Session 1
Topography, Geology and Rainfall - Hong Kong

[9:00 – 10:30 am, 18 February 2009]

Dr. H.K. Tam

Geotechnical Engineering Office

Objective of this session:

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


Location of Hong Kong
China
Hong Kong
Taipei
台灣
Hanoi
河內
Vientiane
永珍
Yangon
仰光
Bangkok
泰國
越南
柬埔寨
Phnum Penh
金邊
西沙群島
南中國海
菲律賓
馬尼拉
Manila
南沙群島
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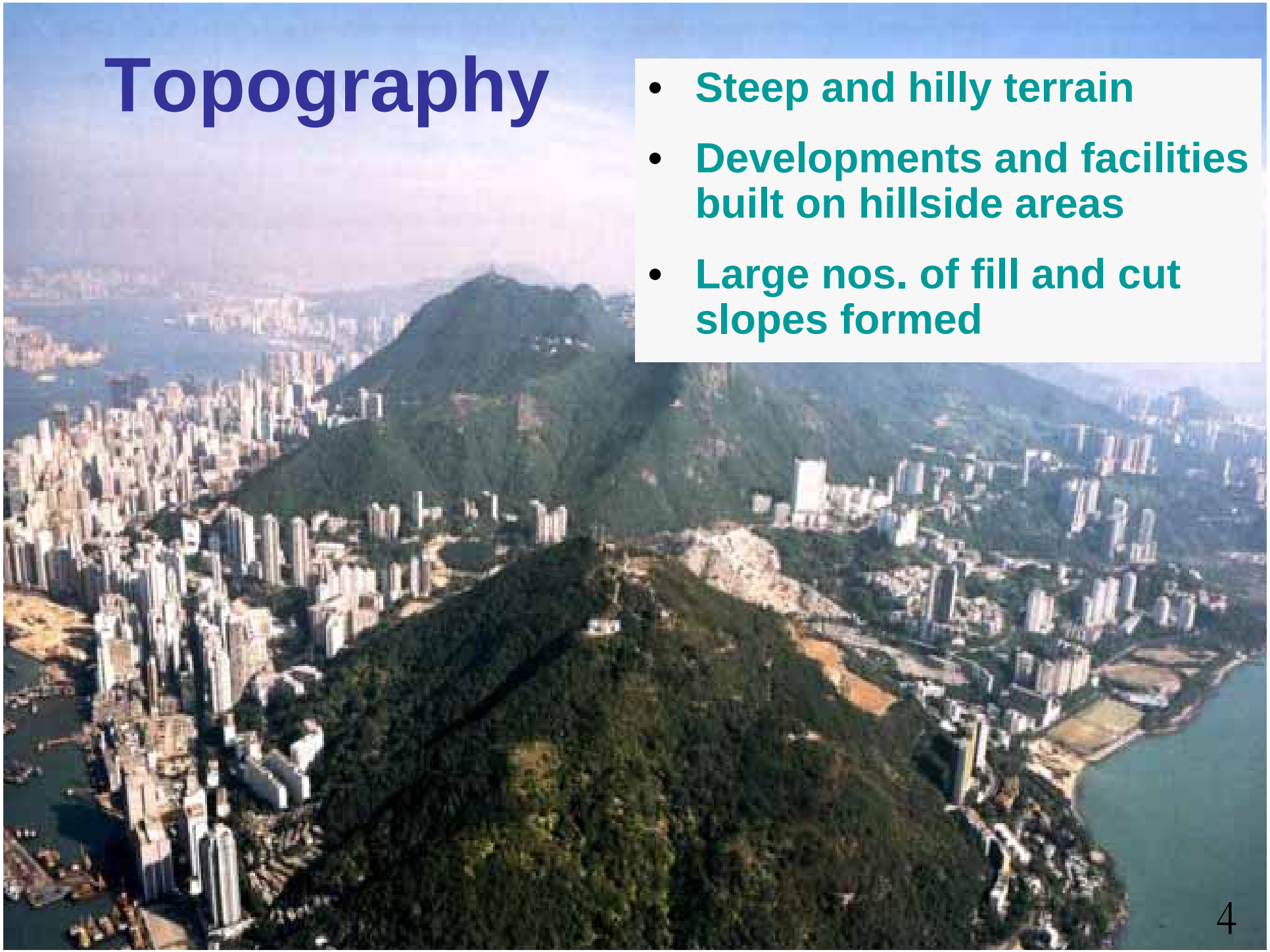
Topography

