the Fat Tau Chau granite. It is later than the Hong Kong granite but its relation to the D'Aguilar Peak is unknown. This granite is pinkish in colour and is also of a porphyritic structure.

No consolidated rocks of a younger age than the Fat Tau Chau granite were seen in the area..

Representing the final phases of igneous activity in the area are found several lamprophyre and aplite dykes. Asa rule they are seen to cut the Hong Kong granite with which they appaar to be genetically associated.

"The general geology as now interpreted from limited observations may be expressed in the following geological tables.

TABLE OF FORMATIONS FOUND IN HONG KONG

	Dykes
	Intrusive contact
	Fat Tau Granite
	Intrusive contact
	D'Aguilar Peak Granite
	Intrusive contact
	Hong Kong Granite
	Intrusive contact
	Tai Mo Shan Granite
	Intrusive contact
	Rocky Harbour Volcanics
Upper	Junk Bay Formation
Mesozoic	Repulse Bay Volcanics
	Tolo Channel Series

TABULAR STATEMENT OF GEOLOGICAL EVENTS

QUATERNARY	EROSION and depression of coast with formation of Fiords.
TERTIARY. . . (PLIOCENE (MIOCENE. . . . . Uplift of peneplain (. . . . . Erosion (OLIGOCENE (EOCENE	
	Erosion
	INTRUSION OF DYKES
	INTRUSION OF THE FAT TAU CHAU GRANITE INTRUSIONS OF D'AGUILAR PEAK GRANITE
	INTRUSION OF HONGKONG GRANITE
	OROGENIC MOVEMENTS
	INTRUSION OF TAI MO SHAN GRANITE
UPPER	VULCANISM: Accumulation of the Rocky Harbour Volcanics
MESOZOIC	SEDIMENTATION: deposition of the Junk Bay formation
	VULCANISM: Accumulation of the Repluse Bay Volcanics
	SEDIMENTATION: deposition of the Tolo Channel series

CHAPTER THREE

PETROGRAPHY

The Tolo Channel Series.

Distribution.

"The Tolo Channel Series occurs as isolated patches around the Tolo Channel and Tolo Harbour.

"The finest exposure of this series occurs on the peninsula between Tolo Channel and Plover Cove where the basal members of the series can be seen. The series occur in the form of a sharp anticline, the axis of which crosses the narrow strait between Harbour Island and the above mentioned peninsula. The trend of the axis is northwesterly with a pitch also to the northwest. Hence the rocks which form the hills to the north and south of Tolo Channel rise stratigraphically in the series. The hills between Tolo Channel and Starling Inlet are composed of sedimentary rocks, and their examination was left to Dr. Williams. The north shore of Tolo Channel is mainly underlain by greatly weathered sandstone of this series. Outcrops of black shales form an elliptical-shaped mass stretching from Tsin Hang to Min Au. Exposures are seen along the shore and in the cuts of the Kowloon-Canton Railway where the contact between the argillites and the Tai Mo Shan granite is exposed. Three Fathoms Cove forms an indentation into a mass of the series which strike approximately north and south and dip to the east apparently forming the axis of an easterly plunging syncline. Conglomerates of the series cut across the peninsula north of the village of Sham Chung and lying conformably above themis a series of tuffaceous sandstone and argillite, which are well exposed along the shores of the inlet to the south of Flat Reef."

Description.

"The Tolo Channel Series consists of basal group of conglomerates composed of well rounded pebbles of white quartz in a matrix of white sandstone which is overlain by an alternating series of white sandstone, tuffaceous sandstone and greyish black argillites, all highly weathered."

The conglomerates of this group which were studied in thin sections are all more or less tuffaceous in nature. Many of them are what might be referred to as non-contemporaneous tuffs 1/ and may be called volcanic conglomerates. The origin and nature of their primary constituents is apparently igneous but they are related to exogenetic rocks by the process of their deposition and by their occurrence in beds intercalated with ordinary sediments. The fragments in many cases have a rolled appearance but some also show igneous origin by their irregular outline, in cases showing embayed borders. In them are found minerals which do not ordinarily withstand the weathering which they would be subjected to in the formation of ordinary detrital sediments, which points partly to their tuffaceous nature and partly to an extremely short transportation.

On the other hand the presence of unstable minerals predisposes the rocks to subsequent alteration. The highly weathered nature of the rocks is particularly noticeable and though this is characteristic of all the rocks of the area and is the result of climatic conditions yet it is an evidence of the presence of unstable minerals. Bombs, lapilli or streaks of lava, scoriaceous or amygdaloidal, are not characteristically present, but in some of the specimens very little evidence of water sorting is seen and the character of the matrix though difficult to decipher is evidently tuffaceous.

1/: Holmes, Arthur "Petrographic Method and Calculations" p.368

Two specimens taken along the road to Fan Ling, north of Tai Po (78) and (203) are very similar and the rocks are evidently of igneous origin. (78) is a fairly coarse-grained rock with dark grey almost black matrix, in which can be seen quartz and feldspar crystals of varying sizes. In the rock are fragments of a dark and a light grey groundmass which though not seen in the thin section seem to be crystallysed lava. Quartz occurs as large and small crystals, some showing embayed borders and others shadowy extinction. Feldspar also occurs as crystals and fragments of crystals showing effects of corrosion and weathering to calcite. Both orthoclase and plagioclase crystals are present. Well developed cleavage is seen on the orthoclase and Carlsbad twins are found. The Plagioclase shows Albite twinning. Biotite occurs as light brown and reddish brown pleochroic flakes scattered in between the large quartzes and feldspars and along their borders. Black grains of magnetite are seen along with the biotite and a few prism of apatite are present. The fragments show no alignment to deposition planes, occuring at all angles. The matrix is crystalline quartz, no glass being present. The rock might be designated as a crystalline detrital-tuff.

(203) is very similar. Quartz occurs similarly but the crystals have been somewhat rounded. Feldspar occurs as above, but also a fragment of microcline was seen. Biotite is found as above. Considerably more secondary calcite has been developed and small veins occur which cut across quartz fragments showing that the rock has undergone considerable alteration since its formatinn. The matrix is similar. This rock may be called a volcanic conglomerate which has had very little water sorting.

Two specimens from the south shore of Tolo Channel were examined.

(162) is a medium grained white conglomerate rock which weathers to a rough yellowish surface on which the quartz fragments stand out as in some of the rhyolite porphyries to be mentioned below. In the thin section large quartz grains, shattered and corroded, are seen, and a few orthoclase fragments, in a dense siliceous matrix. The rock has been greatly weathered and suggests the weathered form of (78) and (203). (163) is a coarse conglomerate consisting of reddish and white rounded pebbles in a reddish matrix. The thin section shows rounded and shattered quartz fragments in a dense siliceous matrix, through which has been developed grains of secondary quartz. This tuffaceous matrix comprises most of the rock.

On Port Island is found a coarse grained red tuffaceous conglomerate that weathers to a deep red rough surface. The thin section (184) shows rounded quartz pebbles and grains, some showing corrosion and others shattered in place. Some magnetite grains are present and the dense siliceous matrix is covered with a brown dust, an iron decomposition product.

Near Haikowi Island is found another coarse-grained conglomerate light greenish in colour. The thin section (178) shows large and small grains of quartz in a dense matrix, which is covered with clayey decomposition products. Any feldspars present have been completely altered and the clayey appearance suggests their presence at some stage.

Near Lai-Chi-Chung occurs a fairly coarse-grained light grey tuffaceous conglomerate. The thin section (175) shows large and small rounded quartz grains, some of which have been shattered and others corroded. Feldspar occurs very sparingly as rounded crystal fragments. A few muscovite flakes were seen. The matrix is dense and siliceous, in

places covered with brown dust indicating considerable weathering.

Sandstones:

The sandstones of this series vary considerably in appearance. They are all more or less weathered and exhibit transition phases from the tuffaceous conglomerates to the tuffaceous sandstones, to the more finely compacted well sorted sandstones, to almost quartzite in some cases. None evidence transportation over any considerable distance so that from the thin sections examinedd it seems apparent that the allogenic constituents are of local origin. The authigenic constituents are often of a tuffaceous nature and in some cases considerable secondary quartz has been developed which witnesses the subsequent alteration of the beds after deposition and the consequent effacing of their original characteristics, which, together with the profound weathering to which they have been subjected, makes their interpretation rather difficult.

Three specimens from the vicinity of Tai Po have been examined. Along the railway at about the 14 mile post occurs a fine grained dark reddish sandstone which weathers to a smooth shiny surface (88). Quartz occurs as rounded grains of considerably varying size. The quartz contains fluid cavities and rutile inclusions which bespeak a plutonic origin. A very few grains of orthoclase and oligoclase occur. Biotite is present in considerable amount as brown pleochroic flakes developed interstitially in relation to the quartz grains, and a few black opaque magnetite grains are seen. . The matrix is dense and siliceous and the presence of so much biotite suggests that it may be of a tuffaceous nature or at least that it has had little transportation. Another sandstone (235) found near Tai Po is fine-grained and light grey in colour and has a quartzitic appearance. Quartz occurs as rounded or sub-rounded grains and indicate

little transportation. Some show shattering since deposition, with matrix developed in the interstices. A few muscovite flakes were seen and a crystal of zircon. The matrix is dense and siliceous, though considerable white mica is also developed, and it comprises but a minor portion of the rock. On the trail to Sha-ho-Tung north of Tai Po occurs another sandstone, light reddish grey in colour which weathers to a fairly rough light brown surface. The thin section (239) shows sub-rounded quartz grains of irregular shapes and sizes in a dense siliceous matrix. A few black opaque grains of magnetite were seen and a zircon crystal. The matrix is covered with brown limonite stain in places.

