# Session 1
# Topography, Geology and Rainfall - Hong Kong

[9:00 – 10:30 am, 18 February 2009]

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Geotechnical Engineering Office

1

Objective of this session:

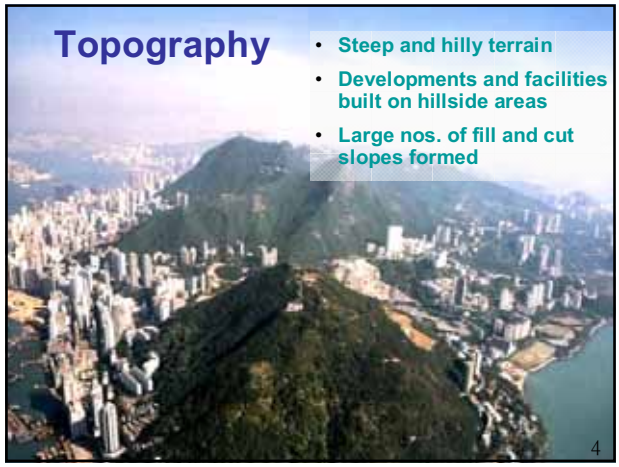
- Geographical location and topography of Hong Kong
- Geology, soils and rocks
- Rainfall

2

## Location of Hong Kong


## Topography

- Steep and hilly terrain
- Developments and facilities built on hillside areas
- Large nos. of fill and cut slopes formed



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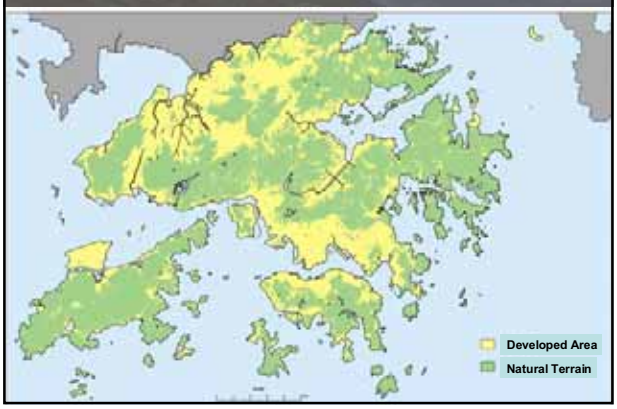
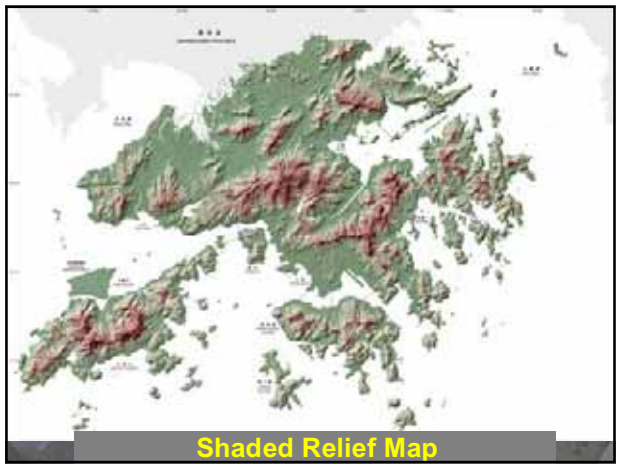
## Hong Kong in the Past

## Natural Terrain Covers ~60% of the Land Area




## Geology of Hong Kong

- Rock identification, structure, weathering, erosion, superficial deposits
- GIS Geological Maps
- e-Memoirs and Sheet Reports

9

## Applied Geology

- Collect/record/archive data/specimens
- Archive/database specimens/data
- Interpret geology (maps/reports)
- Develop geological models (slopes/tunnels)


## Awareness of what is known and what is available - Issues to Consider

- Identifying main rocks and superficial deposits
- Identifying adverse geological materials and conditions (marble, soft materials, deep weathering, permeable materials etc.)
- Understanding varied rock types and materials and complex relationships/ structures

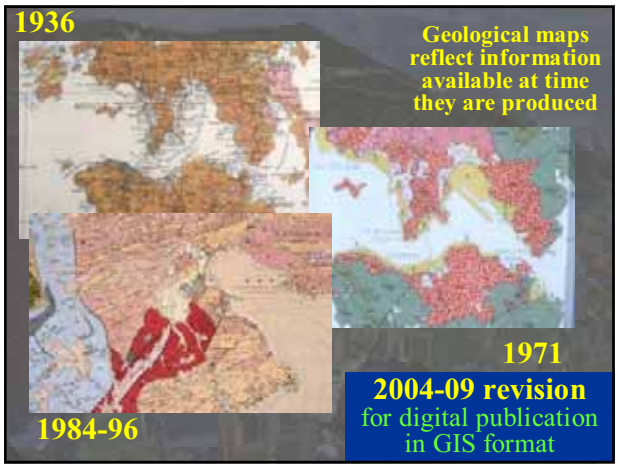
11

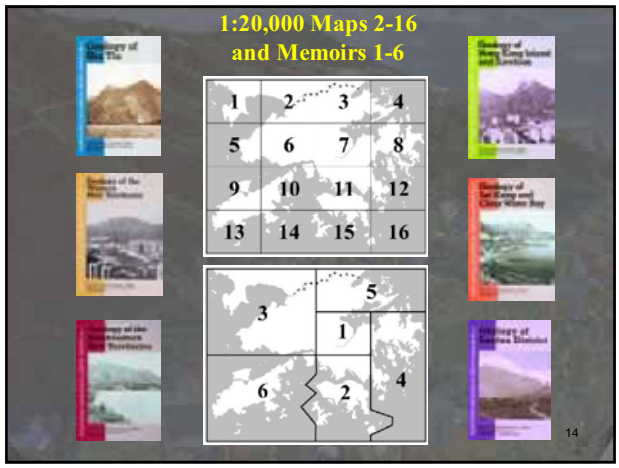
## HKGS/CEDD
## Existing geological information sources

- Geological Maps: scales 1:100K, 1:20K, 1:5K
- Geological Memoirs 1-6 & SAR-wide memoirs
- Geological Sheet Reports 1-6
- Specialist Geological Study reports
- Geoguide 2 - Guide to Site Investigation
- Geoguide 3 - Guide to Rock & Soil Descriptions

Note: HKGS = Hong Kong Geological Survey

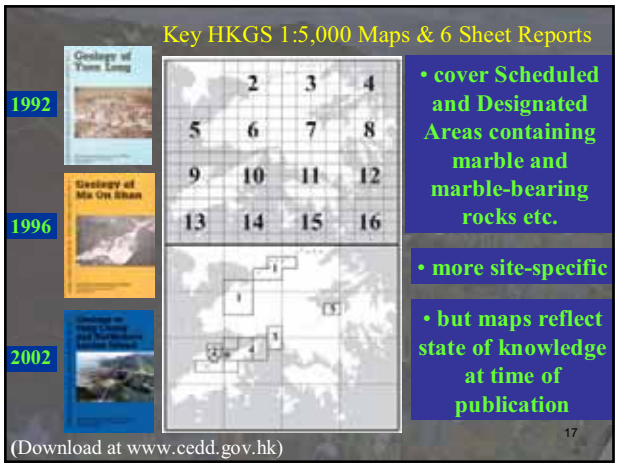
12

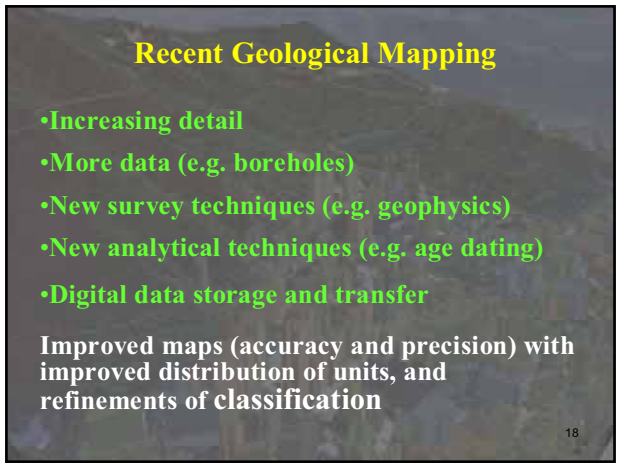

1936
Geological maps reflect information available at time they are produced
1971
2004-09 revision
for digital publication in GIS format
1984-96