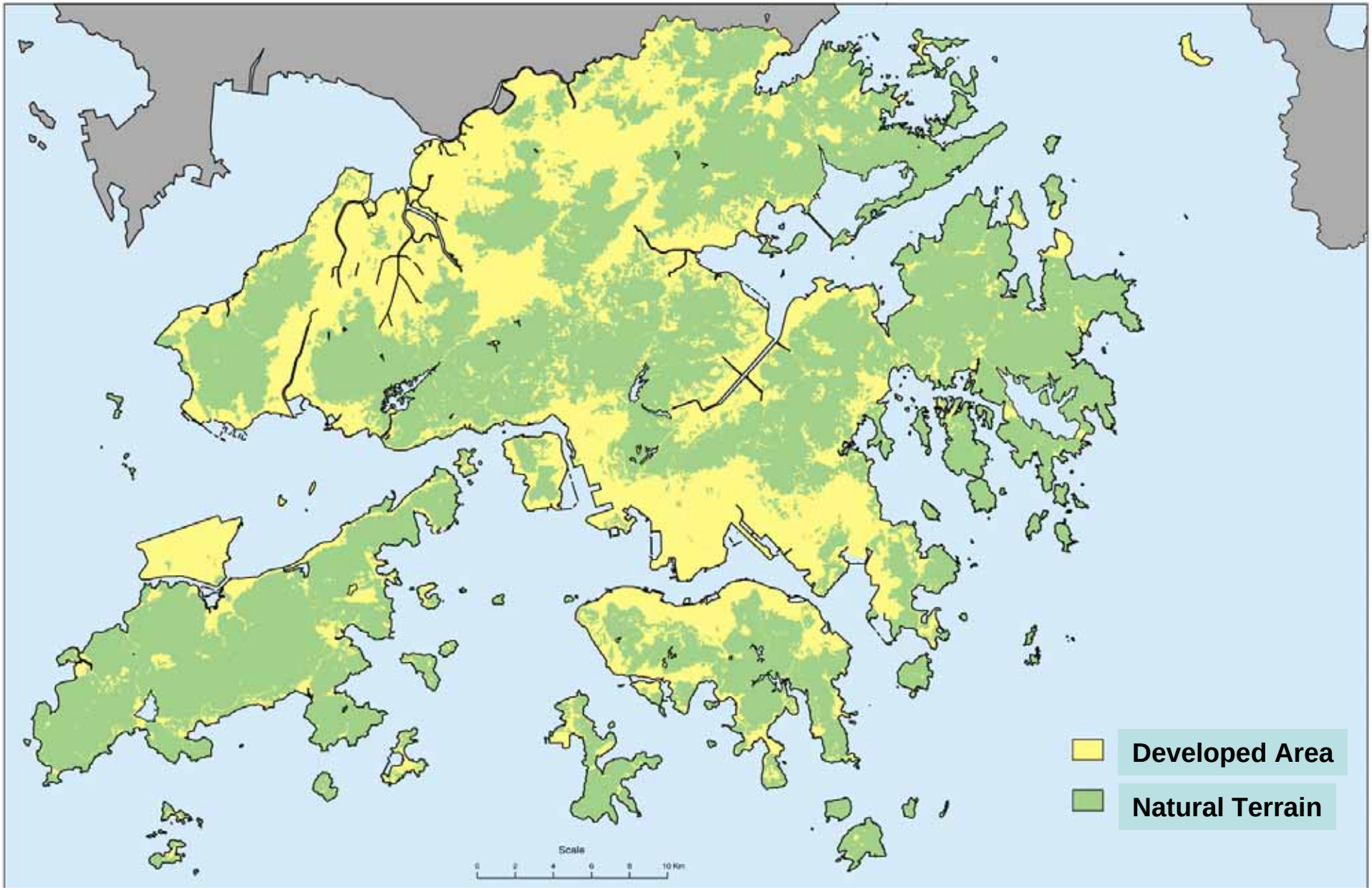


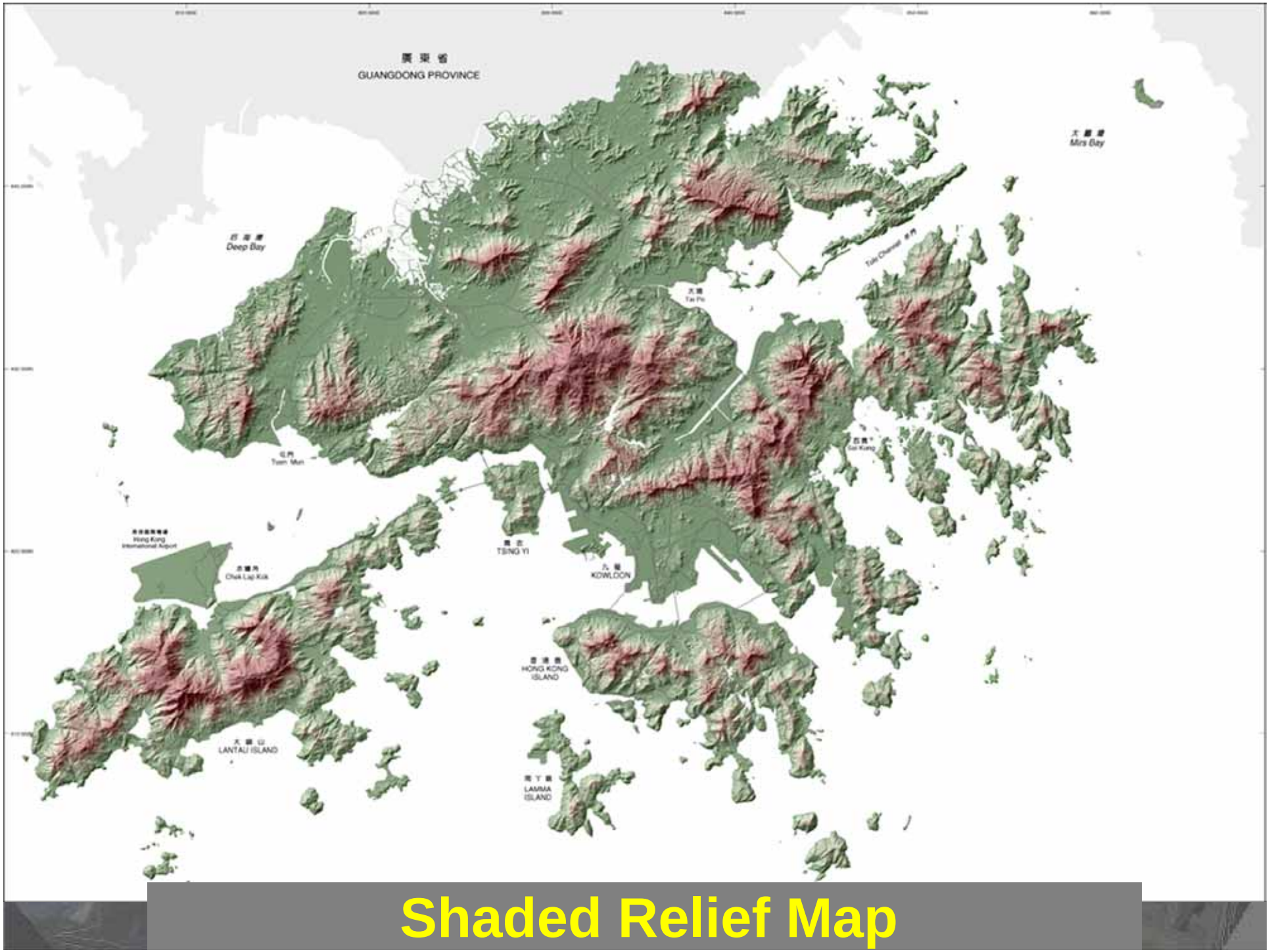
- Steep and hilly terrain
- Developments and facilities built on hillside areas
- Large nos. of fill and cut slopes formed

Hong Kong in the Past


c. 1865

Natural Terrain Covers ~60% of the Land Area




廣東省
GUANGDONG PROVINCE
Deep Bay
Mirs Bay