In the northwest side of Segan Island at the entrance to Three Fathoms Cove and on the island to the south of it occur two greatly weathered sandstones. The first (111) is fine grained, light reddish in colour, and weathers to a light reddish brown. Quartz occurs as rounded grains of great variation in size. Some have been greatly shattered and contain glass cavities which point to a volcanic origin. A few flakes of muscovite were seen. The matrix is tuffaceous in nature and is greatly decomposed being covered with brown dust and clayey decomposition products. (112) is a similar rock but is even more weathered. The rocks appear to be of a tuffaceous nature.

Three specimens from Haikowi Island were examined in the thin sections. (136) is a fine grained light reddish grey argillaceous sandstone. Quartz grains are not numerous and vary considerably in size. The matrix composes most of the slide and contains a great deal of clay material as well as silica. Another specimen (137) is white and sugary in the hand specimen., Quartz occurs as small grains, and, as in (136) contains rutile inclusions which suggest plutonic quartz. A few flakes of musocvite are

present and some magnetite grains. The matrix is siliceous with considerable micaceous material developed. The chief authigenic mineral is quartz and it occurs sporadically as a secondary outgrowth on the quartz grains. The rock may be called a silicified sandstone. (139) is very similar though less secondary quartz is developed. There is a greater variation in the size of the grains a few being comparatively very large. A great deal of white mica is also developed in the matrix suggesting an argillaceous character.

From around Plover Cove two sandstones were examined. Near the east end occurs (179) a fairly coarse grained sandstone, with a dense red and black matrix. Rock is composed mainly of small quartz grains with considerable secondary quartz developed around them, and a few small magnetite grains, in a siliceous matrix. The development of secondary quartz is sufficient to make the rock a silicified sandstone. The other specimen (211) is light reddish in colour and exhibits a tuffaceous nature. The large and small quartz grains are rounded, but some also show corrosion. The matrix is siliceous but is stained by iron decomposition products.

On Port Island occurs a red tuffaceous sandstone which is similar in composition to the tuffaceous conglomerate (189) described from the island. The quartz grains are rounded, some show corrosion and some are shattered, and occur in a dense tuffaceous matrix.

A fine grained medium dark and yellowish grey sandstone (140) occurs on Bush Reef. The allogenic constituents are rounded quartz grains, a few small grains of plagioclase feldspar and some relatively large flakes of muscovite. The main authigenic mineral is quartz, but also in the matrix a great many small slightly pleochroic flakesof

biotite occur and a few small magnetite grains.

Near Hok Ma Chaw is found a sandstone which exhibits a schistose structure. The rock (216) is fine grained reddish grey in colour and weathers to a smooth reddish grey clayey surface. Quartz occurs as small grains and there is an abundance of flaky muscovite and considerable secondary magnetite in the thin section. The rock hasnot been sufficiently altered to become a true schist, but it possesses a shhistose structure indicated by the superabundance of white mica and its more or less parellel alignment.

A pebble in a conglomerate from Three Fathoms Cove was examined in thin section and was found to be quartzitic. Quartz grains containing rutile needles, a few flakes of muxcovite and a few magnetite grains are seen. Most of the original siliceous matrix has disappeared and the spaces between the quartz grains is taken up by the development of secondary quartz. Small veins of fine quartz occur in the thin section.

Argillites occur in the series and two thin sectionswere examined. One (113) from near Tai Po Market showed a few quartz grains scattered in the dense black clay material and developed alongg cracks. Parts of the slide were covered with iron stain. Both are very fine grained and dark grey, but in the second (173) from Knob Reef in the Tolo Channel, contains somewhat more quartz than the first, and may be called a siliceous argillite.

One chert from the series was examined (133). The section shows cryptocrystalline quartz and a great deal of chalcedonic quartz. Bunches of allotriomorphic crystals of quartz are developed throughout the section, No trace of spicules of any kind were seen.

In rather doubtful relation, but apparently interbedded with the sediments is found some volcanic rock. This occurs along the south shore of the Tolo Channel and its relation to the sediments was not clearly seen. On a point jutting out into the Channel occurs a dense black porphyritic rock (155) which weathers to a rough dark brown pitted surface. Quartz and feldspar phenocrysts and lenses of microcrystalline quartz are seen in the hand specimen. In the thin section quartz occurs as corroded phenocrysts and in the groundmass. Feldspars, orthoclase and albite plagioclase, occur as phenocrysts only, some showing corrosion. The groundmass is mainly cryptocrystalline, but microcrystalline lenses occur and in them are seen spherulitic growths. The rock is apparently a rhyolite porphyry.

Another rhyolite porphyry (161) is found in the bay south of Flat reef. It is similar to (155) but is greatly weathered. The rock weathers to a rough yellowish brown surface on which the quartz phenocrysts stand out as in a very coarse sandpaper.

Age and Relations.

"The age of the Tolo Channel series has been determined by Dr. Grabau of the Peking University from a number of ammonites collected on the north shore of Tolo Channel by Dr. Henley. Graham makes the following statement. 'The only identifiable fossils are a part of the outer whorl and impressions of inner whorls of an ammonite referred to Hoplite (Blanfendia) Wallechi (Grey) and described as a new variety var. hong kongensis Grabau, in Bulletin X105, pt. 11, of the National Geological Survey of China. The age is lower Cretaceous.

(A.W. Grabau Bull.Geol.Soc. of China, Vol. 3, 1924, p.87)

"The Tolo Channel series are the oldest rocks seen in the area under examination. It was not observed in contact with younger sedimentary series. The series is cut by the Tai Mo Shan, and Hong Kong granites."

Repulse Bay Volcanics

Distribution

"The volcanics rocks of the formation are well exposed over the southern half of the Island of Hong Kong along the shore of the sea as well as in the numerous rock cuts along the many roads which traverse the island. The slope of the hills which lie to the west of Junk Bay as well as the range of hills between Junk Bay and Port Shelter are underlain by these volcanics. The peninsula between Hebe Haven and Port Shelter is also made up of the Repulse Bay Volcanics."

Description.

These rocks represent the beginning of the tremendous outpourings of acid volcanic rocks which are found in this area. They vary in type from dense flow rocks with few or no phenocrysts developed, to rhyolite porphyries in which the phenocrysts make up most of the rock. They are in the main of varying shades of grey in colour, more or less modified by the number of phenocrysts present, though some reddish types occur. The phenocrysts are typically quartz and feldspar and the groundmass is usually of cryptocrystalline quartz in which bands of microcrystalline quartz are seen. Most of the rocks show the effects of deep weathering. All are more or less crystallised. No glassy volcanics were examined in the thin sections.

It has been suggested that this group of rocks be subdivided

into at least two series. This subdivision is made from the field observations and the rocks will be described accordingly.

The lower and older series is well exposed "on Victoria Peak and on Mount Kellet as well as on the motor road from Mt. Davis to Aberdeen." The series consists of rhyolites and rhyolite porphyries "in which occur a few bands of red tuffaceous rocks which yield a north-easterly strike."

On Mt. Kellet two specimens of dense rhyolite occur. One (4) is a dense, dark red rock showing flow structure in the hand specimen. The thin section reveals a highly altered nature. No phenocrysts are seen. The groundmass is mainly cryptocrystalline quartz in which is developed bunches of microcrystalline quartz and a great many spherulitic growths of feldspar. It shows flow structure and is nearly everywhere covered with black magnetite dust and some kaolin. Some altered hornblende occurs as bent flakes and a great deal of green pleochroic chlorite is present as its decomposition product. A few hexagonal prisms of apatite occur and there is an abundance of rutile needles in some of the small quartz crystals of the groundmass. (9) is similar but it is dark grey in colour and in place of the hornblende small flakes of biotite are seen.

On the west side of Barrack Square occurs a dark grey green rock (8) which more nearly approaches a hypabyssal type. A few quartz phenocrysts occur but the phenocrysts are mainly of orthoclase and oligoclase. Both feldspars are corroded and contain glassy inclusions. Biotite and muscovite occur as flaky crystals in the groundmass and some accessory magnetite is present. Needles of rutile showingknee-shaped twins occur in the feldspar and a few rough pinkish isotropic grains of

garnet are found. The groundmass is microcrystalline quartz. The rock is a quartz porphyry and it represents a phase of the volcanic series which cooled slowly enough to allow the groundmass to become microcrystalline, possibly it was the lower part of a thick band of flow rock.

Four specimens of rhyolite porphyries were examined, one from Victoria Peak, Lizard Road (25) two from near Aberdeen (27) and (28), and one (33) from near the Taikoo Sanitorium. (25) consists of large corroded quartz phenocrysts, a great many orthoclase phenocrysts, some showing Carlsbad twinning, and some greatly weathered plagioclases, in a groundmassof cryptocrystalline quartz with some lenses of microcrystalline quartz. Some hornblende altering to chlorite occurs and a great many biotite flakes are seen in the groundmass. Rutile needles are seen in some of the quartz crystals and magnetite and apatite occur as accessories. In (27) colourless flakes of muscovite occur also and garnet as an accessory. The groundmass shows flowage around the phenocrysts and bands of quartz crystals are developed. Bands of evident micrographic structure also occur. No plagioclase or hornblende was seen in this section. In (28) oligoclase plagioclase is present showing both Carlsbad and Albite twinning. Muscovite is not present but tabular crystals of biotite are developed. A zircon crystal was observed and a few crystals of what is suggested to be vesuvianite.

A specimen of red tuffaceous rock (30) from Wanchai on the Aberdeen Road was examined. It is apparently a greatly altered rhyolite tuff. The original character of most of the fragments is completely obscured though corroded crystals and fragments of quartz and orthoclase do occur. A zircon crystal was seen and some apatite crystals. The groundmass material is completely covered with flaky kaolin though bunches

of microcrystalline quartz are seen.