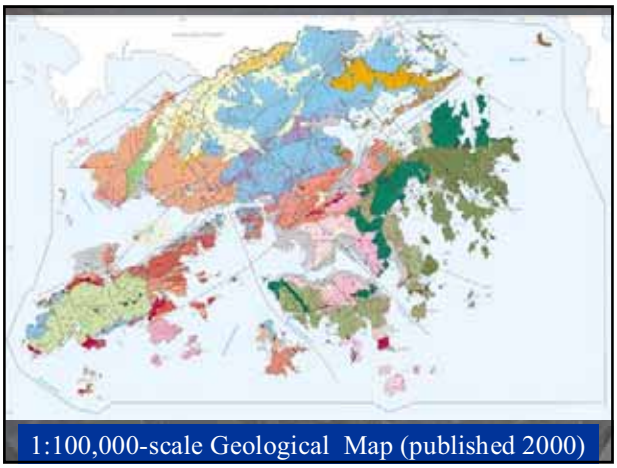

1:20,000 Maps 2-16
and Memoirs 1-6
1 2 3 4
5 6 7 8
9 10 11 12
13 14 15 16
3 5 1 6 2 4
14


1:20,000-scale geological maps
Information on solid geology and superficial deposits but not site-specific


HKGS retrieval based on geographic location (grid coordinates) uses GIS: The Geological Modelling System


Key HKGS 1:5,000 Maps & 6 Sheet Reports
1992
1996
2002
2 3 4
5 6 7 8
9 10 11 12
13 14 15 16
• cover Scheduled and Designated Areas containing marble and marble-bearing rocks etc.
• more site-specific
• but maps reflect state of knowledge at time of publication
17
(Download at www.cedd.gov.hk)


Recent Geological Mapping
•Increasing detail
•More data (e.g. boreholes)
•New survey techniques (e.g. geophysics)
•New analytical techniques (e.g. age dating)
•Digital data storage and transfer
Improved maps (accuracy and precision) with improved distribution of units, and refinements of classification
18



1:100,000-scale Geological Map (published 2000)

## The Quaternary Geology of Hong Kong with 1:100,000-scale geological maps

- Presents a comprehensive overview of the Quaternary Geology of Hong Kong, including its superficial deposits, both onshore and offshore, geomorphology, and weathering of insitu rock. The superficial deposits are described in terms of their age, stratigraphy, composition, engineering characteristics, and resource significance.

'Engineering Soil'*

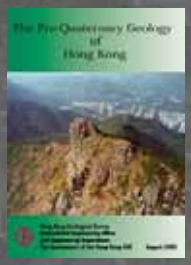
* Not engineering geology manuals

20

## The Pre-Quaternary Geology of Hong Kong with 1:100,000-scale geological maps

- Presents a comprehensive overview of the Pre-Quaternary Geology of Hong Kong, including its stratigraphy and structure. The classification and description of the rocks are discussed in detail and their ages and distributions are described and interpreted. Hong Kong rocks are also considered in relation to regional stratigraphy and tectonics.

'Engineering Rock'*

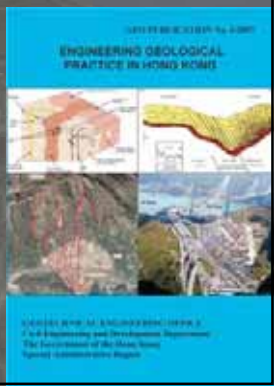


* Not engineering geology manuals

21

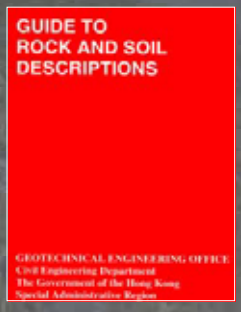
## Engineering Geological Practice in Hong Kong - GEO Publication No 1/2007

- Introduce the principles of engineering geology as applicable to Hong Kong
- Illustrate the application of these principles to civil engineering works




## Geoguide 3 – Guide to Rock and Soil Descriptions

- Presents a recommended standard of good practice for the description of Hong Kong rocks and soils for engineering purposes




23

## Some Common Rock Types


24

## Some Common Rock Types


25

## Some Common Rock Types


26

## Some Common Rock Types


27

## Some Common Rock Types


28

## Some Common Rock Types


29

## Classification and Distribution of Rocks and Superficial Deposits

- Sedimentary rocks
- Volcanic rocks
- Granitic rocks
- Metamorphic rocks and fault-related rocks
- Onshore and Offshore Superficial deposits

30

## 3 main groupings of rocks

- Older, localised sedimentary rocks, including marble, mainly in NW/NE New Territories
- Extensive volcanic and granitic rocks, some sedimentary rocks
- Younger sedimentary rocks, including those offshore

31

## Sedimentary Rocks

Grain-size and Compositional Classification, eg

- Conglomerate >2 - <60mm
- Sandstone >0.06 - <2mm
- Siltstone > 0.002 - <0.06mm
- Claystone <0.002mm

Detrital - Mudstone, siltstone, sandstone, conglomerate, and breccia

Chemical and Biological - Limestone and chert

32

## Key Older Sedimentary Rocks (c.340Ma)

Lok Ma Chau Formation

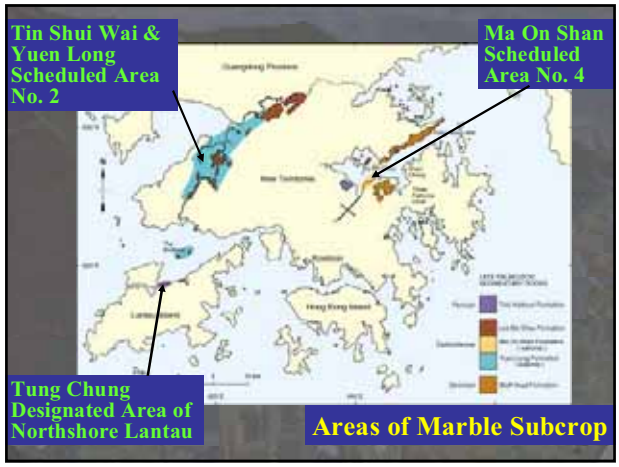
Tai Shek Mo Member - Metasandstone with metaconglomerate

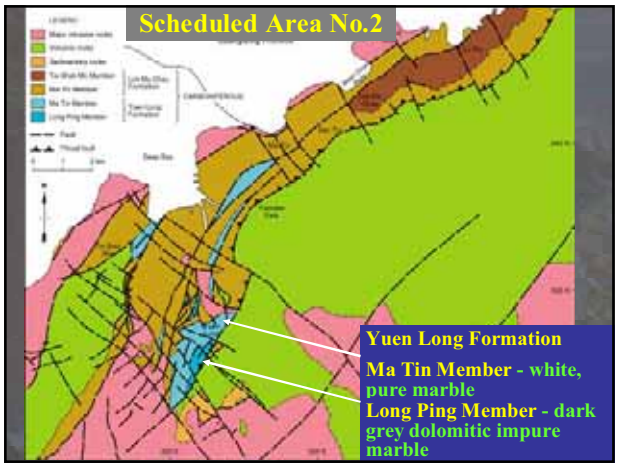
Mai Po Member - Metasiltstone with graphite schist

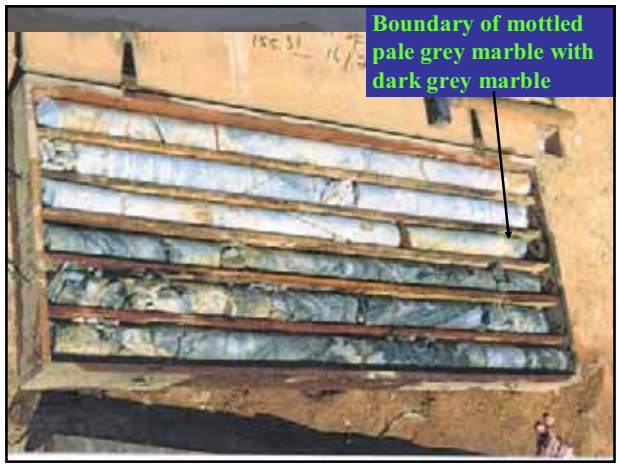
- Yuen Long and Ma On Shan Formations

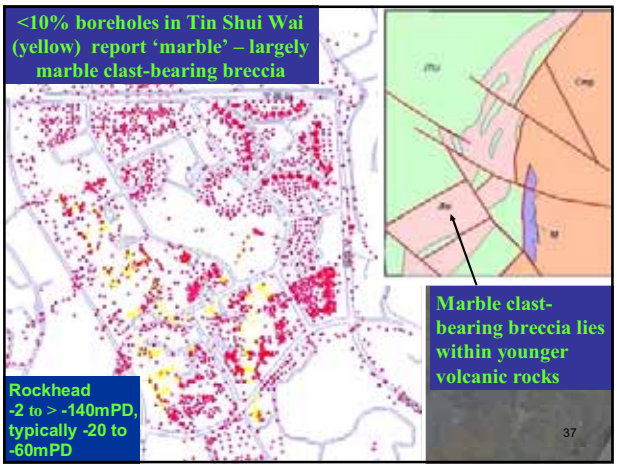
Marble (>50% carbonate) + cavity/cavity-infill Pure and Impure (up to 17% impurities)