Tai Po
Tuen Mun
Hong Kong International Airport
Chek Lap Kok
TSING YI
KOWLOON
HONG KONG ISLAND
LANTAU ISLAND
LAMMA ISLAND
Shaded Relief Map

Geology of Hong Kong

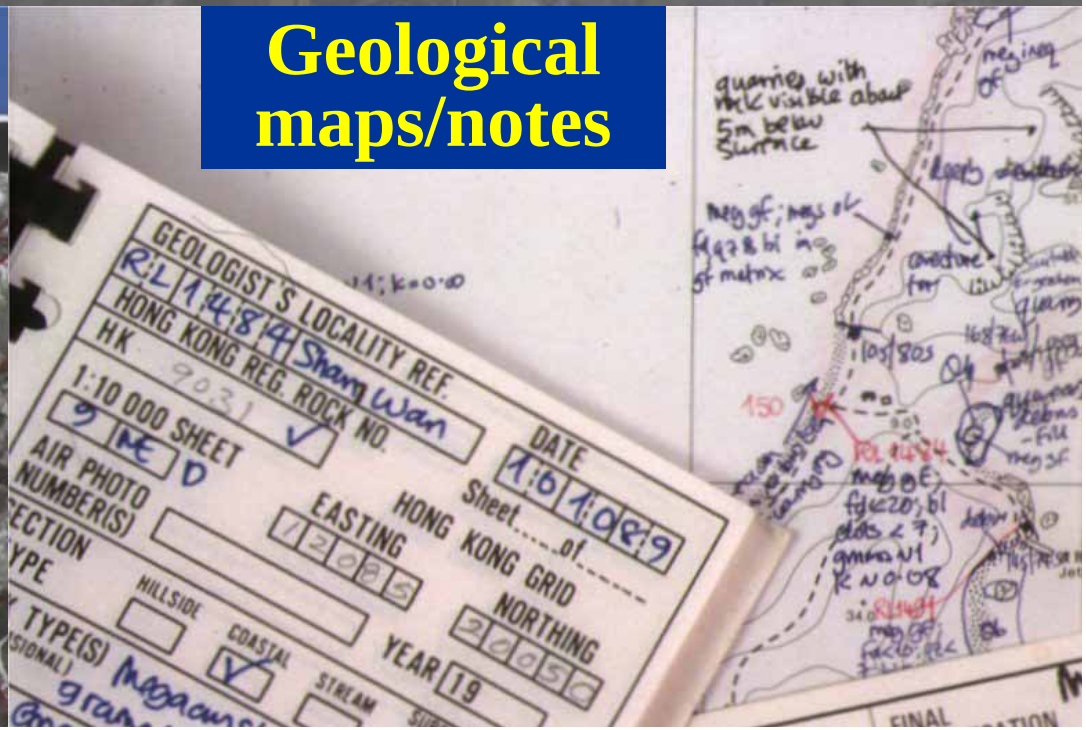
- Rock identification, structure, weathering, erosion, superficial deposits
- GIS Geological Maps
- e-Memoirs and Sheet Reports