"The upper division of this formation is exposed on Apli Chau and along the motor road from Aberdeen to Sai Wan on the eastern side of Hong Kong Island." This phase is also seen on the shores of Junk Bay. The rocks of this upper division do not differ materially in petrographical character from those of thelower, all being very acid volcanics.

Three specimens from Apli Chau Island were examined. (66) is a dull reddish grey rhyolite with no phenocrysts developed. The groundmass is cryptocrystalline quartz and in it are a few small biotite and muscovite flakes, Rutile needles, some apatite crystals and a few small corroded quartz.

(45) from Wong Nei Chung at the Gap to Repulse Bay and (49) on the Sheko road at the cut are very similar. (45) is more weathered and lighter in colour than (49) though considerable kaolin is developed in each. Corroded quartzes and weathered feldspars occur in both. Biotite is confined to flakes in the groundmass in (49) but a few tabular crystals are developed in 45 and a considerable amount in the groundmass The groundmasses are similar, consisting of microcrystalline quartz and feldspar exhibiting a rather slowly cooled phase not typical of these rocks At the Stone Hill Bridge occurs a dark grey rhyolite porphyry (47) in which is seen corroded and shattered quartzes, orthoclases showing zonal banding due to alteration, greatly decomposed plagioclases in a cryptocrystalline groundmass which shows flow structure and bands of microcrystalline quartz. Magnetite and garnet occur accessory and small flakes of biotite altering to chlorite.

At Sai Wan on the northeast side of the island occurs a

dark greenish grey rock (20) which may be called a potash rhyolite porphyry. This is a somewhat different type than met heretofore. Quartz does not occur as phenocrysts. The main phenocrysts are orthoclase and some albite. Hornblende, a few small grains of augite and biotite and biotite flakes occur. Apatite and zircon are accessory. The groundmass is cryptogrystalline with microcrystalline quartz in bunches.

(281) from the west side of Junk Bay and (277) from Hebe Haven are typical of the upper division and are similar. Both are dark coloured rhyolite porphyries. Both have a cryptocrystalline quartz groundmass showing flowage around the phenocrysts. Corroded quartzes and feldspars occur with orthoclase.predominating. In (281) a few granular bits of augite are seen and some flakes of muscovite. In (277) biotite and a very little hornblende occur. Rutile needles are seen in the feldspar and secondary calcite developed. Apatite and magnetite are accessory.

Age and Relations.

"The Repulse Bay volcanics were not seen in contact with the older rocks but from their areal distribution and their stratigraphical position in regard to the younger formations they are considered to be younger formations than the Tolo Channel Series and to overlie them conformably.

"On the eastern shore of Junk Bay just north of Tin Ha Wan the contact between these and the Junk Bay Formations is exposed. The basal member of the Junk Bay formation, a conglomerate in which are seen pebbles of the underlying volcanics, rests upon the eroded surface of the volcanics. The erosion interval does not represent any great time interval. It is considered probable that the volcanics represent

merely an interruption of the processes of sedimentation represented by the Tolo Channel Series and the Junk Bay formation. Another outcrop of the contact can be examined on the north shore of Port Shelter east of the village of Sin Jin.

"There is no evidence which will date the age of these volcanics since they were not seen in contact with the fossiliferous Tolo Channel Series and the Junk Bay formation has yielded no fossils. However, from the general consideration of their parallel structure to the sedimentary series, for the present they may be considered to be of Lower Cretaceous Age.

"These volcanics are cut by the Tai Mo Shan and Hong Kong granites as well as by the associated dykes of these granite intrusions.

The Junk Bay Formation

Distribution.

"The Junk Bay formation is typically exposed on the east shore of Junk Bay, north of Tin Has Wan. From here it foes north across the peninsula and is exposed on the shore of Port Shelter. The next exposure is on the northern end of Sharp Island. It then crosses to the mainland and is exposed around the shores of the bay where Wong King Li is situated. The extensions of this belt to Mirs Bay has not been definitely located although on the western shore of Mirs Bay near Wan Sai, there is an exposure of tuffaceous sandstones which correspond in lithology and thickness to the Junk Bay formation. The southern extension of these rocks passes under the sea and probably reappears at the southeasterly point of cape D'Aguilar where only a small exposure was seen."

Description.

The series in the field consists of a basal comglomerate containing pebbles of the underlying volcanics with a siliceous and tuffaceous cement, overlain by a series of tuffaceous sandstones, with a few layers of siliceous argillites. "The strike of the formation is given as north and south with a dip of 45 degrees to the east in Junk Bay. Farther north in Port Shelter it swings to the northeast and retaining the same dip is exposed on Mirs Bay near Nam Sham. The tuffaceous nature of this formation is explained by its intimate relation to the underlying volcanics which are suggested to represent but an interruption in the process of sedimentation.

Only two thin sections of this formation were examined, (40) from the east side of Junk Bay is a fine grained fairly dark siliceous argillite. An argillaceous rock in which were seen a considerable number of small quartz grains, a few feldspar grains and much black magnetite dust. In Hwang Ngai Chau Wan on the north shore of Port Shelter occurs a greatly altered tuffaceous sandstone (298(. Its sedimentary character is completely obscured in the thin section. A few large quartz and feldspar crystals were seen which appear to be endogenetic but their presence is explained by the tuffaceous nature of the rock. Fibrous scales of muscovite occurand black grains of magnetite. The matrix is dense and obscured by decomposition products.

Age.

"The Junk Bay formation rests conformably upon the underlying Repulse Bay Volcanics and is overlain conformably by the Rocky Harbour Volcanics, the contact being exposed in Rocky Harbour on the Island near Wong Nei Chau. It is cut by the Fat Tau Chau Granite on Sharp

Island and on Junk Bay near Tau Ha Wau.

No fossils have been found in the Junk Bay formation but from their parallel relation to the Tolo Channel series and the Repulse Bay Volcanics they may be considered of lower Cretaceous Age.

Rocky Harbour Volcanics

Distribution.

The volcanics rocks of the formatinn forma wide belt along the southeastern border of the New Territories where it borders on Mirs Bay. The most southerly exposure forms the island of Tung Lung. The belt there runs north, forming the eastern part of the peninsula between Junk and Clearwater Bays as well as the small islets such as the Ninepin group. Trio, Steep and Table islands, farther north Shelter Keui, Sharp and High Islands and all the islands of Rocky Harbour are formed of the columnar jointed lava. The volcanics are continued on the main land and are found around Fung Bay, Nam She Bay, Long Harbour and part of the eastern shore of Three Fathoms Cove. To the north they form Grass Island and part of Port Island.

Description.

"The volcanics occur as steep cliffs along the sea front and these cliffs are remarkable for their basaltic jointing resembling the jointing seen in the Giant's Causeway of Iceland. Many sea caves and stacks occur and in one instance on Bluff Island a natural bridge was observed."

The rocks consist of acid volcanics in the main, varying greatly in colour and in the number of phenocrysts developed. No glassy groundmass was observed and the alteration of the groundmass has gone on to such an extent that no ordinary indications of devitrifidd glass

are present. The weathering of the groundmass has proceeded to such an extent that in many cases the more resistant phenocrysts of quartz and orthoclase are made to stand out giving a very coarse and rough surface to the rock. Flow structure was not a prominent feature in the field, but it was noticed very prominently near the base of the flow on the noth shore of the isthmus between High Island and the mainland.

The specimens examinèd are described as nearly as possible in order from the southern part of the flow to the northern.

On the east side of Junk Bay two rhyolite porphyries (42) and (43) occur which are very similar. Corroded quartz, orthoclase, and albite plagioclase are found in each as phenocrysts, but they are few in number. Biotite occurs in (42) and magnetite and apatite are accessory in both. The groundmass in each is cryptocrystalline and shows flow structure.

Bands of microcrystalline quartz occur. In (43) spherulitic growths were seen in the groundmass. In both, inclusions were present and as under the microscope they were seen to be microcrystalline quartz they are suggested to be cognate inclusions or "enclaves homoeogenes".

(305) from the north Ninepin and (304) from Basal Island are similar in mineral composition. The same phenocrysts occur as above but more ferromagnesian minerals are developed, hornblende, biotite and some augite occur. The groundmasses arecompletely crystallysed showing a rather slow cooling though flow structure is seen in (350).

On Slope Island (286) an almost black variety occurs. The groundmass shows flow structure and some phenocrysts are elongated. (270) from the south end of Sharp Island is greenish grey in colour and has fewer phenocrysts developed. (286) is lighter in colour than (270)

has more phenocrysts developed and shows spherulitic growths in the groundmass. (251) from Nga Ju Tan has many more phenocrysts developed than any of the above and more ferromagnesians are present.

(262) from Sam Po Yik Chau and (263) from Kwai Chau are both very dark in colour but the groundmass of each is typically cryptocrystalline quartz showing flowage around the phenocrysts and in (263) spherulitic growths are developed.

Two rhyolite porphyries from Fung Bay were examined. (198) shows greatly corroded quartzes and weathered feldspars in a dense cryptocrystalline groundmass which shows flowage around them. Phenocrysts are few, secondary calcite is developed from the feldspar and garnet occurs as an accessory. The rock is dark greenish in colour. (200) is reddish but of similar mineral composition. The groundmass does not show flowage but bands of microcrystalline quartz are developed.

Three specimens were examined from the east shore of Three Fathoms Cover (191) is a greatly weathered flow rock in which considerable secondary chlorite and magnetite is developed. Albite plagioclase is present. (192) is darker in colour and contains aligoclase and the groundmass shows flowage. (130) is similar but some hornblende is developed and bands of micrographic structure occur in the groundmass. (190) from Sham Chung is similar but no ferromagnesians are developed. (188) from the divide between Na Chi Chong and Sham Chung is nearer the hypabyssal type than the volcanic. A great many pink feldspars and quartzes occur in a dark grey and reddish groundmass. A few granular bits of augite occur, rutile needles were seen in the quartz and apatite is accessory. Secondary chlorite and magnetite are scattered throughout the section. The groundmass is microgranitic and must have cooled under

hypabysal conditions.