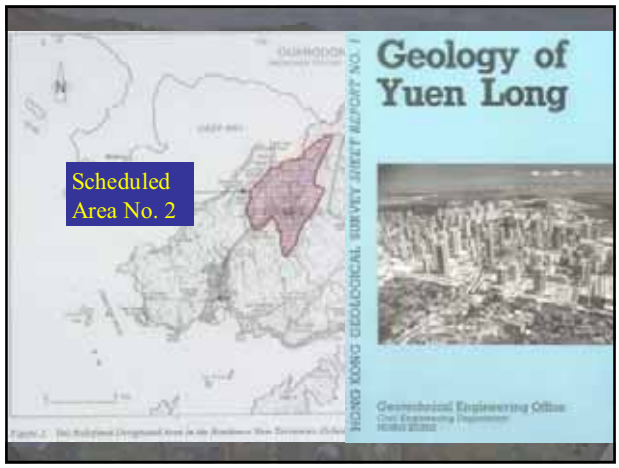
33

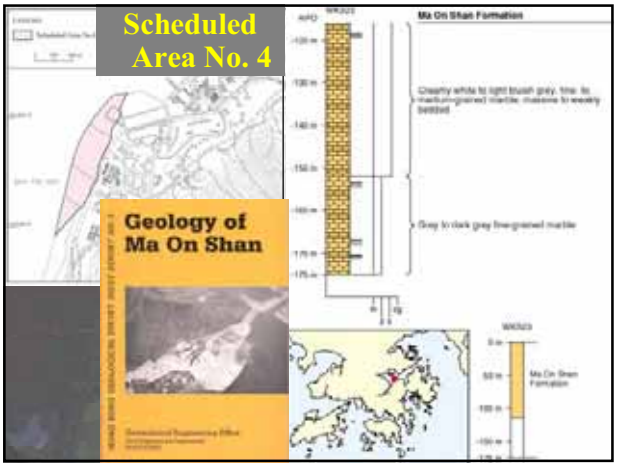


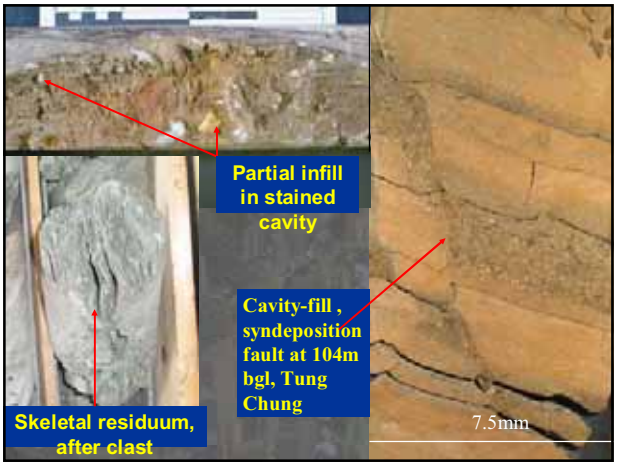




<10% boreholes in Tin Shui Wai (yellow) report 'marble' – largely marble clast-bearing breccia
Marble clast-bearing breccia lies within younger volcanic rocks
Rockhead -2 to > -140mPD, typically -20 to -60mPD
37

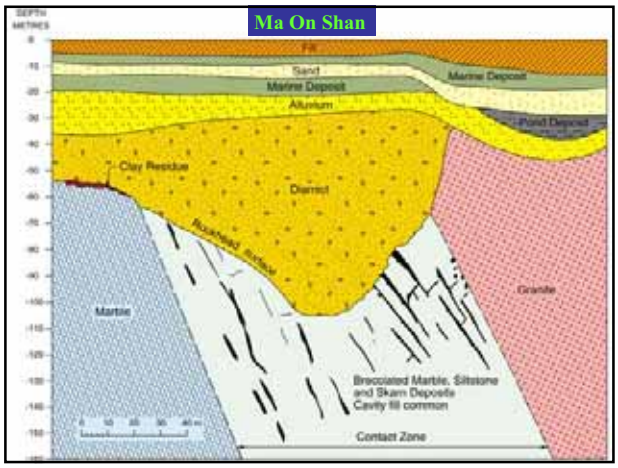

Geology of Yuen Long
Scheduled Area No. 2


Scheduled Area No. 4
Geology of Ma On Shan


Cavity development in marble NW New Territories
PHASE 3 GROUND INVESTIGATION
HOLE NO. TS200/DHPZ/164
DEPTH 51.81 m TO 54.76 m


Partial infill in stained cavity
Cavity-fill , syndeposition fault at 104m bgl, Tung Chung
Skeletal residuum, after clast
7.5mm


White marble with brown clay cavity infill, Ma On Shan



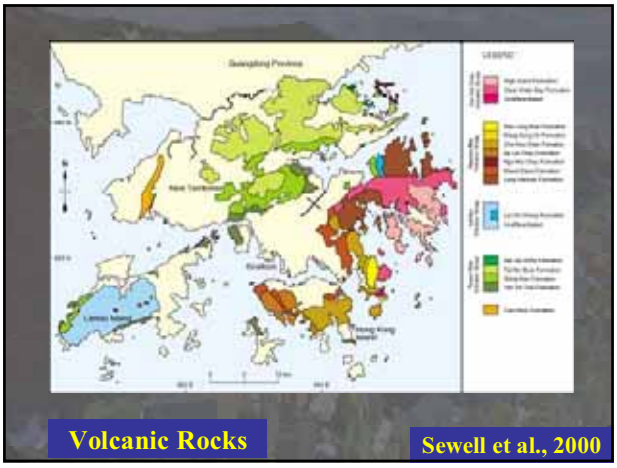


## Volcanic & Granitic Rocks

(% land surface of Hong Kong)

- Granitic Rocks 20%
- Dyke Rocks 5%
- Volcanic Rocks 50%

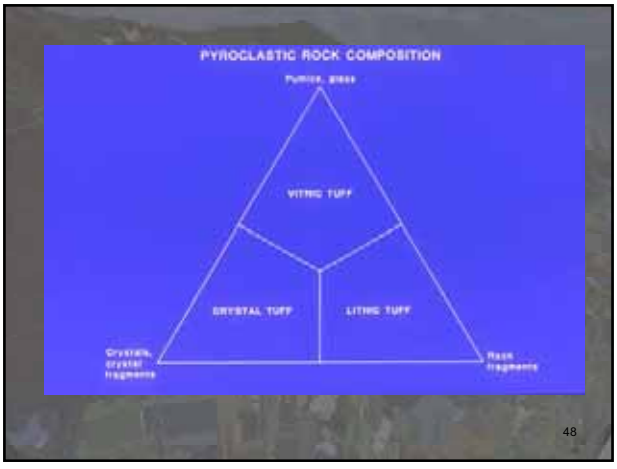
45



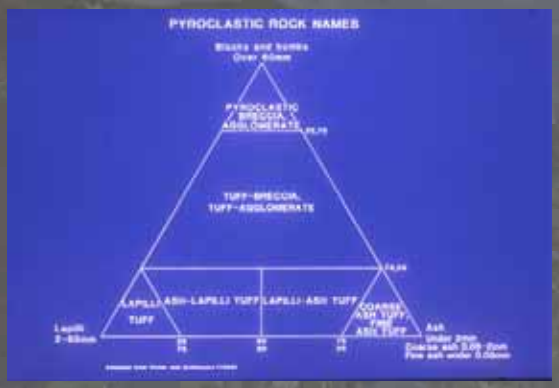

**VOLCANIC ROCKS**

**TUFF - Dominant (fragmental exploded from volcano) classified on grain size and components**

**LAVA - Subordinate (molten rock extruded from volcano) classified on grain size and composition**




48

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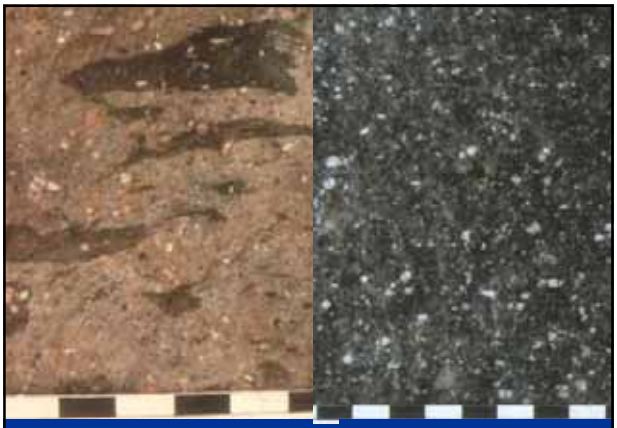