Applied Geology

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

Aerial Photographs

Geological maps/notes



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**

HKGS/CEDD
Existing geological information sources

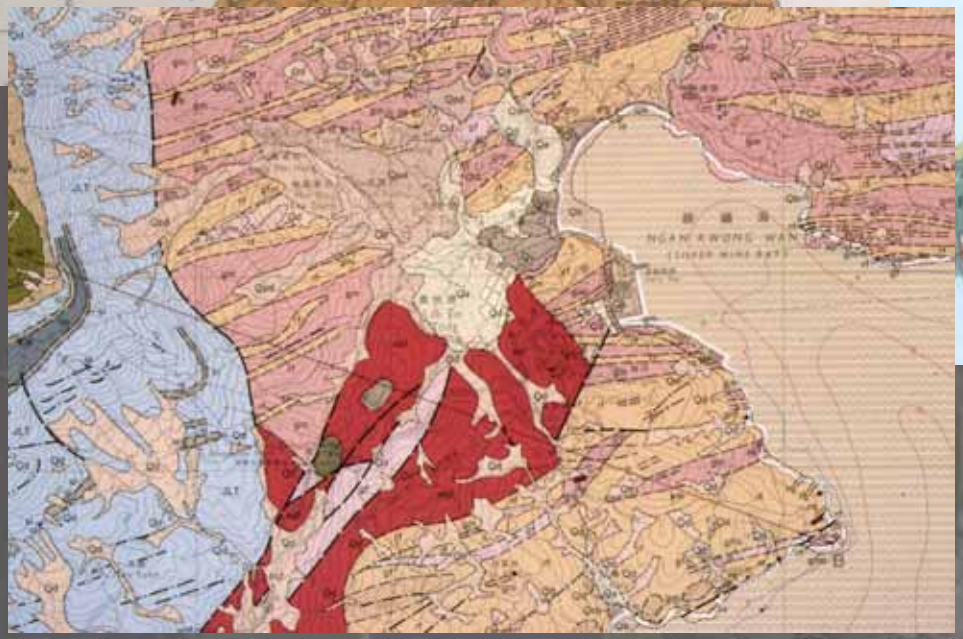
- **Geological Maps: scales 1:100K, 1:20K, 1:5K**
- **Geological Memoirs 1-6 & SAR-wide memoirs**
- **Geological Sheet Reports 1-6**
- **Specialist Geological Study reports**
- **Geoguide 2 - Guide to Site Investigation**
- **Geoguide 3 - Guide to Rock & Soil Descriptions**

Note: HKGS = Hong Kong Geological Survey

1936

Geological maps reflect information available at time they are produced

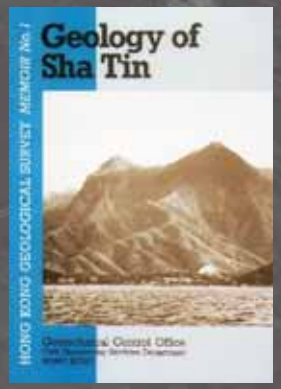
1971

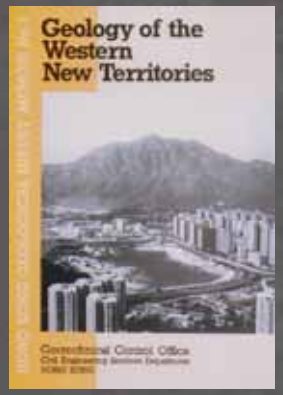


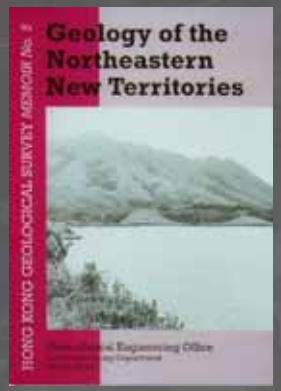
1984-96

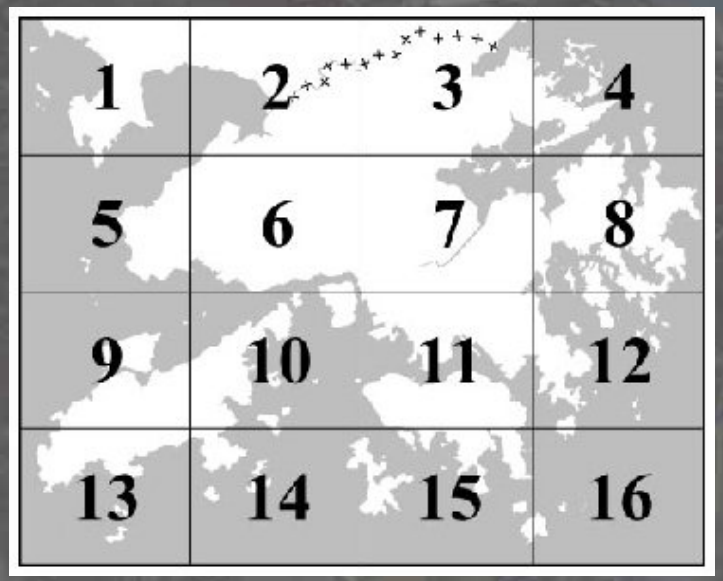
2004-09 revision
for digital publication in GIS format