At Chek Kang two very dark and greatly altered rhyolites occur. (232) is dark reddish and segregations of magnetite grains are seen on the surface. A great deal of secondary calcite is developed in cracks in the rock, lined with quartz crystals. Some orthoclase crystals showing Carlsbard twinning occur in the dense groundmass which shows flow structure. (234) is similar but dark green in colour and flowage is shown by bands of dense reddish dust alternating with layers of microcrystalline quartz. These specimens represent a rather basis end phase of a flow and are greatly altered.

In Na, She Bay typical examples of the dark flow rocks are present (223) is greatly altered so that the feldspars are only seen as weathered outlines under crossed nicols . (221) is a more typical rhyolite porphyry. (226) has some augite as weel as hornblende developed. In this rock a xenolith or "enclave enallogene" of tuffaceous sandstone was seen.

A number of specimens from Long Harbour were examindd.(144) greatly resembles those to the south but the amount of quartz as phenocrysts is considerably less. Feldspars are greatly weathered to calcite and epidote. (149) and (150) are two very dark coloured types. Quartz as phenocrysts is absent and the feldspars are greatly weathered. The usual ferromagnesians are present and the typical cryptocrystalline quartz groundmass showing flowage around the few phenocrysts. (168) is of the light coloured variety. Large corroded quartzes occur and oligoclase plagioclase. The ferromagnesian minerals are scarce and garnet and apatite occur accessory. (169(is a greatly weathered light coloured rhyolite. Secondary kaolin, muscovite, and calcite occur. The rock has become

wholly micro crystalline though its original spherulitic nature can be seen. It is now micrographic in parts and some spherulitic growths can be observed. (170) is a dark reddish rhyolite in which bands of micro-crystalline quartz and spherulitic growths are present in a dense gound-mass showing fluxion structure.

On Port Island two specimens of the dark type of rhyolite porphyry were examined (180) and (181) and showed the characteristic structures and minerals of the type. In (181) micrographic structure was seen in one phase in the groundmass.

Age and Relations.

"The exact contact of the Rocky Harbour Volcanics with the underlying Junk Bay formation was not seen but many observations were made on both sides of the contact. These pointed to a conformable cntact the Junk Bay formation passing under the volcanics. Hence the volcaniss represent merely a break in the sedimentation by the outpouring of lava.

"These volcanics were not seen in contact with any later sedimentary rocks except the unconsolidated sands. They are cut by the Fat Tau Chau granite on Junk Bay, Joss House Bay and Sharp Island.

"Since the Rocky Harbour Volcanics rest conformably upon the Junk Bay formation, they belong to the same period as the formation which is probably Lower Cretaceous, although in appearance they resemble a more modern formation."

Tai Mo Shan Granite

Distribution.

The main area of Tai Mo Shan extends from the island of Lan Tan northeastward through the region of the mountain Tai Mo Shan to Tolo Harbour. The belt averages two miles in width. Smaller areas, in the form

of dykes occur on the island of Hong Kong, on High West Peak, Victoria Peak and crossing the walk from Mount Kellett to Aberdeen.

Description

Megascopically the Tai Mo Shan intrusives are dark grey porphyritic rocks. Their porphyritic nature is not particularly noticeable in the hand specimen but it is brought out by weathering. In the field a striking feature was the irregularity of grain. Quartz, feldspar, and biotite crystals and often angular and rounded graments of the intruded volcanic series are seen in a dense groundmass.

These rocks are in the main acid hypabysals ranging in type from those approaching more nearly the plutonic habit, granite porphyries 1/ to those of a more distinctly hypabysal habit, quartz-porphyries.

In these rocks quartz occurs as rounded and corroded phenocrysts and is the main constituent of the groundmass. The feldspars are orthoclase and acid plagioclase ranging from albite to oligoclase. They are corroded and usually show considerable weathering. Carlsbad and Albite twinning is common. Tabular crystals of biotite are found and flakes of muscovite in some cases. Hornblende weathering to chlorite is often present and granular augite showing alteration to uralite is seen in minor amounts. Apatite is a common accessory while magnetite zircon, and garnet sometimes occur.

A number of specimens from the vicinity of Tai Po and across Tolo Channel to the north were examined. (83) on the railroad south of Tai Po Station is a hypabysal type and shows effects of considerable strain. Quartz and orthoclase phenocrysts are shattered and give shadowy extinction. Zonal banding is seen in the plagioclase. All the

1/ Harker "Petrology for Students" p.99

typical ferromagnesian minerals occur and prisms of apatite are seen included in hornblende. The groundmass is cryptocrystalline. (84) also along the railroad is a very dark granite porphyry. Very large weathered crystals of feldspar were seen and some micropegmatitic growths of quarta and feldspar. A great many prismatic crystals of augite occur as a vein seen in the section. Augites scattered in rock are seen changing to uralite. In (87), which occurs in a railroad cut south of Tai Po, considerable amounts of hornblende and augite are developed, more than is usually found. Rutile needles were seen in some quartzes. The groundmass is cryptocrystalline.

On the mainland near No Kot Chio (102) a much lighter coloured variety of quartz porphyry occurs. Its mineral content is typical. Biotite occurs as large tabular crystals some being bent. Hornblende and augite are very minor in amount. The groundmass is dense quartz.

(208) on Padi Berd Island in Plover Cove is a quartz porphyry with the usual phenocrysts. The ferromagnesian minerals are augite and hornblende. In this rock an intergrowth 1/ of feldspar and augite was seen of the same type as the micropegmatitic intergrowth of quartz and feldspar.

A greatly altered specimen of Tai Mo Shan was taken from Sha Lo Tung. Alteration has proceeded to such an extent that in the thin section all the original characteristics of the rock are obscured. In the hand specimen it is a quartz porphyry.

Two specimens of dykes of Tai Mo Shan were examined. On the east side of Apli Chau a dark grey quartz porphyry occurs (70). The usual phenocrysts are present. Orthoclase is abundant and epidote is seen secondary. A little augite was seen. Biotite occurs as flakes in

1/ Harker, p.25 "Petrology for Students"

the groundmass which is finely crystalline quartz,

On the island of Hong Kong, along Harlech road, on Victoria Peak, a similar rock occurs. Effects of strain are seen in the thin section. Quartz phenocrysts are shattered and show shadowy extinction. No ferro-magnesian minerals except biotite were seen but there is considerable secondary chlorite and magnetite developed. The groundmass is more coarsely crystalline in patches. Zircon occurs as an accessory.

The Tai Mo Shan intrusive body has not been sufficient examined in the field to determine its form. It has however, a linear form and a strike conforming to the general strike of the whole mountain mass. The prevalent hypabysal character of the rock and the form of the intrusive body suggest a sill. It may thus represent the beginning of igneous action which was to culminate in the intrusion of the Hong Kong and associated granites.

Age.

"The Tai Mo Shan intrusion cuts the Tolo Channel Series at Tolo Harbour as well as the Victoria Volcanics and it is cut by the Hong Kong granite. It is thus the first intrusion of deep seated rocks recorded in the Hong Kong Area.

"Since this intrusion cuts the Tolo Channel Series and is itself cut by the Hong Kong granite, it is associated with Lower Cretaceous rocks and is hence of Lower Cretaceous age."

The Hong Kong Granite

Distribution.

The Hong Kong granite occupies the largest area in the colony of Hong Kong. It is part of a huge batholith extending from Hong Kong to Ning Po which is comparable in size to the Coast Range Batholith of British

Columbia. It occurs in three main belts separated by intruded rock. The easterly belt occupies the greater part of Stanley and D'Aguilar peninsulas and the neighbouring islands. The central area and the largest includes the greater part of Lamma Island, the islands between Lamma and Lan Tau and the eastern shore of Lan Tau. This mass extends northwestward as far as Tolo Channel. The southern slope of Hong Kong Island is underlain by volcanics which are a roof pendant in the granite batholith. The westerly belt was not studied in detail but is believed to occupy a wide area extending along the western border of Lan Tau as well as the Islands to the west and northwestwards through the New Territories as far as the boundary between them and China.

Description

The typical Hong Kong granite is coarse grained, holocrystalline, equigranular and light pinkish in colour. There are however, many modifications to finer grained and darker coloured varieties. In its chilled contact phase such as found against the roof pendants of Repulse Bay Volcanics on Mt. Nicholson it is a granite porphyry, usually with quartz and orthoclase phenocrysts in a fine grained light or medium grey groundmass. This granite is generally deeply weathered and bowlders, resembling glacial erratics but which are simply erosion remnants, are seen resting on the hills, particularly in the vicinity of Kowloon.

In the thin section the Hong Kong granites are seen to be typical acid granites. The quartz is seldom idiomorphic except where enclosed by microcline and frequently shows inclusions of rutile needles. The dominant feldspar is usually orthoclase in which Carlsbad twinning is common and the decomposition is to kaolin, sericite and sometimes epidote. Microcline is quite frequently seen and is abundant in some speciments. The soda-feldspars

range from albite to oligoclase. Brown pleochroic biotite is common but muscovite is very rare. Green hornblende is sometimes found and minor amounts of rough granular augite. Apatite is a common accessory, zircon sometimes occurs and also magnetite and garnet. Micropegmatitic growths are frequently seen.