Fine Ash Vitric Tuff (eutaxite) Coarse Ash Crystal Tuff

## LAVA

- Mainly rhyolitic
- Mainly very fine-grained

## Volcanic Rocks

All very quartz rich (except in Tuen Mun area)

Mainly - coarse ash crystal tuff, or fine ash vitric tuff

- Four groups of 'rhyolitic' formations (same age /chemistry) each of similar characteristics – may be equivalent to formations in Guangdong = suitable level of classification for engineering

Tsuen Wan, Lantau, Repulse Bay and Kau Sai Chau volcanic groups

52

## DYKE ROCKS - Classified on basis of composition, grain size, dominant crystals

- Feldsparphyric Rhyolite
- Quartzphyric Rhyolite
- Aplite
- Pegmatite
- Basalt/Lamprophyre
- Can significantly influence local hydrogeology
  - especially basaltic dykes
  - have influenced some significant landslides

53

GEO, CED 1986


Dykes are generally under-represented on maps


NE Lantau

DYKE ROCK
Feldsparphyric Rhyolite

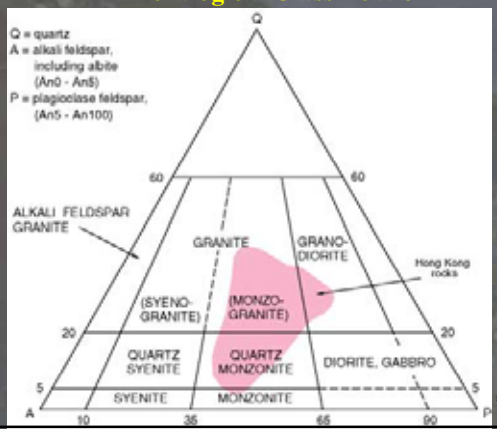
## Classification Scheme for Granitic Rocks

Based on measurable grain size and mineral (chemical) composition

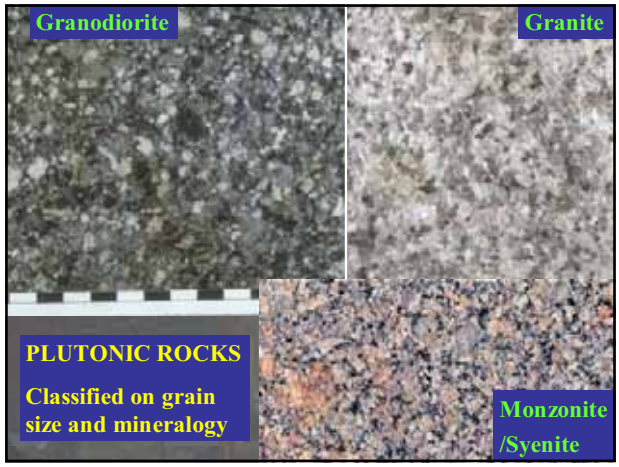
- Grain size
  - Coarse-grained >6mm
  - Medium-grained >2mm - <6mm
  - Fine-grained <2mm
- Mineralogy – proportions of quartz (Q) alkali feldspar (A) and plagioclase (P)

56

## Mineralogical Classification




57



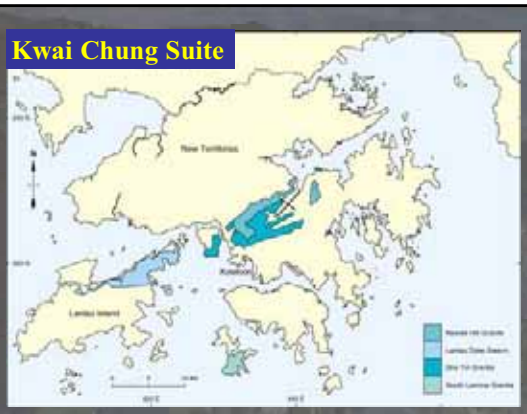

## Granitic Rocks

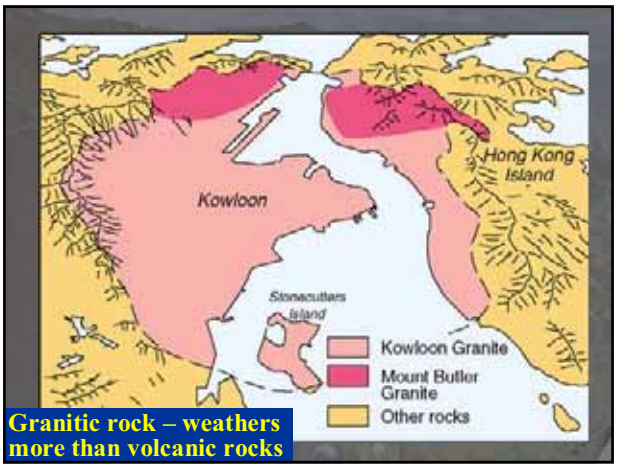
- As with volcanic rocks, many individual intrusions (units)
- Granitic rocks are grouped (chemistry/age) into four suites, each with their own similar characteristics
- Lamma, Kwai Chung, Cheung Chau and Lion Rock suites

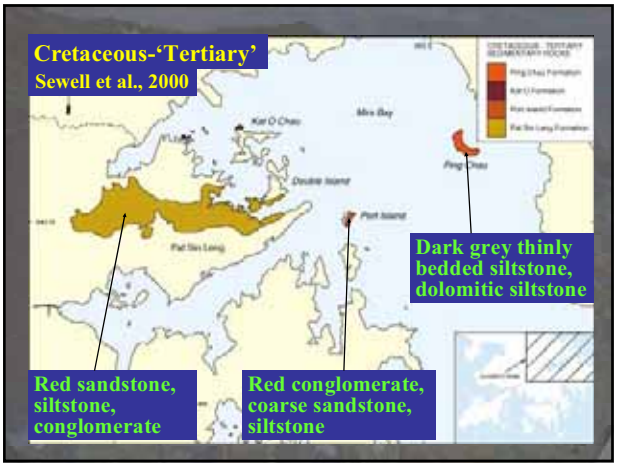
59


Tai Mo Shan Area

60




## METAMORPHIC ROCKS

- mainly dynamic (thrust-fault-related) foliated (schist, mylonite)
- contact – hornfels, recrystallization: also skarns where carbonates affected (calc-silicates, iron-rich rocks)

## FAULTS

- thrust, normal, strike slip: resulting in foliation, brecciation, gouge etc.

64

## HONG KONG STRUCTURES

| | |
|---|---|
| • FAULTS | normal, thrust, strike-slip |
| • FOLDS | |
| • BEDDING | |
| • CONTACTS | granites, dykes, veins |
| • FOLIATIONS | volcanic, metamorphic |
| • LINEATIONS | |
| • JOINTS | columnar, tectonic, sheeting, stress relief |
| • FRACTURES | |

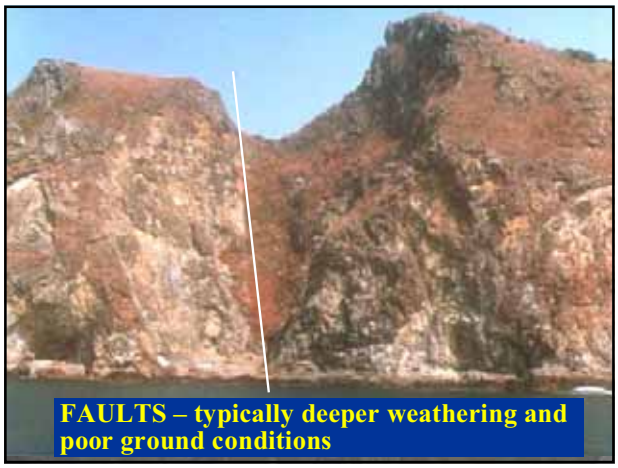
65

## HONG KONG STRUCTURES
### Importance to engineers

- Define areas/zones of contrasting material type (lithology, strength)
- Control material weathering grades, rock mass weathering characteristics (PW zones) and rockhead depth and form
- Influence hydrogeology
- Influence instability etc.

Maybe structures more important to the engineer than rock type? - in rock? - in soil?