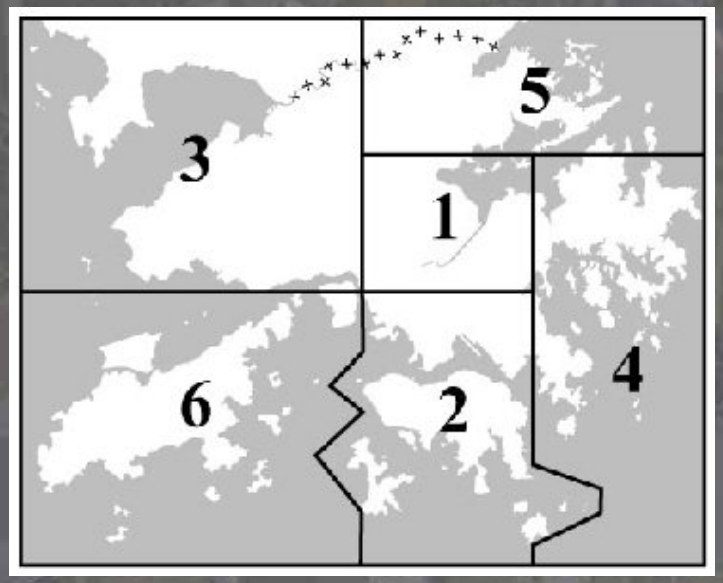
1:20,000 Maps 2-16 and Memoirs 1-6

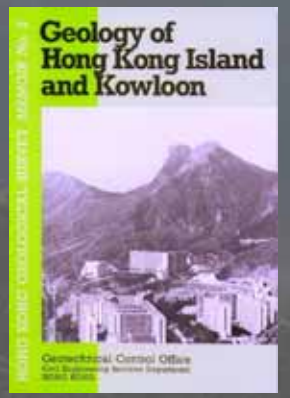


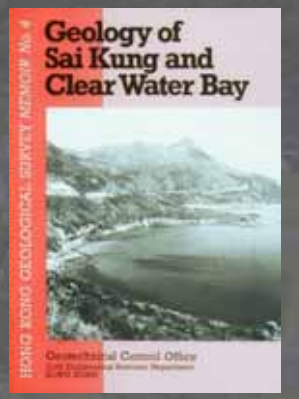


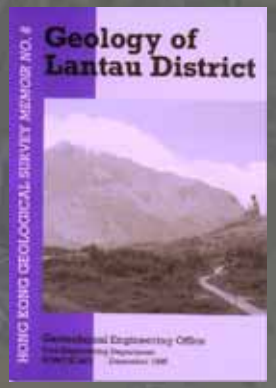




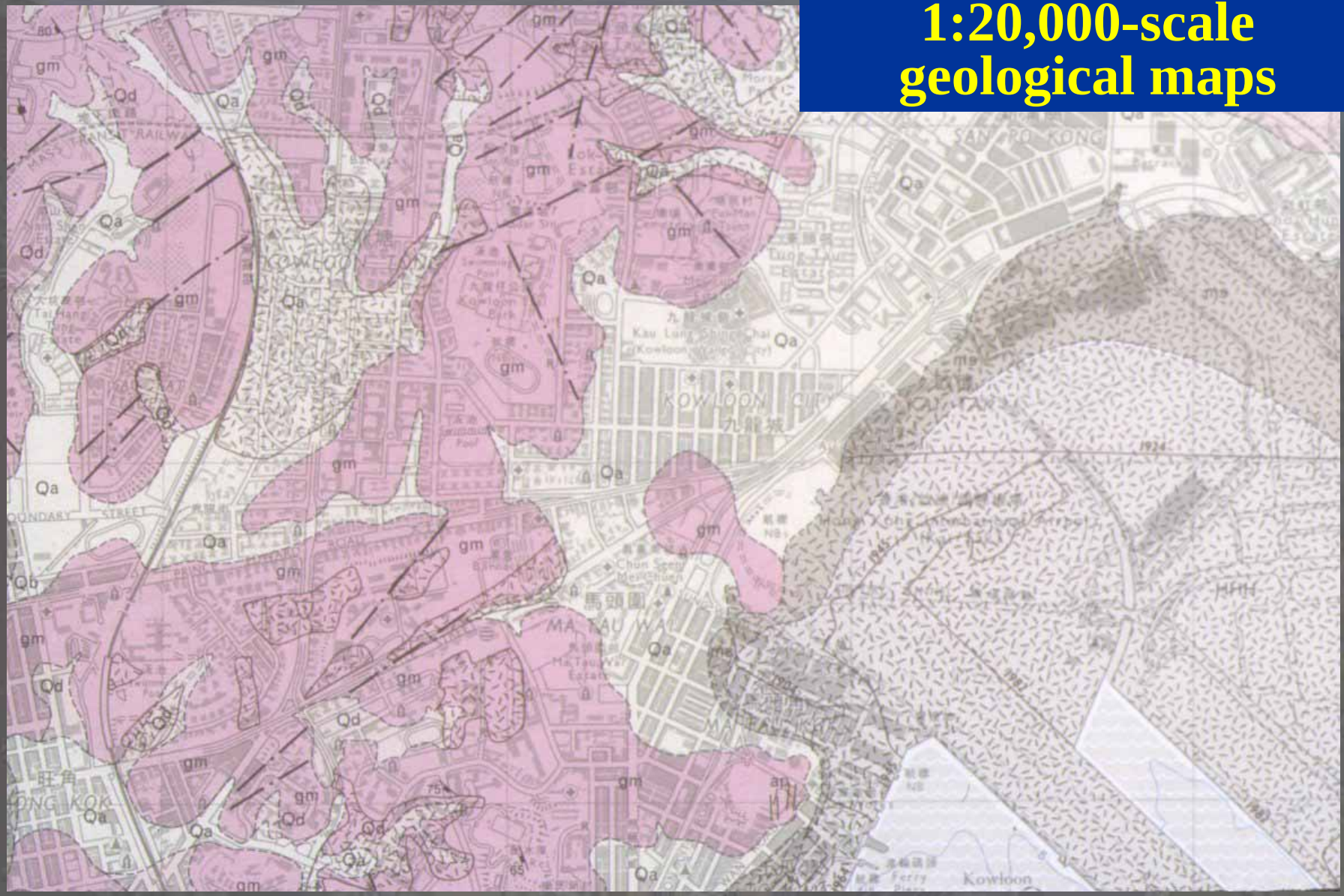






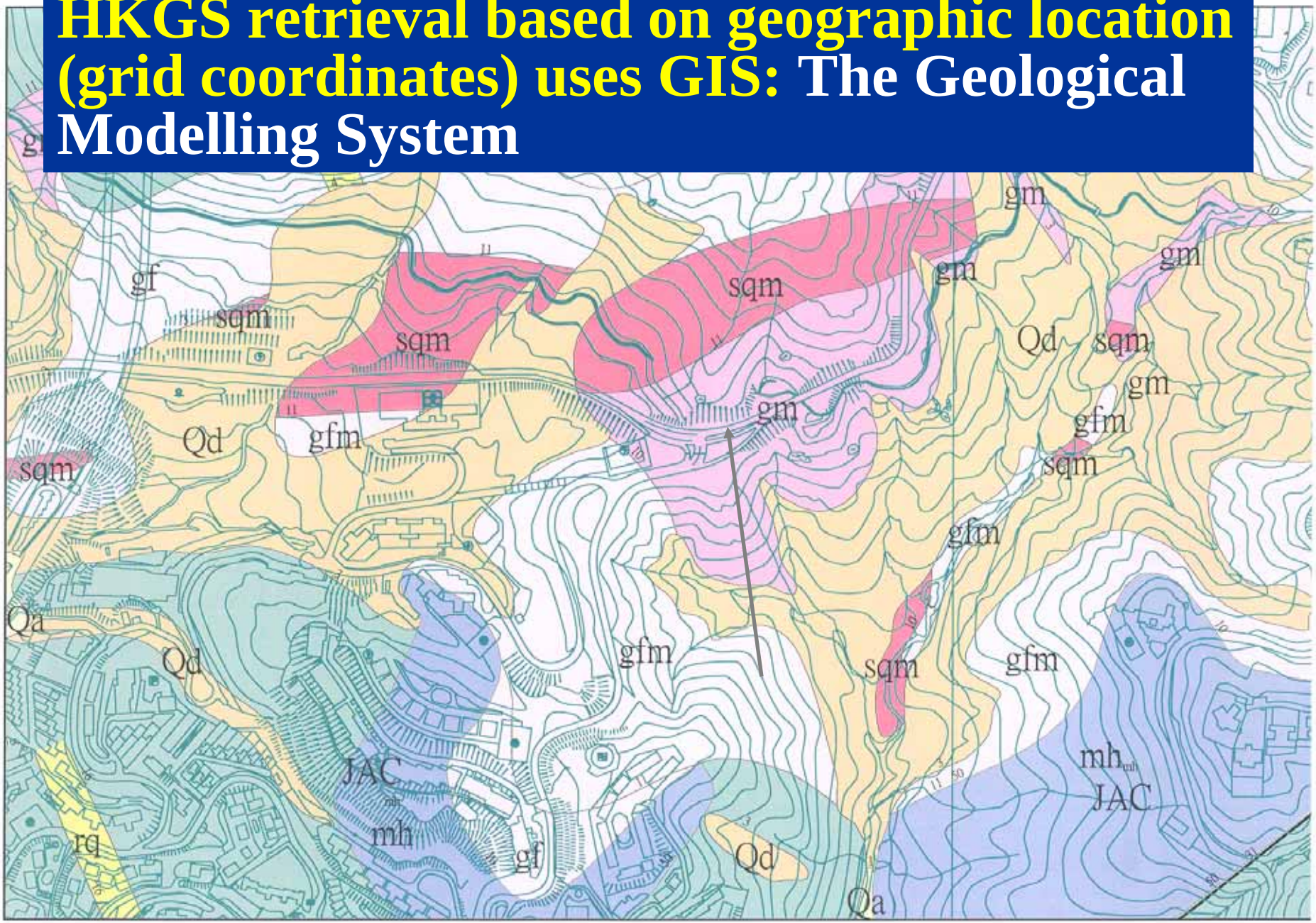


1:20,000-scale geological maps



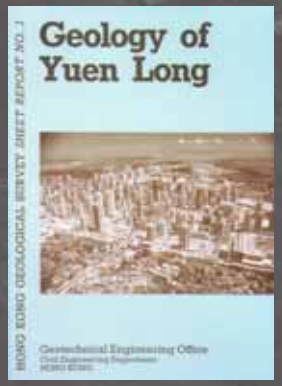
Information on solid geology and superficial deposits but not site-specific