On Lamma Island three very typical specimens were found. (15) from Picnic Bay is a potash granite. Microcline showing grid-iron structure is abundant and albite occurs sparingly. Garnet occurs as an accessory. The texture is hypidiomorphic. (16) is very similar but microcline is less abundant and the plagioclase is oligoclase. The feldspars show zonal growth. Considerable biotite altering to chlorite is present and some hornblende. Magnetite and zircon are accessory and secondary epidote is seen on the orthoclase. These two rocks illustrate very clearly two possible phases in the crystallisation of the same magma. (15) is the phase which has been allowed to cool the more slowly. A magma at the stage of (16) if not consolidated at that point, but allowed to cool more slowly and crystallysation to continue, would reach, in time, a phase corresponding to (15). Slower cooling of (16) would allow the ferromagnesian minerals to sink, oligoclase would disappear and albite take its place, and more microcline would form, giving such a type as (15).

A contact phase from Lo Tiko Wan was examined (17), and is microgranite1/. It is the chilled margin against Tai Mo Shan intrusives. The rock consists of an aggregate of small quartz and plagioclase crystals with a few large feldspars. Micropegmatitic intergrowths are seen. The rock is less alkaline than the more slowly cooled granitic phase.

On the island of Hong Kong a great variety of phases are found, the typical granitic, the chilled contact against roof pendants and the dyke

1/ Harker p.99 "Petrology for Students"

phase. Many dykes, off shoots of the granite, are found cutting the Repulse Bay Volcanics.

Of the granites (38) from Deep Water Bay is a light grey coarse grained rock. Its mineral contdnt is typical. (48) is similar but more greatly weathered. The feldspars show banding and are kaolinized and sericitized Ferramagnesians are present but little developed. Garnet occurs accessory. Some micropegmatitic growths are seen. (320) from West Bay is very coarse grained and pinkish. It contains some microcline. Muscovite is present as well as hornblende and biotite. Garnet is accessory.

On Stanley Peninsula and D'Aguilar Peak varying types occur. (53) is an ordinary granite. (56) is similar with some microcline and a few flakes of muscovite. Garnet is accessory. (60) has a rather porphyritic appearance. Biotite is found and apatite is accessory.(376) is a biotite granite. Micropegmatitic intergrowths were noted.

The chilled contact and dyke phases are the same. (10) Mount Nicholson is a granite porphyry. Ophitic structure was seen, a large plate of quartz including small feldspars. Orthoclase was somewhat sericitized and oligoclase accompanied it. Biotite represents the ferromagnesians and megnetite and garnet are accessory. The groundmass is a well developed microgranitic type. Garnet is very typical of these contact phases and occurs, not as good crystals, but as rough aggregate usually.

(33) is a rather unusual phase of the chilled magma type, near Tarkoo Sanitorium. Albite plagioclase occurs and some rough granular augite altering to chlorite. In it were seen a few crystals of a reddish brown rough mineral with imperfect cleavage, faint pleochroism and low interference colours which may be vesuvianite. Cf (28) of Repulse Bay Volcanics.

In the eastern part of the island a great many dykes of the granite

are found, cutting the Repulse Bay Volcanics They are all granite porphyries. In them the minerals found are those of the granites. Plagioclase ranges from albite to digoclase. Of the ferromagnesian minerals mica is the representative, usually biotite but sometimes muscovite as well. Garnet is often an accessory and micropegmatitic intergrowths are common.

(21) near Pokfulam's reservoir is a light pinkish grey variety. Garnet and some muscovite are present. Feldspars are greatly weathered and show corrosion. (22) near Cable Bay shows a great deal of micropegmatitic intergrowths of quartz and feldspar and might be called a micropegmatitic granite porphyry.

(23) near Sandy Bay is like (21) but the microgranitic groundmass is on a finer scale and more large quartz phenocrysts are present. No biotite is developed (24) on Mt. Davis shows zonal banding of the feldspars with the more basic cores weathered more than the acid rims.

Near Aberdeen occur a number of granite porphyries. The phenocrysts are of quartz, orthoclase and labite in a microgranitic graundmass. Biotite is present usually as scattered flakes in the groundmass. Apatite and magnatite are accessory. In (31) microcline occur and the accessories are numerous. In (36) muscovite is found, but biotite is abundant. In (37) there is less groundmass and great many phenocrysts.

At Wong Nei Chung on the trail to Repulse Bay occurs (52) a typical granite porphyry. At Sai Wam Creek occurs a very light coloured variety large and small corroded crystals of quartz, weathered orthoclase and albite are seen in a microgranitic groundmass Flakes and tabular crystals of biotite are present.

On the island of Sun Kong occurs a coarse grained light coloured variety (367) which shows large greatly kaolinized and sericitized orthoclase

and some albite. Some of the weathered feldspars appear to have crystallized after thq quartz so they are most likely microcline and the granite a potash granite. There is considerable chlorite after hornblende. (369(is a microgranite. A few feldspars and corroded quartz phenocrysts occur ina well developed microgranitic groundmass. Leached biotite is present with magnetite secondary from it.

Two specimens from the mainland near Amah rock were examined (229) is a potash granite, Oligoclase feldspar is present and considerable weathered microcline as weel as orthoclase. Biotite and hornblende are found in very minor amounts. (230) a dyke just below (229) is a micropegmatitic granite porphyry. The feldspars show zonal banding. Apatite and zircon occur as accessories. Micropegmatitic intergrowths are abundant.

Some specimens of the granite taken from around Tolo Channel were also examined. (77) north of Tai Po Market is a granite porphyry. The feldspars are greatly weathered and granular bits of augite are seen. The groundmass is mocrogranitic. In Plover Cove occurs (210) another granite porphyry in which hornblende is present with a little augite. This is lighter in colour than (77). In Three Fathoms Cove a pinkish granite porphyry occurs (128). Hornblende, augite, and biotite are all present in small amounts. Epidote is seen developed along cracks in feldspars. Apatite and magnetite are accessory and the microgranitic groundmass is well developed. A more reddish granite porphyry (165) occurs in Long Harbour where a mass of Hong Kong granite was seen cutting the Rocky Harbour Volcanics. Quartz present is mainly in the microgranitic groundmass. The plagioclase is oligoclase and the rock is slightly more basic than the general type.

Two similar very coarse granite porphyry dykes were seen cutting the Hong Kong granite, at Mt. Stenhouse on Lamma Island and on the road south of Tai Po. They are not found with any other rocks and are apparently connected with the Hong Kong granite being a late phase of the activity after some consolidation had taken place. Their mineral content and structure is similar to the usual granite porphyries, though the phenocrysts are of much greater size in the hand specimen. In (14) on Lamma Island some microcline occurs and small amounts of hornblende, biotite and augite are present. In (80) near Tai Po, augite and some muscovite was seen and zircon is accessory. The groundmasses are well developed micrographitic.

Age and Relations.

"The Hong Kong granite cuts the Tolo Channel series, the Repulse Bay and Rocky Harbour Volcanics and the Tai Mo Shan granite porphyry. It is cut by the D'Aguilar Peak granite and by the basic and acid dykes. It is overlain unconformably by soil and regolith.

"Since the granite cuts the Tolo Channel series it is posted Lower Cretaceous in age."

D'Aguilar Peak Granite

Distribution

The D'Aguilar Peak Granite is not very extensive. It forms a belt across the southern portion of D'Aguilar peninsula. It also occupies the western slope of Stanley Peninsula and the whole of Round Island.

Description.

Megascopically the granite is grey in colour usually porphyritic in nature with a great many orthoclases showing in a fairly coarse grained groundmass.

Microscopically hypidiomorphic quartz occurs, orthoclase and albite plagioclase. Biotite, muscovite, hornblende, and sometimes augite represent the ferromagnesian minerals. Apatite, magnetite and zircon are accessory.

These are somewhat more acidic than the Hong Kong granites, the proportion of ferromagnesian minerals usually being very small.

In (57) some microcline is present. Zonal banding of the albite was seen. Tabular crystals of biotite are present and hornblende showing good cleavage weathering to chlorite. Apatite and zircon are accessory. Rutile needles are seen in the quartz, and calcite weathering from the plagioclase. (54) a granite dyke is slightly pinkish in colour. The feldspars are greatly weathered. Muscovite, a few crystals of hornblende, and less augite are present. Magnetite is accessory.

(55) is also a granite porphyry. Considerable brown pleochroic tabular crystals of biotite are present and an equal amount of very pleochroic bluish green actinolite. Apatite and zircon occur as accessories. This rock approaches more nearly the composition of normal granite than any other of this group of rocks.

Age and Relations

"The D'Aguilar Peak granite cuts the Hong Kong granite as may be seen on the southern extremity of Stanley Peninsula as well as on the eastern shore of Stanley Bay. It was not seen in contact with younger rocks."

As this granite cuts the Hong Kong granite which has been placed as Lower Cretaceous in age and as it resembles the Hong Kong granite so closely in mineralogical composition, it may also be considered as Lower Cretaceous in age.

Fat Tau Chau Granite

Distribution.

"The Fat Tau Chau granite is well exposed at Fat Tau Chau on the northern end of Junk island. This intrusive mass comes eastward to Junk Bay peninsula forming a bold headland just north of the village of Tin Ha. It does not cross the peninsula to Clearwater Bay. A dyke-like mass of the intrusives crosses part of the peninsula to the south and borders on Joss House Bay . Two other areas of this intrusion were encountered in the colony, one on the northern tip of Sharp Island in Rocky Harbour and the other a dyke-like mass in the central portion of the same island."

Description.

The Fat Tau Chau granites are all pinkish in colour and exhibit a porphyritic structure.Pink feldspars are evident in a groundmass ranging from fine grained to fairly coarse grained.

Microscopically quartz and orthoclase are the principal constituents An acid plagioclase ranging from albite to oligoclase is frequently present in varying but always minor amounts. The ferromagnesians are represented by the micas, hornblende and augite, but in very minor quantities. The accessories apatite, magnetite and garnet are sometimes found.