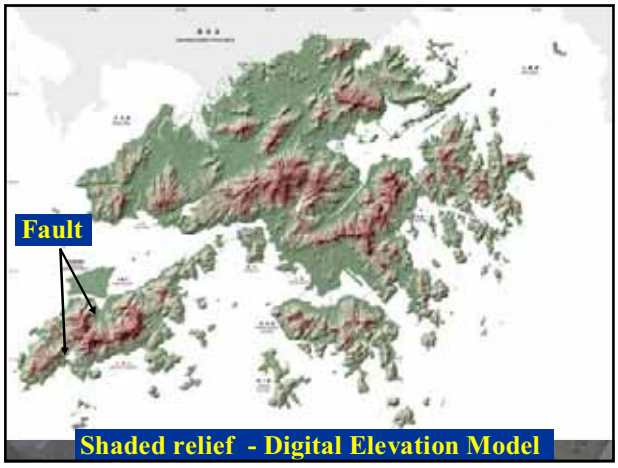
66



FAULTS – typically deeper weathering and poor ground conditions

Tai Lam Fault

68



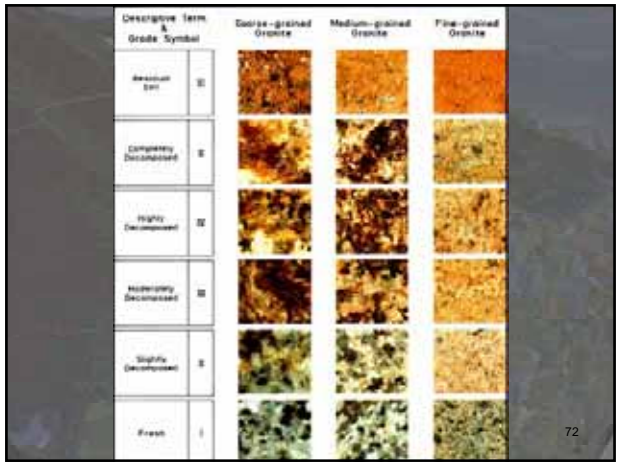

Shaded relief - Digital Elevation Model

Superficial Deposits

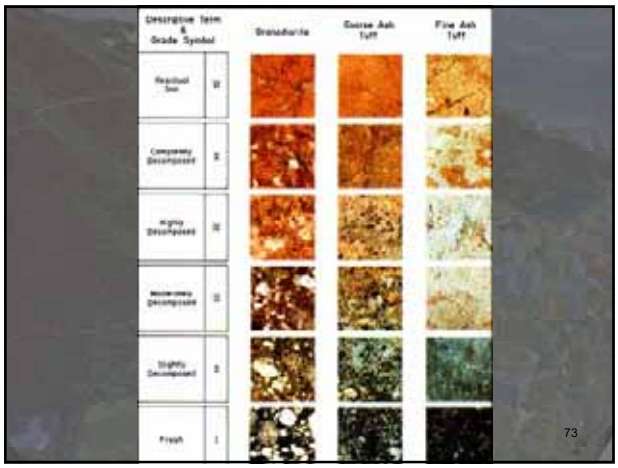
70

## Classification of Rock Material Decomposition Grades

| Descriptive Term | Grade Symbol | General Characteristics for Granitic & Volcanic Rocks & Other Rocks of Equivalent Strength in the Fresh State | Additional Typical Characteristics for Specific Rock Types: Granite | Granodiorite | Coarse Ash Crystal-Lithic Tuff | Fine Ash Vitric Tuff |
|---|---|---|---|---|---|---|
| Residual Soil | VI | Original rock texture completely destroyed. Can be crumbled by hand and finger pressure into constituent grains. | Original rock texture completely destroyed. Feldspars completely decomposed. Quartz is only remaining primary mineral, grains reduced in size and reduced in size compared with fresh condition. | Dark reddish brown. Feldspars completely decomposed. Quartz only remaining primary minerals, grains reduced in size compared with fresh condition. | Brown or reddish brown. Quartz only remaining primary minerals. | Yellowish brown. |
| Completely Decomposed | V | Original rock texture preserved. Can be crumbled by hand and finger pressure into constituent grains. Slakes when immersed in water. Completely discoloured compared with fresh rock. | Yellowish brown to reddish brown. Feldspars completely to highly decomposed, chalky, strength index < 250 kPa. Can rebound from N Schmidt hammer. | Yellowish brown to reddish brown. Feldspars completely to highly decomposed to powdery, to soft, very weak to grounded by pin. Ferromagnesian feldspars grains more easily grounded. Can rebound from N Schmidt hammer. | Brown to reddish brown. Lumps, tuffaceous or welded, highly decomposed, soft, dull, dark green to brown, difficult to distinguish. | Yellowish brown. Lumps, strong or weak. |
| Highly Decomposed | IV | Can be broken by hand into smaller pieces. Makes a dull sound when struck by geological hammer and easily indented by point of geological pick. Does not slake when immersed in water. Completely discoloured compared with fresh rock. | Yellowish brown to yellowish orange/brown. Feldspars powdery. Ferromagnesian feldspars powdery to gritty, equal penetrometer shear strength index < 250 kPa. Positive N Schmidt rebound value < 25. | Yellowish brown to yellowish orange/brown. Feldspars powdery. Ferromagnesian feldspars powdery to gritty. N Schmidt rebound value 15 - 31. | Yellowish brown. Highly decomposed, soft, dull, dark green. | Yellowish grey. Surface can be scratched by knife. |
| Moderately Decomposed | III | Cannot usually be broken by hand, easily broken by geological hammer. Makes a dull or slight ringing sound when struck by geological hammer. Completely stained throughout. | Yellowish brown. Feldspars gritty. Rocks not slaky. N Schmidt rebound value 25 - 41. | Yellowish brown. Ferromagnesian feldspars gritty, decomposed feldspars partly decomposed to gritty, small pieces. N Schmidt rebound value 25 - 50. | Yellowish grey. Matrix moderately decomposed, not slaky, soft, lumps or stained dark brown. | White or light grey. Surface cannot be scratched by knife. |
| Slightly Decomposed | II | Not broken easily by geological hammer. Makes a ringing sound when struck by geological hammer. Faint rock colours generally retained but stained rock. Joint surfaces. | Feldspars hard in slightly gritty consistent feldspars when pink. Rocks slightly stained and dull around edges. N Schmidt rebound value > 41. | Ferromagnesian feldspars slightly gritty. Rocks and feldspars slightly stained and dull. N Schmidt rebound value 41 - 50. | Light grey or greenish grey. Matrix firmness grey, hard, black, may be slightly stained and dull around edges. | Grey, light grey or greenish grey. Clouds appearance. |
| Fresh | I | Not broken easily by geological hammer. Makes a ringing sound when struck by geological hammer. No visible signs of decomposition (i.e. no discolouration). | Overall rock colour grey/white. Feldspars hard and shiny. Rocks shiny, not stained. Quartz colourless or grey, glassy. | Overall rock colour grey. Feldspars hard and shiny. Rocks and hornblende dark, not stained. Quartz colourless or grey, glassy. Hornblende or grey, glassy. | Overall rock colour ranges from light greenish grey (LGM) to grey (TDT). Phenocrysts hard and shiny. Matrix hard and dull, black. Quartz colourless or grey, glassy. | Overall rock colour black. Glassy appearance. |
| General Notes | | (1) Not all these general characteristics are applicable to rocks whose strengths in the fresh state is exceptionally low (e.g. < 1 MPa). Some crystalline rocks may be more appropriate for such materials (see Section 7.3.4). (2) Use of geological hammer applicable mainly to materials contained in a field exposure. | (1) Based on Moye (1955), Hancher & Morris (1981), and unpublished work by the GCO. (2) Assessments of minerals applicable to medium and coarse grained granite, may be difficult or impossible to assess in fine-grained granites. | (1) Based on Irfan & Powell (1985a,b). | (2) Based on unpublished work by the GCO. (3) Refer to Tai Lam Formation (GM - Group Mui Formation (see HKGS, Maps and Memoirs). (4) Mafic minerals referred to are biotite and hornblende. | (2) Based on unpublished work by the GCO. |
| Notes on Index Tests | | (1)(2) Slake Test: Standard already close to saturation moisture content are less likely to slake. (1)(3) Point Load Strength Index: Specimens cut by knife or grooved by pin. Softly cut by knife or grooved by pin with pressure. Powdery / easily grooved by pin, can be crushed to silt fragments, in fingers. Soft easily grooved by pin, can be moulded into plastic to clay in fingers. (2)(3) N Schmidt hammer test rebound values are for hammer face perpendicular to rock face. Use initial reading. Make to ensure good contact and record average value from a minimum of five consecutive rebounds, ignoring obviously low readings. (3)(4) Hand penetrometer test: pencil instrument head slowly and smoothly into sample. Take an average of ten values and divide by ten to give shear strength index. Soil may be reconstituted or very short samples. Dry Test: results in general may be affected by sample moisture content and degree of microfracturing. | | | | |