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

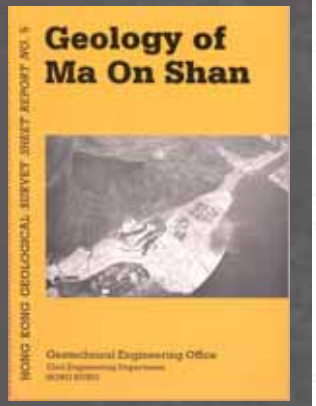


Key HKGS 1:5,000 Maps & 6 Sheet Reports

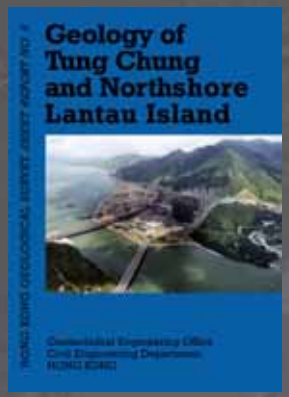
1992

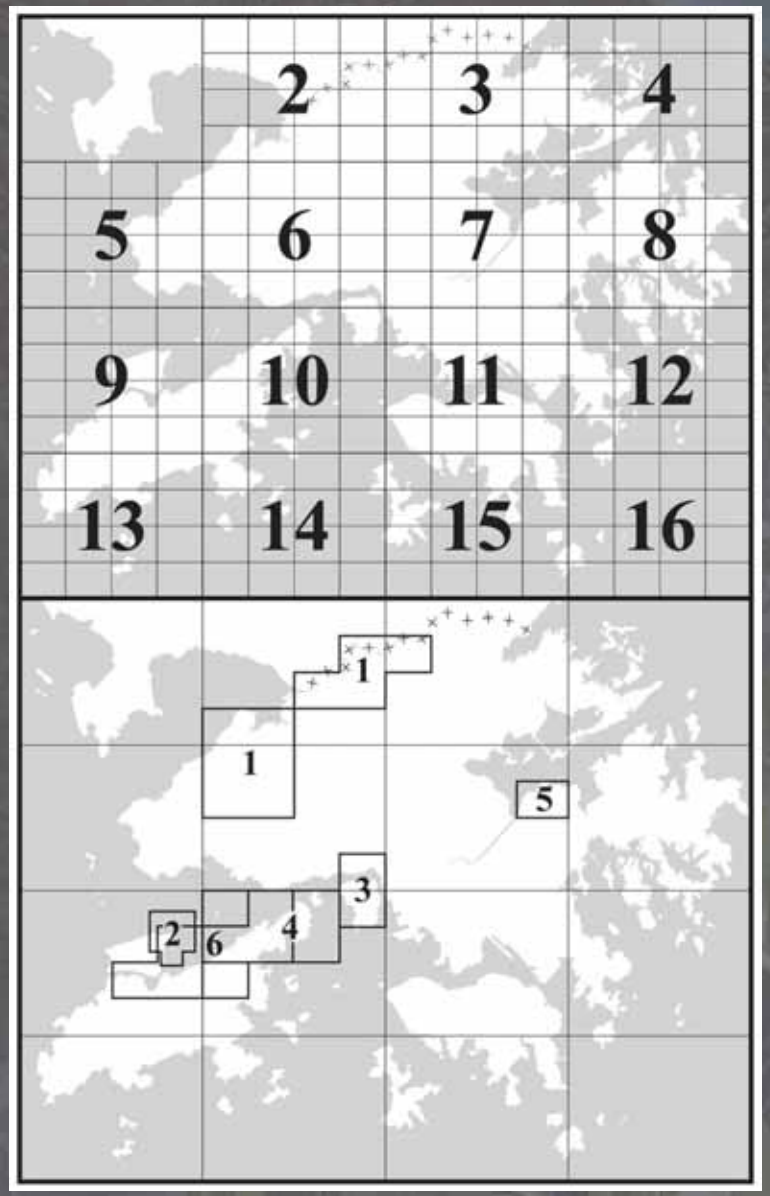


1996



2002





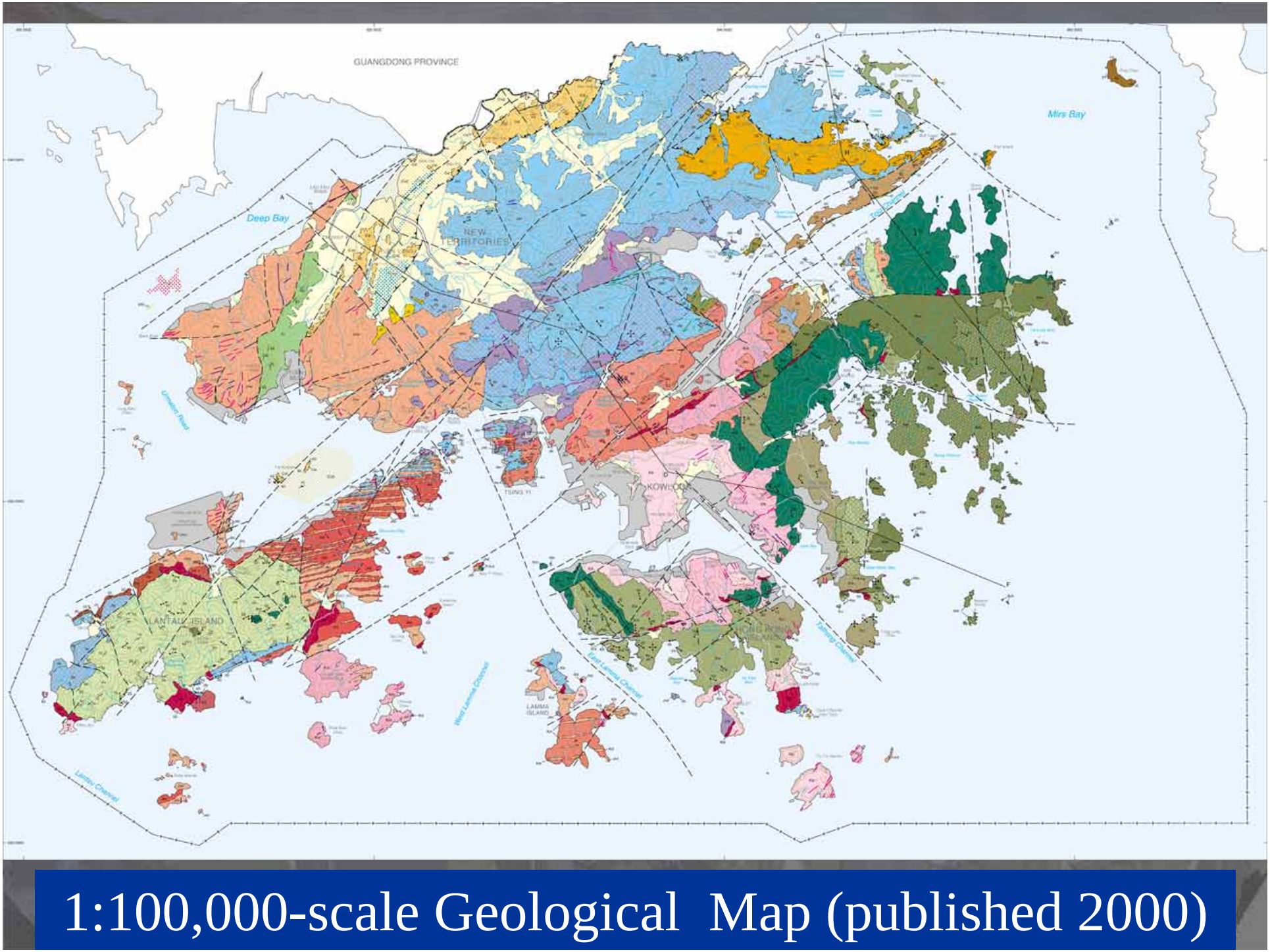
- cover Scheduled and Designated Areas containing marble and marble-bearing rocks etc.
- more site-specific
- but maps reflect state of knowledge at time of publication

(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

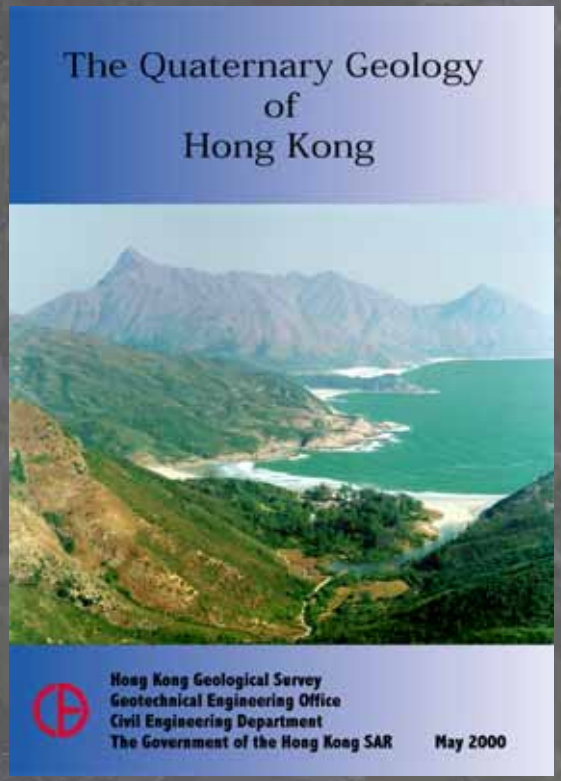


1:100,000-scale Geological Map (published 2000)

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'*

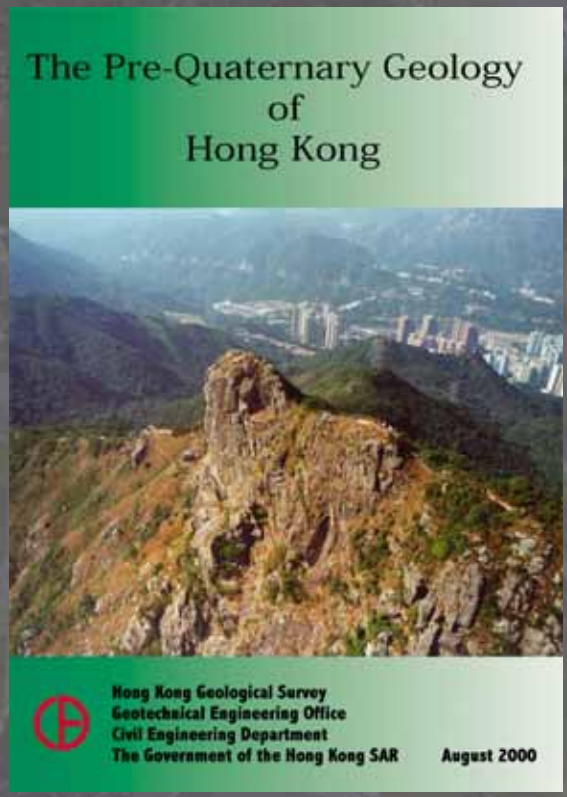


* Not engineering geology manuals

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.