At the west end of Joss House Bay where a dyke-like mass occurs crossing part of the Junk Bay peninsula is found a pink granite porphyry (39). Quartz occurs as large and small hypidiomorphic crystals with

greatly weathered orthoclase and some oligoclase. The ferromagnesians are represented by colourless flakes of muscovite which may be secondary Secondary calcite is seen on the feldspars. Magnetite garnet and apatite are accessory. Some very good examples of leucoxene are seen. This specimen is very leucocratic and might almost be calldd an alaskite,

A speciment (284) from Junk Island is very similar though horn - blende and biotite do occur. The feldspar are all greatly weathered Magnetite and pyrite are accessory and leucoxene was again seen.

Two specimens from Sharp Island are very similar. Quartz occurs only as small hypidiomorphic crystals in the groundmass. In one (268) the plagioclase is albite in the other (260) it is oligoclase.

Minor amounts of hornblende and augite are present in each. The hornblende is secondary uralite from the augite. Apatite and magnetite are accessory. In (260) secondary epidote is seen on the feldspars. The groundmass is acid, composed of quartz are lathe-shaped feldspars.

Age and Relations

"On the western side of Sun Kung Island, one of the Pu Toi group, a dyke of the Fat Tau Chau granite cuts the Hong Kong granite. The relationship to the D'Aguilar Peak granite is unknown. On Sharp Island this granite cuts the Rocky Harbour Volcanics. No consolidated rocks younger than the Fat Tau Chau granite were seen"

Its relation to the Hong Kong granite places it as the same age, Lower Cretaceous"

Dykes

Several dykes of lamprophyric and aplitic varieties were seen at various localities. As a rule they are seen cutting the Hong Kong granite with which they are believed to be genetically associated.

Leucocratic

On the railroad about 1[illegible] post from Tai Po occurs a fine grained white aplite dyke (82). Corroded quartz phenocrysts and greatly weathered and corroded feldspars showing Carlsbad twinning are seen in a microgranitic groundmass of quartz and feldspar. A few black grains of magnetite are seen.

Near Whitehead occurs a brownish white aplite dyke (108). Quartz occurs as phenocrysts and in the groundmass. Greatly kaolinized and sericitized orthoclase and some albite plagioclase are present. A few colourless flakes of muscovite are seen and a great many spherulites. The groundmass is microgranitic.

At the lowest end of Plover Cove a yellowish grey aplite dyke was found. The thin section (206) showed a mixture of quartz and lathe-shaped feldspars in which one rounded quarta phenocrysts was present. Some colourless flakes of muscovite were seen. Parts of the groundmass show a microlitic texture.

Melanocratic.

Near Tsing Hue a fine grained dark greenish dyke was seen. The thin section (326) reveals an extremely melanocratic rock. A few small grains of quartz can be seen and some greatly weathered feldspars. Hornblende occurs sparingly as pleochroic flakes. Augite is the principal constituent of the rock and shows twinning and zonal banding. Considerable secondary chlorite and black magnetite are present. Apatite and magnetite are accessory and one wedge-shaped crystal of titanite was seen. The nature of the feldspars is entirely obscured and offers no criteria for classification. Thus the rock may be called an augite-lamprophyre.1/

1/ Harker p. 132. "Petrology for Students"

On the island of Sur King occurs another augite lamprophyre Augite is the dominant constituent. A great deal of magnetite is developed in the rock with considerable secondary calcite, and chlorite, as well and many small needles of apatite.

At Sai Wan Bay a fine grained dark gr en dyke was seen. A few crystals of quartz are present and a great many highly weathered lathe-shaped feldspars.

Augite occurs as a few granular bits but the dominant ferromagnesian of the rock is hornblende as green pleochroic tabular crystals. Magnetite is present and prismatic crystals of apatite are abundant. The texture is almost pan-idiomorphic. The rock is an altered diabase.

Age and Relations

These dykes are the last phase of igneous activity evidenced in the area. They are seen to cut the Hong Kong granite with which they are considered genetically related. This association with the Hong Kong granite places the age of the dykes as Lower Cretaceous.

Chapter Four

Summary and General Conclusions

The coastal area of southeastern China, where the work upon this thesis is based was carried on, is similar in appearance to that of British Columbia. High mountains are seen flanking the coast line. The Coast line is indented by numerous fiords, the lower reaches of the great rivers are flooded and their mouths dotted with islands, the result of the sinking of the continentin the Quaternary period. A fringe of islands skirtsthe coast line. These islands are but mountainous ridges which have risen out of the sea by virtue of orogenic movements in the Upper mesozoic which folded the sediments and were accompanidd by a vast amount of igneous activity.

It is in this area that the work of investigation was carried on under considerable difficulty at times. The extremely rugged nature of the coast line and the varying andpowerful currents among the islands made the examination of them most difficult in many cases.

The oldest rocks found in the area are sediments and have been determined of Lower Cretaceous age. These are described as the Tolo Channel Series and consist of a basal conglomerate overlain by an alternating series of fine tuffaceous conglomerate, tuffaceous sandstone, sandstone and greyish black argillites. The whole series has been greatly weathered. The tuffaceous nature of the sediments is almost ubiquitous. This indicates a phase of vulcanism the original character of which has been completely effa ced by the subsequent great flows of lava and igneous intrusions. The grading from conglomerates to sandstones, to argillites, with prevalent tuffaceous nature of the coarser types, and the recurrence of this series, showsa time of encroaching and receding seas in a reginn

in which volcanic activity of the explosive ejection type was proceeding almost continuously.

This minor volcanic activity developed and finally great outpourings of lava took place and the Repulse Bay Volcanics were accumulated. Two subdivision of these volcanics can be made, a lower, generally of lighter colour with which are found interbedded a few bands of red tuffaceous rock, and an upper, generally darker in colour and noticed in places in the field to be of an agglomeratic nature. Thus it would appear that this period of accumulation of volcanics was one of the intermediate type of volcanic activity, exhibiting in its rock types both explosive ejections and quiet extrusions.

Following this a period of sedimentation is evidenced by the Junk Bay Formation. This series, consisting of a basal conglomerate, overlain by a series of tuffaceous sandstones and a few layers of argillite, marks the return of conditions as they were during the deposition of the Tolo Channel series. However, it would appear that the explosive type of vulcanism was slightly more prevalent.

The accumulation of the Rocky Harbour Volcanics followed in a period of mainly the quiet type of volcanic activity. Vast outpourings of acid lavas occurred, only the southern end of which is seen in this area. A great variety of types of flow rocks occur but their acid nature is prevalent throughout.

The first evidence of igneous activity other than vulcanism is the intrusion of the Tai Mo Shan granite sill. This sill is composed of acid hypabysal porphyries. Though essentially acidic in nature it is more basic than the succeeding granite intrusions. In it are developed more ferromagnesian minerals than are found in the granites and it is consider-

ably darker in colour.

Following this is the intrusion of the Hong Kong granite which is part of a huge batholith extending from Hong Kong to Ning Po. This intrusion is the main accompaniment of the orogenic movements which folded the sediments and caused the formation of the Coast Ranges of southeastern China.

The Hong Kong granite yields a great variety of granites but the general type is of a rather acid nature. These granites are greatly weathered and their original characteristics are frequently greatly obscured. Normal granites occur but a number are more acid than the normal type.

In comparing this batholith with the Coast Range batholith of British Columbia it will be noticed that this batholith is granitic in its revealed portions whereas the Coast Range Batholith of British Columbia is granodioritic. N.L.Bowen 1/ points out that by the crystallisation differentiation of a magma the following course taken by a liquid can be traced: basaltic--dioritic--granodioritic--granitic, etc. The upper layer of a batholith could be granitic, further down granodioritic, and so on. The Coast Range of British Columbia was intruded during the Jurassic and has been undergoing erosion since then. The Hong Kong batholith was intruded in the Lower Cretaceous and thus suffered less erosion. Hence its more acid nature is what would be expected from the consideration of the crystallisation differentiation of a magma and its age.

Another thing to be noticed in the comparison of these two batholiths is that in the Coast Range batholiths of British Columbia the roof pendants are only seen along its flanks. In the Hong Kong batholiths

1/ N.L.Bowen, "Later Stages of Evolution of Igneous Rocks" P.75.

roof pendants of the Repulse Bay Volcanics are seen to make the tops of the mountains, such as Mt. Nicholson on the island of Hong Kong. This clearly points to the lesser amount of erosion it has undergone and to the fact that it is only the upper layer of the batholith that has been exposed so far.

Following the intrusion of the great batholith there are two much smaller granitic intrusions found in this area which have been called the D'Aguilar Peak and the Fat Tau Chau. They are both seen to cut the Hong Kong granite but their relation to one another is unknown. They both appear to be related to the major intrusions in their mineralogical composition and both exhibit a porphyritic rather than a granitic structure.

An order of intrusion can be seen in these granites which would suggest that the Fat Tau Chau granite is later than the D'Aguilar Peak. The D'Aguilar Peak is very similar to the Hong Kong though as a rule less ferromagnesian minerals are developed. This shows an increasing acidity of the magma. The Fat Tau Chau shows a tendency toward increasing alkalinity. Quartz is still abundant in most cases but in some it is confined to the groundmass, the phenocrysts being orthoclase and acid plagioclase.