72



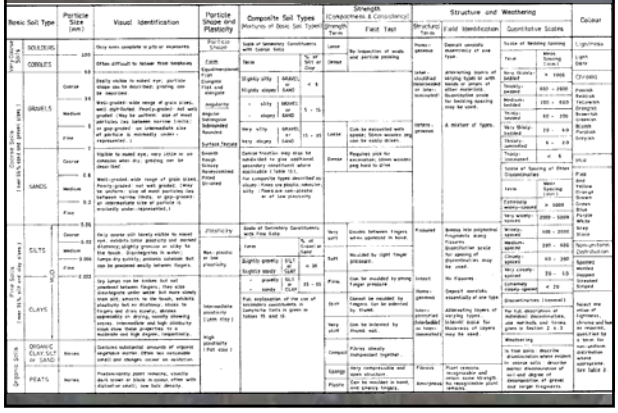

## Classification of Solid Rocks and Superficial Deposits in Hong Kong

| Superficial Deposits | Grain Size (mm) | Solid Rocks: Sedimentary Rocks | Pyroclastic Rocks | Igneous Rocks | Metamorphic Rocks |
|---|---|---|---|---|---|
| | | Detrital Rocks: Conglomerate; Sedimentary Breccia; Sandstone; Siltstone; Claystone | Pyroclastic Breccia; Lapilli Tuff; Coarse Ash Tuff; Fine Ash Tuff | Acid: Pegmatite; Granite; Aplite; Rhyolite; Dacite. Intermediate: Granodiorite; Quartz Monzonite; Quartz Syenite; Quartz Latite; Quartz Trachyte; Trachyandesite; Andesite. Basic: Gabbro; Basalt; Lamprophyre | Foliated: Schist; Phyllite; Mylonite. Non-Foliated: Fault Breccia; Granite Gneiss; Marble |
| Boulders | 200 | | | | |
| Cobbles | 60 | | | | |
| Gravel: Coarse | 20 | | | | |
| Gravel: Medium | 6 | | | | |
| Gravel: Fine | 2 | | | | |
| Sand: Coarse | 0.6 | | | | |
| Sand: Medium | 0.2 | | | | |
| Sand: Fine | 0.06 | | | | |
| Silt (Mud) | | Mudstone; Chert; Limestone and Dolomite, Evaporites | | | |
| Clay (Mud) | 0.002 | | | | |

Legend :
◆ Equivalent to Dolerite in Allen & Stephens (1971)

Note : This table is based on the classification scheme used by the Hong Kong Geological Survey.

## Rapid Identification & Description of Soils




## Classification of Rock Mass Weathering Zones

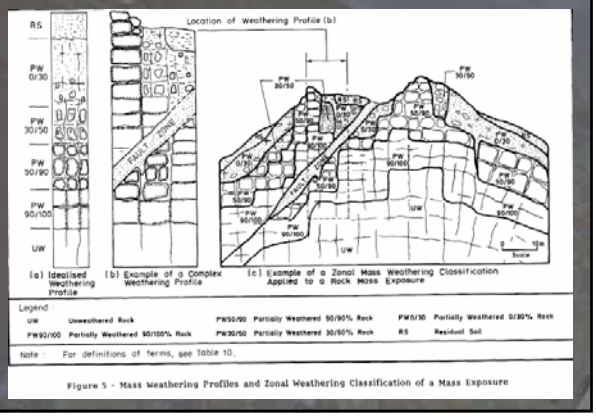



Figure 5 - Mass Weathering Profiles and Zonal Weathering Classification of a Mass Exposure

## Classification of Rock Mass Weathering Zones

| Zone Description | | Zone Symbol | Zone Characteristics |
|---|---|---|---|
| Residual Soil | | RS | **Residual soil derived from insitu weathering; mass structure and material texture / fabric completely destroyed : 100 % soil** |
| Partially Weathered Rock | 0/30 % Rock | PW 0/30 | **Less than 30 % rock Soil retains original mass structure and material texture / fabric (i. e. saprolite)** Rock content does not affect shear behaviour of mass, but relict discontinuities in soil may do so. Rock content may be significant for investigation and construction |
| | 30/50 % Rock | PW 30/50 | **30 % to 50 % rock** Both rock content and relict discontinuities may affect shear behaviour of mass |
| | 50/90 % Rock | PW 50/90 | **50 % to 90 % rock** Interlocked structure |
| | 90/100% Rock | PW 90/100 | **Greater than 90 % rock** Small amount of the material converted to soil along discontinuities |
| Unweathered Rock | | UW | **100 % rock** May show slight discolouration along discontinuities |

## British Soil Classification Systems for Engineering Purposes

| Soil Groups (1) | | | Subgroups and Laboratory Identification | | | | |
|---|---|---|---|---|---|---|---|
| GRAVEL and SAND may be qualified by an additional secondary constituent for coarse fraction where appropriate (Table 15) | | | Group Symbol (2)(3) | Subgroup Symbol (2) | Fines (% less than 0.06mm) | Liquid Limit (%) | Name |
| Coarse Soils (less than 35% of material is finer than 0.06 mm) | GRAVELS (more than 50% of coarse material is of gravel size) | Slightly silty or clayey GRAVEL | G | GW GP | GW GPu GPg | 0 - 5 | Well-graded GRAVEL Poorly-graded/Uniform/Gap-graded GRAVEL |
| | | Silty GRAVEL, clayey GRAVEL | G-F | G-M G-C | GWM GPM GWC GPC | 5 - 15 | Well-graded/Poorly-graded silty GRAVEL Well-graded/Poorly-graded clayey GRAVEL |
| | | Very silty GRAVEL Very clayey GRAVEL | GF | GM GC | GML, etc GCL GCI GCH GCV GCE | 15 - 35 | Very silty GRAVEL : subdivide as for GC Very clayey GRAVEL ( clay of low, intermediate, high, very high, extremely high plasticity ) |
| | SANDS (more than 50% of coarse material is of sand size) | Slightly silty or clayey SAND | S | SW SP | SW SPu SPg | 0 - 5 | Well-graded SAND Poorly-graded/Uniform/Gap-graded SAND |
| | | Silty SAND Clayey SAND | S-F | S-M S-C | SWM SPM SWC SPC | 5 - 15 | Well-graded/Poorly-graded silty SAND Well-graded/Poorly-graded clayey SAND |
| | | Very silty SAND Very clayey SAND | SF | SM SC | SML, etc SCL SCI SCH SCV SCE | 15 - 35 | Very silty SAND : subdivide as for SC Very clayey SAND ( clay of low, intermediate, high, very high, extremely high plasticity ) |
| Fine Soils (more than 35% of material is finer than 0.06 mm) | Gravelly or sandy SILTS and CLAYS (35% - 65% fines) | Gravelly SILT (4) Gravelly CLAY (4) | FG | MG CG | MLG, etc CLG CIG CHG CVG CEG | < 35 35 - 50 50 - 70 70 - 90 > 90 | Gravelly SILT : subdivide as for CG Gravelly CLAY ( of low, intermediate, high, very high, extremely high plasticity ) |
| | | Sandy SILT (4) Sandy CLAY (4) | FS | MS CS | MLS, etc CLS, etc | | Sandy SILT : subdivide as for CG Sandy CLAY : subdivide as for CG |
| | SILTS and CLAYS (65% - 100% fines) | SILT (M - soil) CLAY (5)(6)(7) | F | M C | ML, etc CL CI CH CV CE | < 35 35 - 50 50 - 70 70 - 90 > 90 | SILT : subdivide as for C CLAY ( of low, intermediate, high, very high, extremely high plasticity ) |
| Organic Soils | | Descriptive letter 'O' suffixed to any group or sub-group symbol. | | Organic matter suspected to be a significant constituent. Example MHO : Organic SILT of high plasticity. | | | |
| Peat | | Pt Peat soils consist predominantly of plant remains which may be fibrous or amorphous. | | | | | |

## Application of Engineering Geology in Landslide and Slope Studies

79

- Development of the geological model with focus on the key factors contributing to the failure of large cut slopes in Hong Kong
- The role of discontinuities in the stability of weathered rock slopes (including saprolite)

80

## The Geological Model for Slope Engineering

Engineering geology is the application of the science of geology to ground engineering.

It involves the formation of geological models that are specifically targeted towards the needs of the engineering project.

The geological model in slope and landslide studies is targeted towards facilitating geotechnical risk assessments, slope designs and investigations into the causes of landslides.