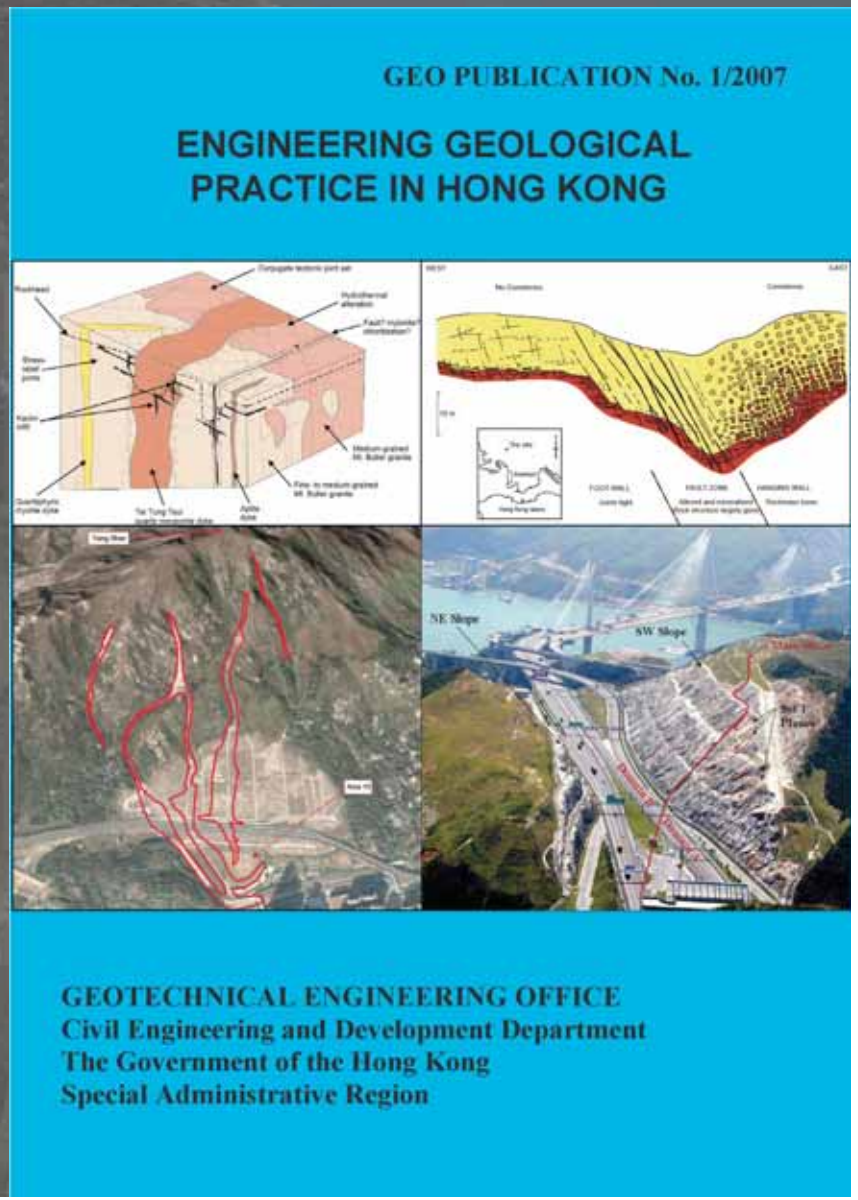
'Engineering Rock'*



* Not engineering geology manuals

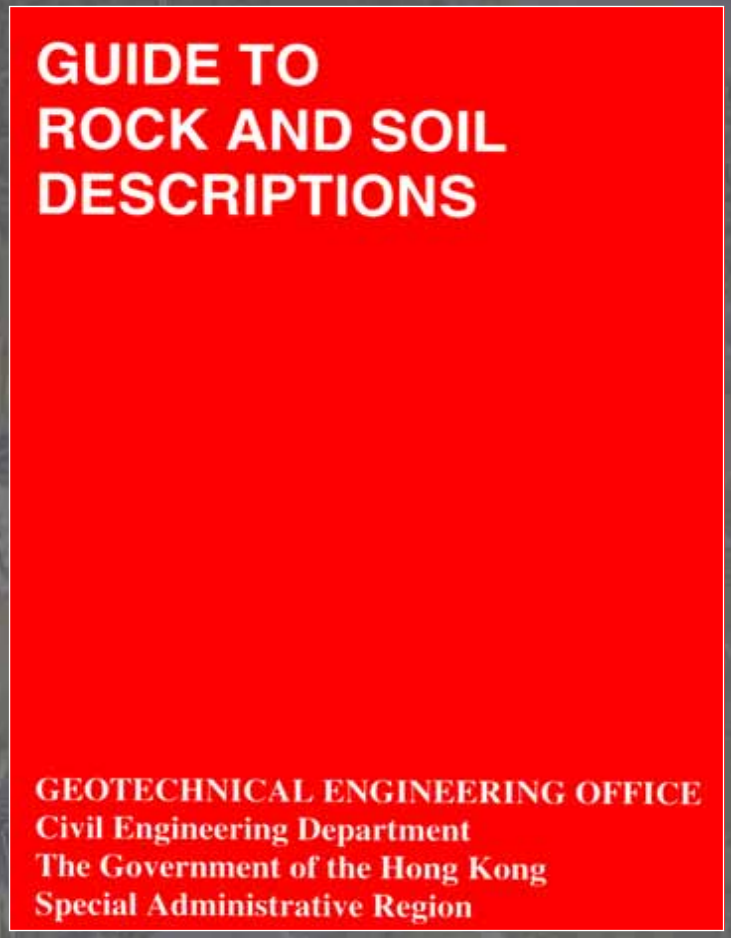
Engineering Geological Practice in Hong Kong - GEO Publication No 1/2007