This order of intrusion which shows increasing acidity of the liquid for a time and increasing alkalanity in its later stages, has been described by N.L.Bowen who would modify "the normal order of decreasing basicity" thusly:

"Instead of decreasing basicity or increasing acidity it would be more correct to say increasing alkalinity, for in thelater stages increasing acidity of the liquid does not hold. Increasing alkalinity appears, however, to be maintained throughout" 1/

1/ N.L.Bowen,"Later Stages of Evolution of Igneous Rocks" P.82

In connection with the Hong Kong granite a number of granite porphyry dykes have been described which do not differ from it essentially in composition. Such dykes are called aschistic by Brögger.1/

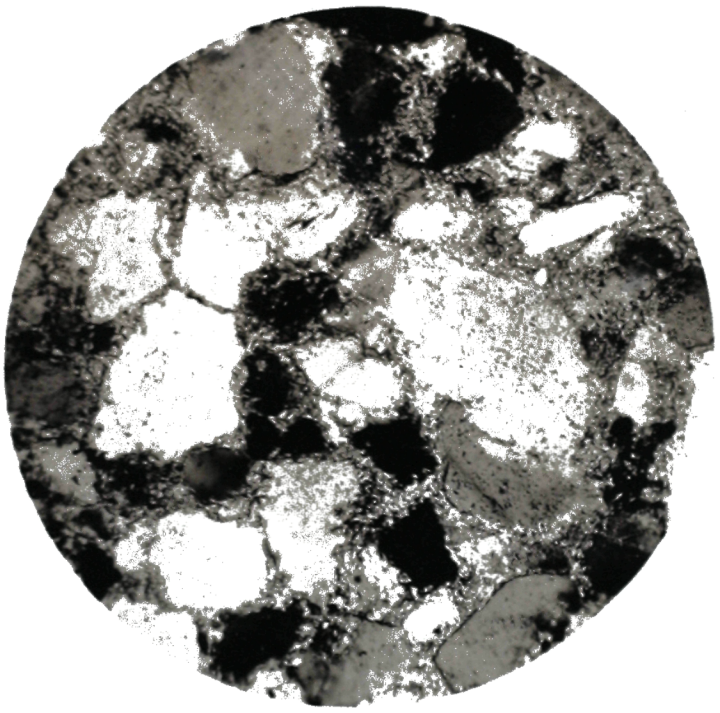
Distinct from these are the lamprophyric and aplite dykes found in the area. These greatly differentiated dykes are called diaschistic2/ and to express the particular relation which these two groups bear to one another the same author uses the term complementary3/ The intrusion of such greatly differentiated dykes after a period of much batholithic intrusion is apparently the normal occurrence.4/

These dykes are considered to be genetically related to the Hong Kong granite. They represent the extremes of differentiation, the leucocratic representing a part of the magma from which the ferromagnesian minerals have been removed and the melanocratic a part in which the ferromagnesian minerals are concentrated. The mechanics of the differentiation of such dykes has not been clearly established.

1/ Harker "Natural History of Igneous Rocks" p.11
2/ Ibid, p.111
3/ Ibid, p.112
4/ Ibid, p.25

ILLUSTRATIONS

PLATE I

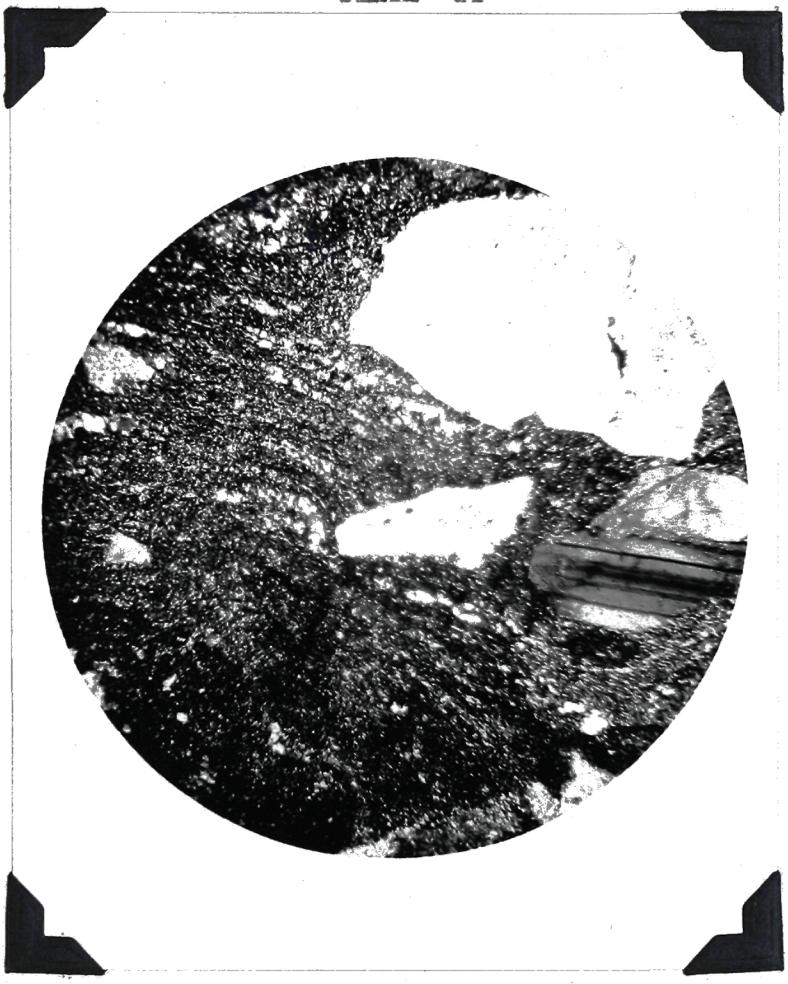


x 100

Tolo Channel series. Slide No. 235.

Sandstone - Sub-rounded quartz grains, some shattered with matrix developed in cracks. Matrix dense siliceous and micaceous.

PLATE II



x 100

Repulse Bay Volcanics Slide No. 27.

Rhyolite porphyry. Dense groundmass showing flow structure. Large upper phenocryst in microcline. Lower right is plagioclase showing twin lamellae. Small centre is microcline. Small bits of quartz in groundmass.

PLATE III

x 100

Rocky Harbour Volcanics Slide No. 200

Rhyolite porphyry. Corroded quartz phenocryst, embayed and corroded by very finely cryptocrystalline groundmass. Two black spots are holes in the slide.

PLATE IV

x 100

Rocky Harbour Volcanics Slide No. 305

Rhyolite porphyry. Weathered plagioclase, showing Carlsbad and Albite twinning. Outer edge completely kaolinized. Kaolinized feldspar in centre; weathered orthoclase to left. Microcrystalline groundmass.

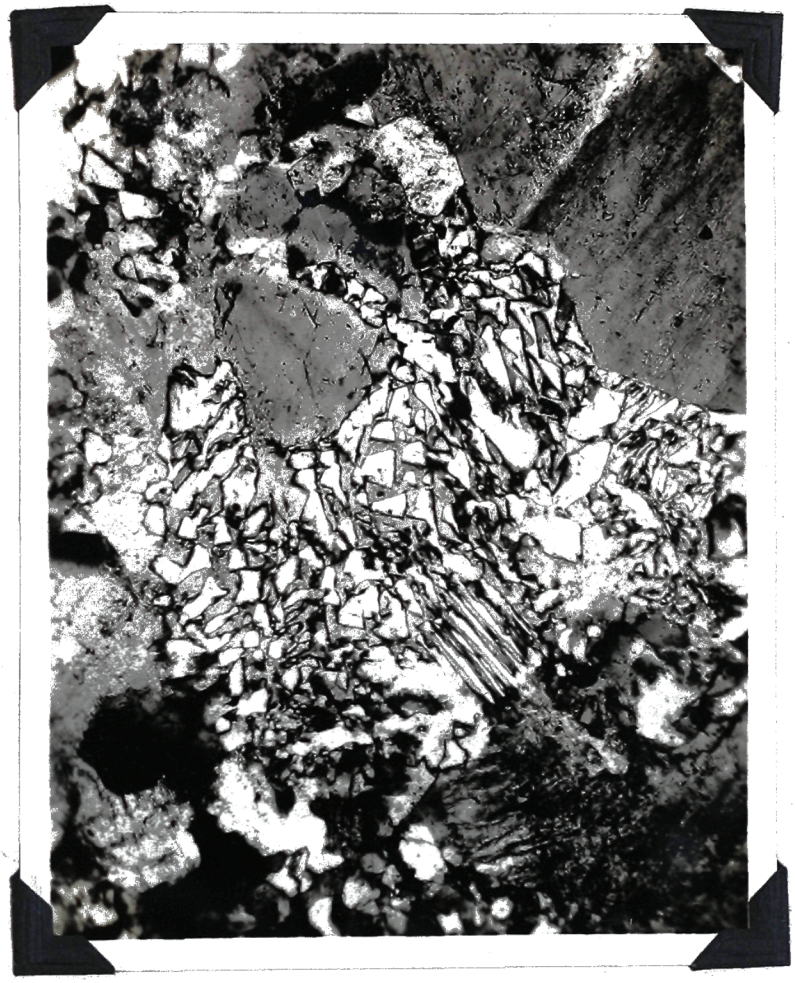
PLATE V

x 100

Rocky Harbour Volcanics Slide No. 180

Rhyolite Porphyry. Greatly weathered corroded iron stained hornblende crystal, changing to chlorite and calcite. Light crystal to right, quartz. Greatly weathered feldspars below. Dense groundmass flowing around phenocrysts.