81

## Questions?

82

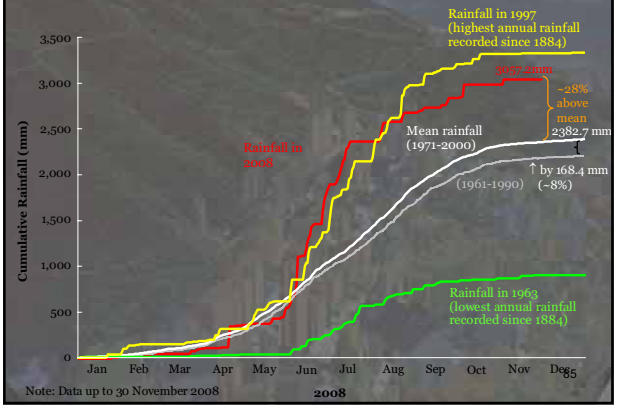
## BREAK

83

## Rainfall in 2008

84

## Annual Cumulative Rainfall



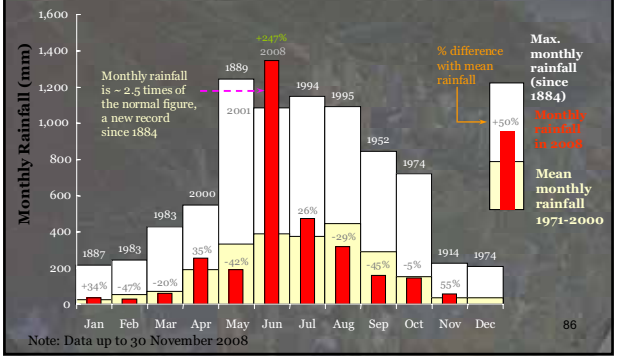

Note: Data up to 30 November 2008

2008

85

## Monthly Rainfall in 2008

(Comparison with maximum and mean monthly rainfall recorded at HKO)




Note: Data up to 30 November 2008

86

## Warnings Issued

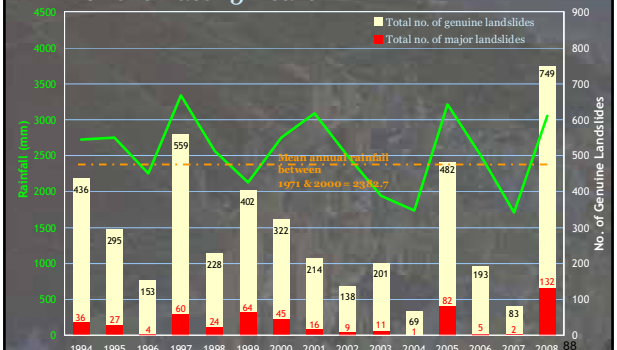
issued by the Hong Kong Observatory in 2008

| Month | Monthly Rainfall (mm) | No. of Warnings Issued | | | | |
|---|---|---|---|---|---|---|
| | | Tropical Cyclone | Landslip Warning | Amber Rainstorm | Red Rainstorm | Black Rainstorm |
| Jan | 33.3 | | | | | |
| Feb | 27.5 | | | | | |
| Mar | 57.2 | | | | | |
| Apr | 255.0 | 1 | 1 | 2 | 1 | 1 |
| May | 191.9 | | | 4 | | |
| Jun | 1,346.1 | 1* | 3 | 4 | 6 | 1 |
| Jul | 471.1 | | 1 | | | |
| Aug | 314.0 | 2* | | 2 | | |
| Sep | 159.2 | 1* | | | | |
| Oct | 144.6 | 1 | | | | |
| Nov | 54.3 | | | | | |
| **Total** | **3,057.2** | **6** | **5** | **21** | **7** | **2** |

Note: * denotes Tropical Cyclone Signal No. 8 or above hoisted

87

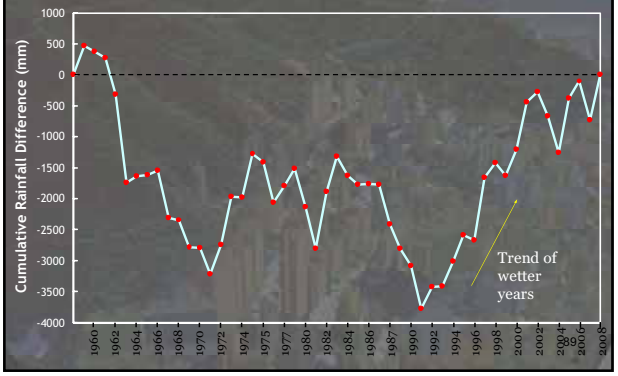
## Rainfall and Landslides for the Past 15 Years




Note: Data up to 30 November 2008

88

## Cumulative Difference from 50-Year Average Annual Rainfall




89

## Rainstorms in 2008

90

- Five rainstorms in 2008 triggered the issue of the Landslip Warnings
- The Landslide Potential Index (LPI) for these rainstorms are :

| Rainstorm | LPI |
|---|---|
| 19 April 2008 | 2.0 |
| 7 June 2008 | 12.3 |
| 13 June 2008 | 1.4 |
| 25 June 2008 | 1.7 |
| 10 July 2008 | 1.0 |

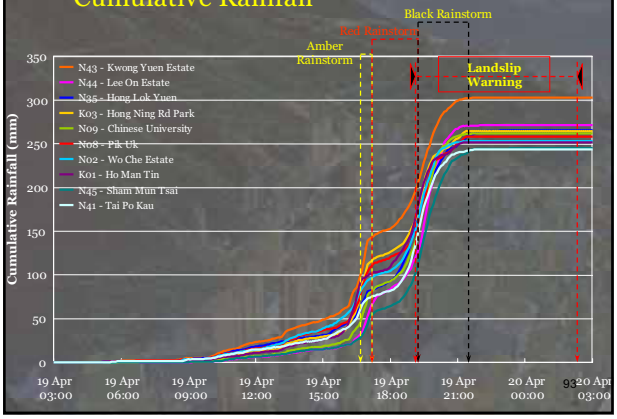
- The LPI depicts the relative severity of a rainstorm with respect to its potential to cause landslides. For comparison, the LPI of the rainstorm in late July 1994, which led to 5 deaths at Kwun Lung Lau, is set to be 10.

91

# Rainstorm of 19 April 2008

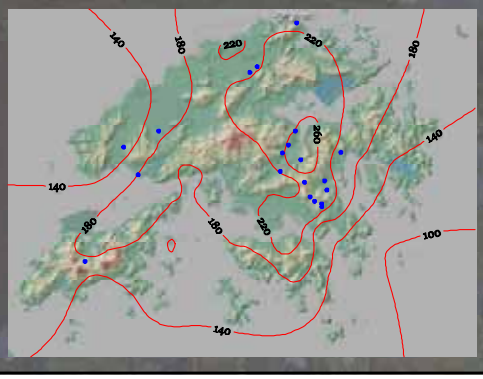
92

## Cumulative Rainfall




93

## Maximum Rolling 24-hour Rainfall

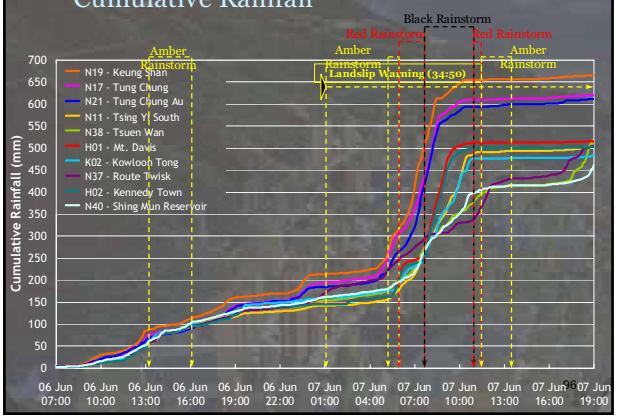



94

# Rainstorm of 7 June 2008

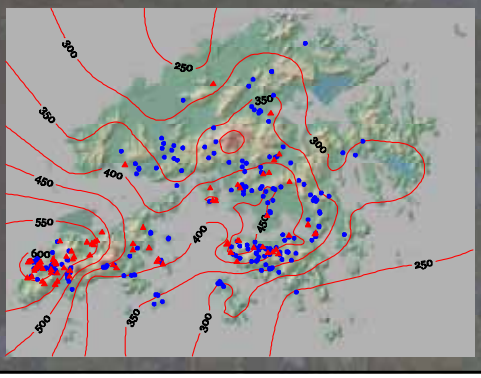
95

## Cumulative Rainfall



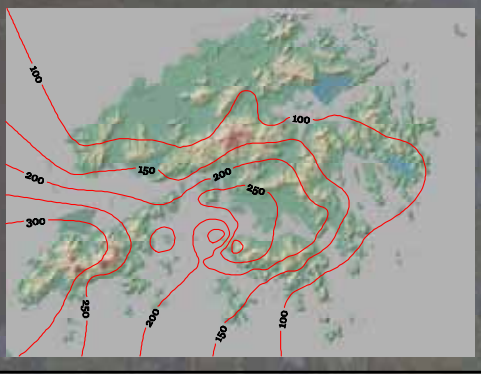

96

## Maximum Rolling 24-hour Rainfall



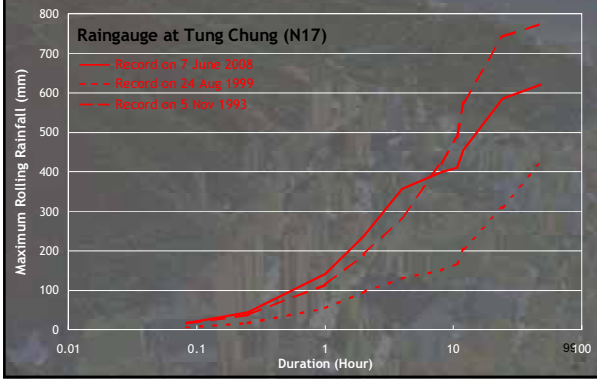

97

## Maximum Rolling 4-hour Rainfall



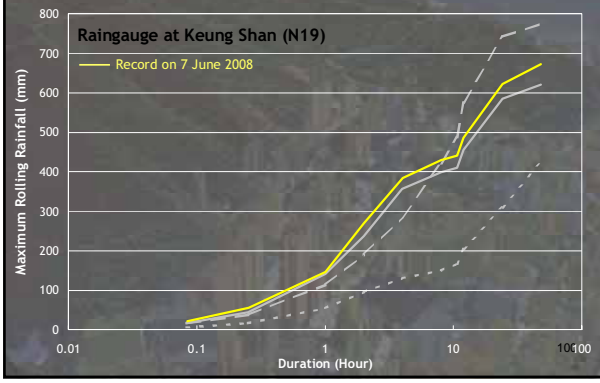
98

## Rainfall Profile at Lantau



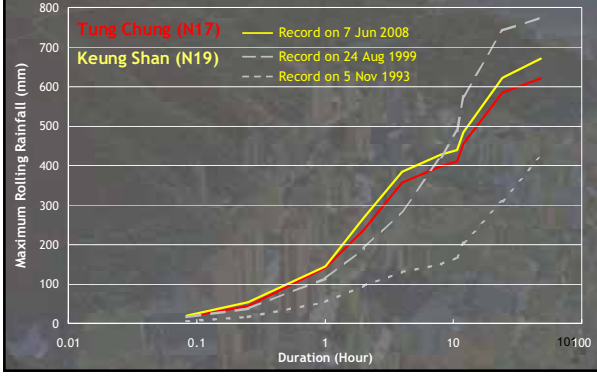

99

## Rainfall Profile at Lantau




100

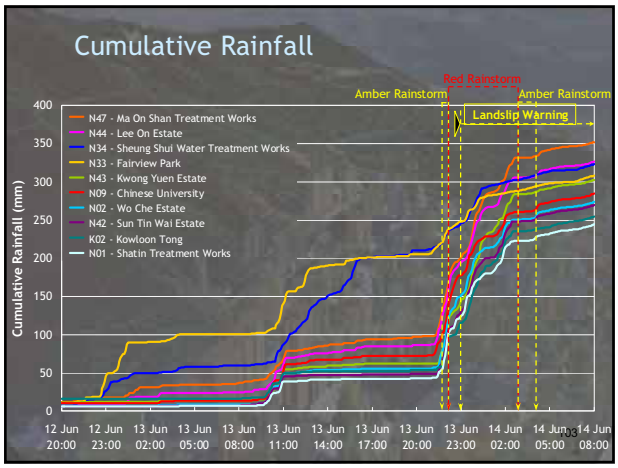
## Rainfall Profile at Lantau

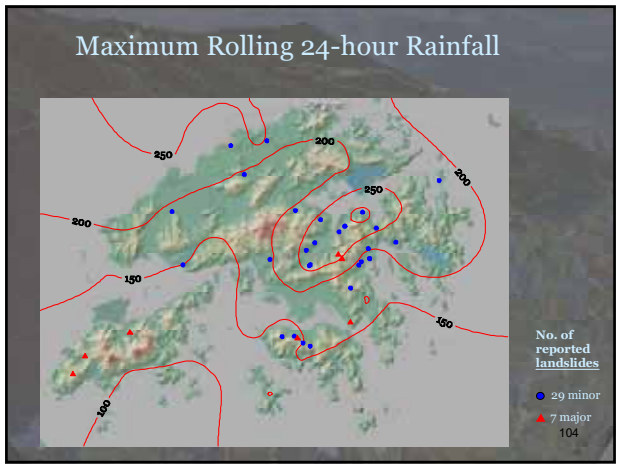



101

## Rainstorm of 13 June 2008

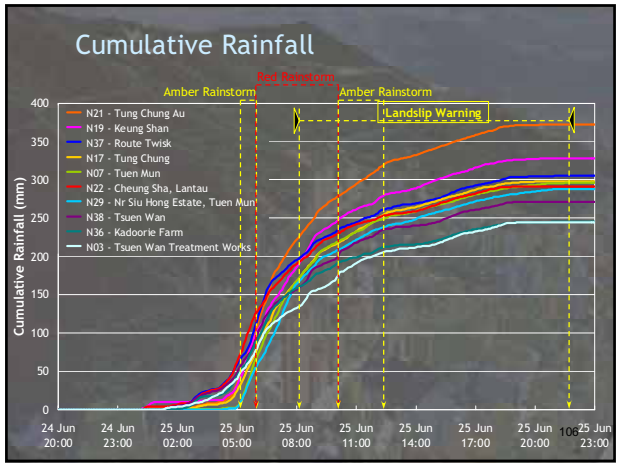
102

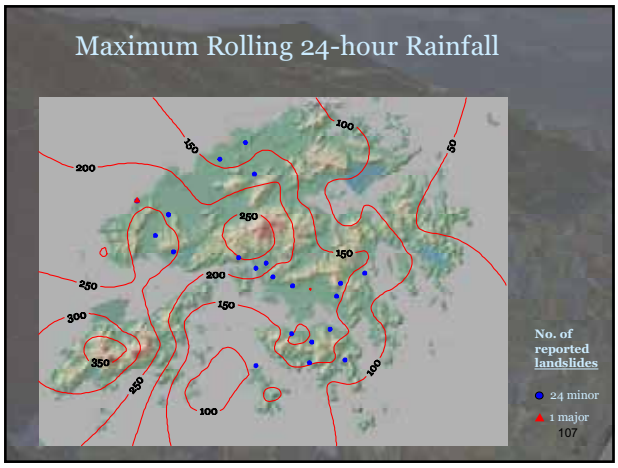



Rainstorm of
25 June 2008

105

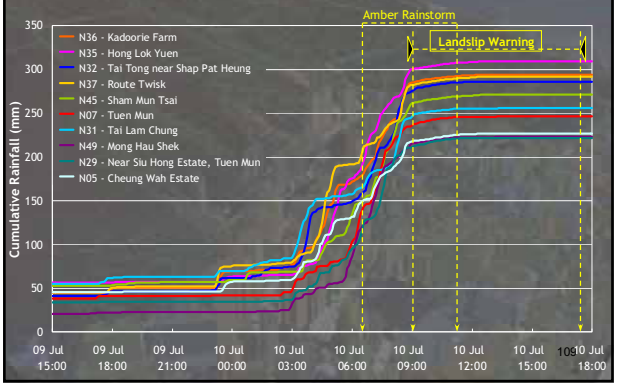



Rainstorm of
10 July 2008

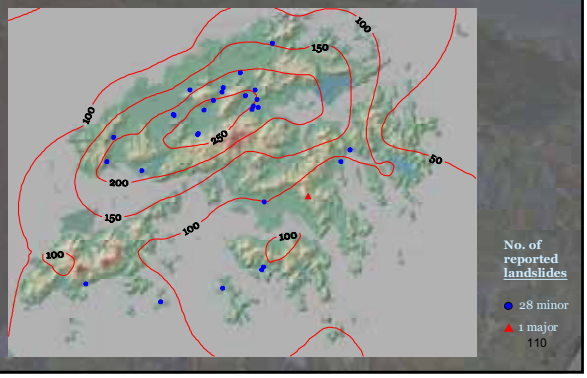
108

## Cumulative Rainfall




109

## Maximum Rolling 24-hour Rainfall




110

## Summary

- Annual rainfall ~28% above mean and so far 761 landslides reported
- Monthly rainfall in June and hourly rainfall recorded on 7 June at HKO's principal raingauge broke the records since 1884
- 5 rainstorms triggered the issue of the Landslip Warnings
- The most severe rainstorm on 7 June 2008 caused >300 reported landslides and > 1,500 landslides on natural hillsides

111

## Questions?

112

## Thank You

113