PRATE VI

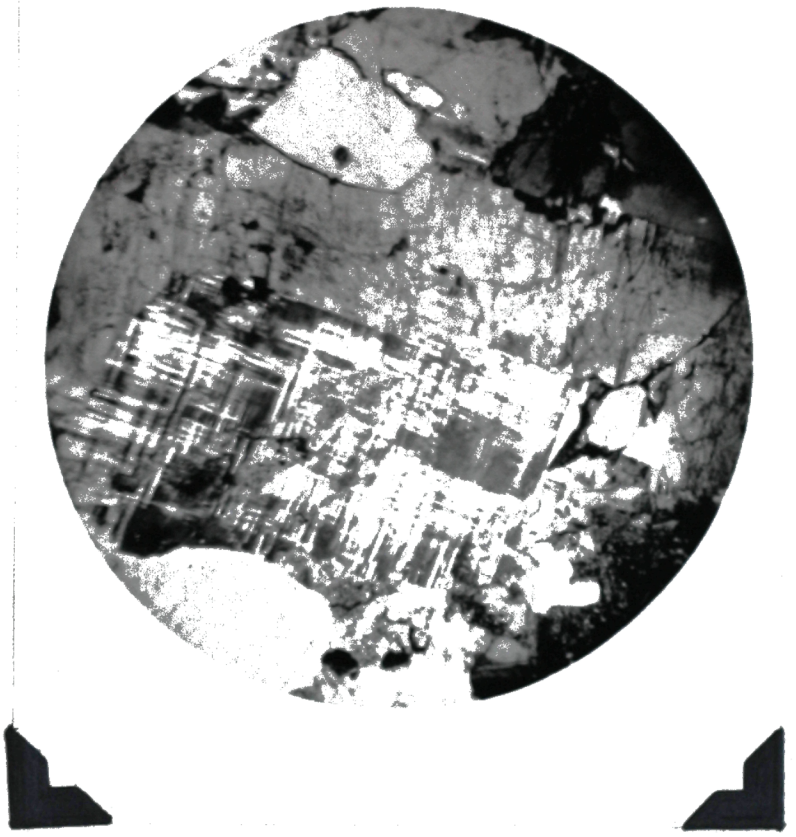


x 150

Hong Kong Granite Slide No. 230

Micropegmatitic granite porphyry. A dyke in the Hong Kong granite shows micropegmatitic intergrowth of quartz and feldspar. Dark grey is feldspar and light grey, quartz.

PLATE VII

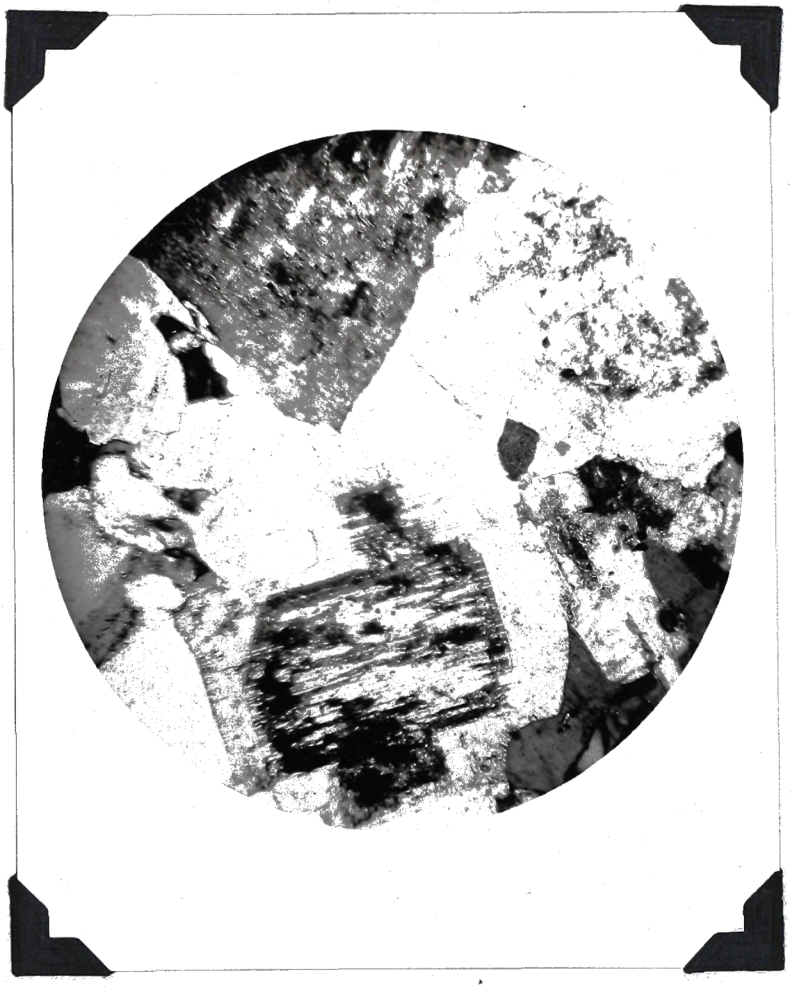


x 100

Hong Kong Granite Slide No. 16

Granite. Microcline showing grid-iron structure. Directly beneath is quartz. Dark on edge to right is plagioclose at extinction. Above this to left is quartz and to right, dark part is weathered microcline.

PLATE VIII

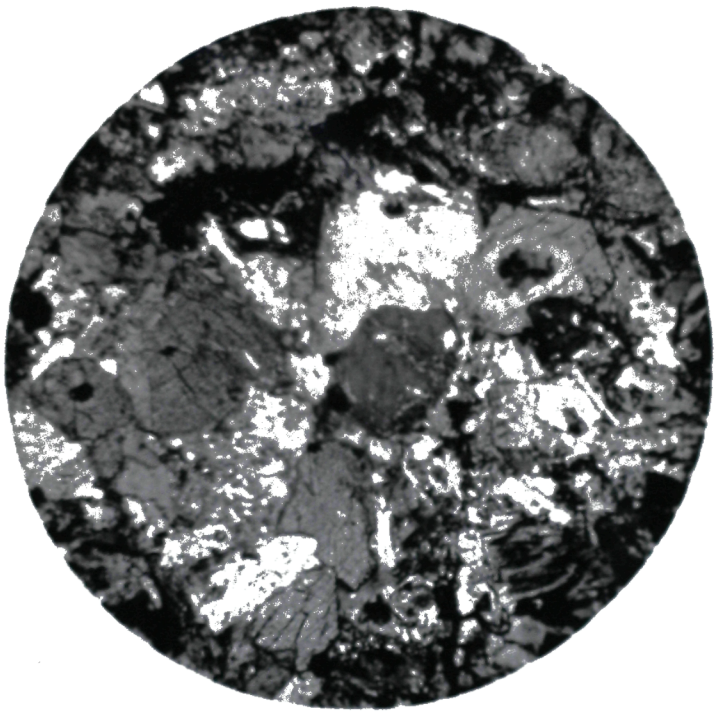


x 100

D'Aguilar Peak Granite Slide No. 57

Alkali Granite. Zonal feldspar showing weathering of inner part and twinning. Light part above is quartz. Small dark patch to right of centre is a flake of biotite. Upper right is weathered feldspar. Upper left is weathered microcline.

PLATE IX



x 100

Dyke Slide No. 326

Augite Lamprophyre. Augite crystals; black centres are magnetite. Material to lower right with black streak is chlorite. Some quartz and weathered feldspars in background.

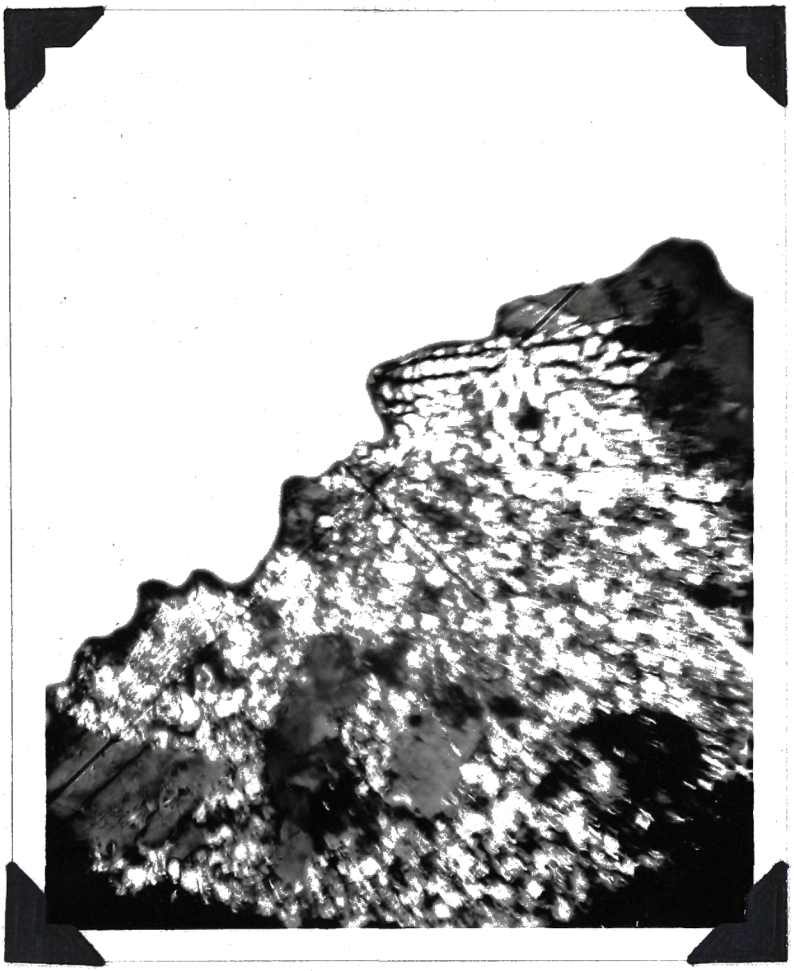
x 300

Peculiar structure developed in a rhyolite porphyry of the Repulse Bay Volcanics, slide No. 69.

Material seems to have the same optic index as feldspar. As the stage is turned three distinct phases are repeated in each quadrant of the circle. These phases are noticed particularly under crossed-nicols.

x 300

PLATE XII



x 300