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

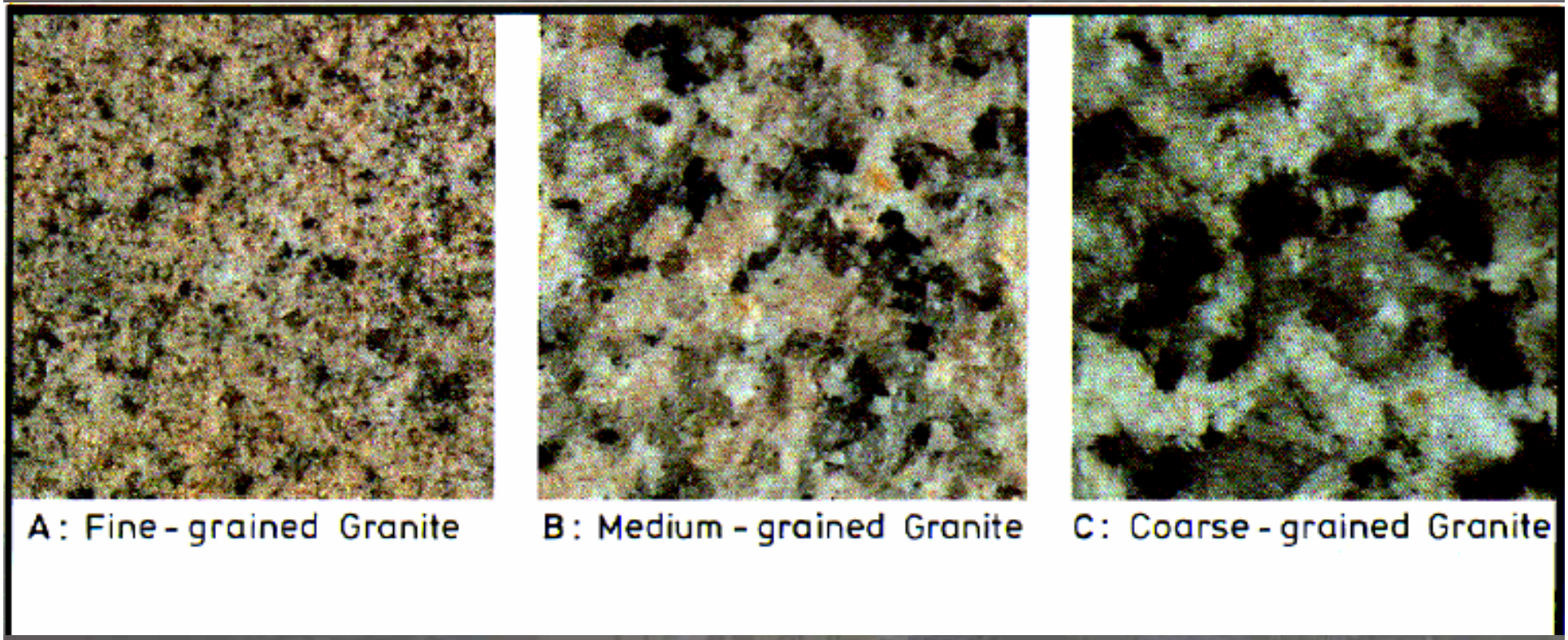


Geoguide 3 – Guide to Rock and Soil Descriptions

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



Some Common Rock Types

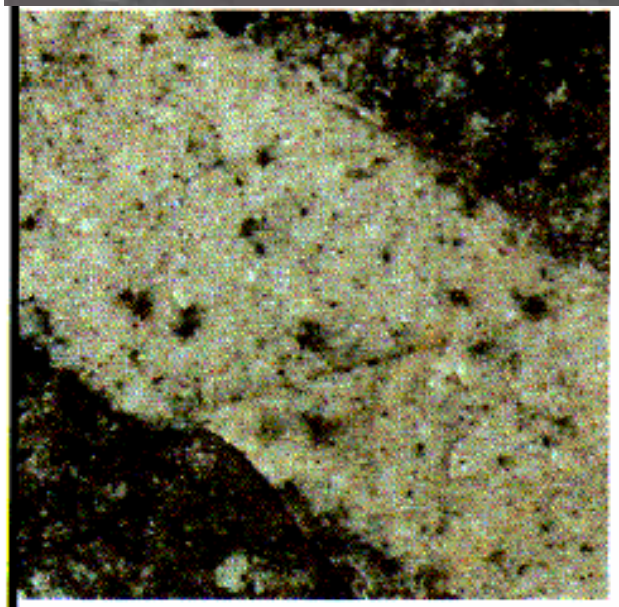


A : Fine - grained Granite

B : Medium - grained Granite

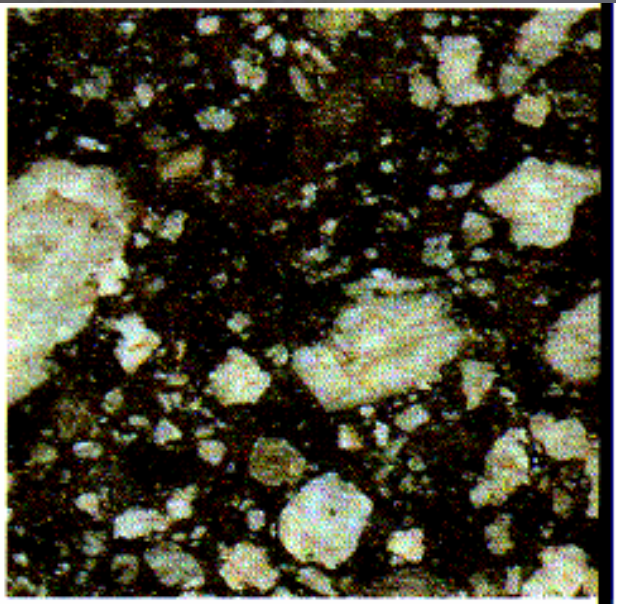
C : Coarse - grained Granite

Some Common Rock Types



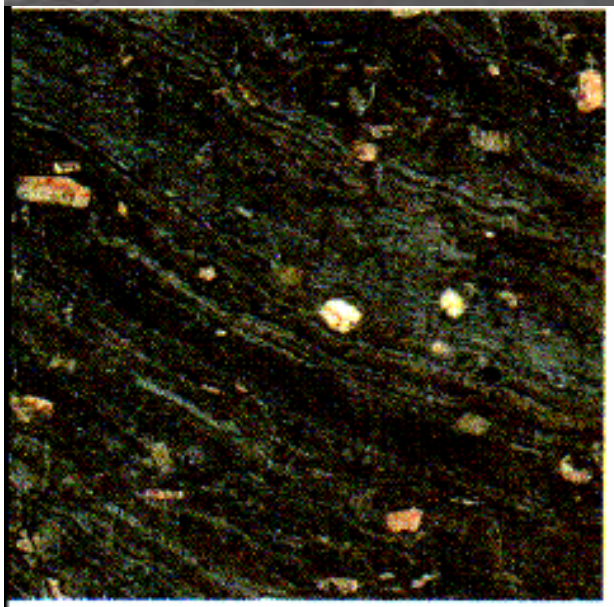
D : Aplite
(intruding granodiorite)

E: Pegmatite

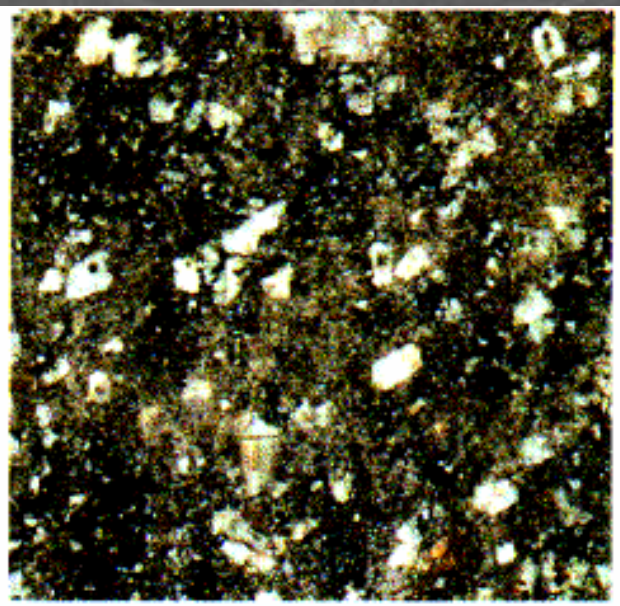


F: Granodiorite

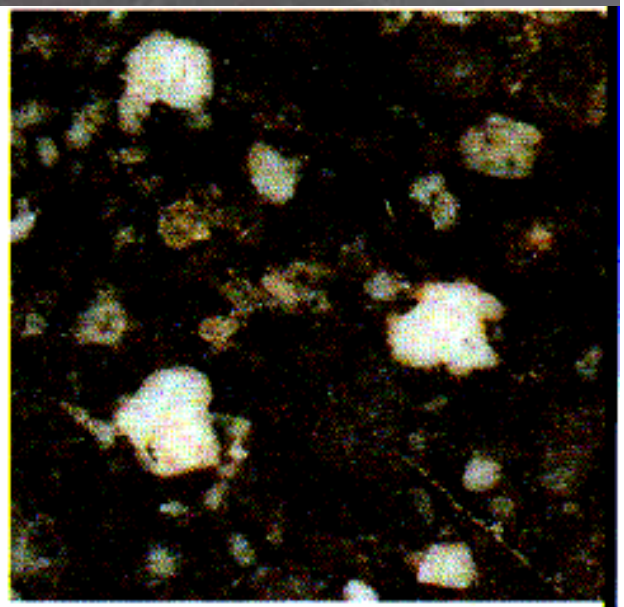
Some Common Rock Types



G : Rhyolite

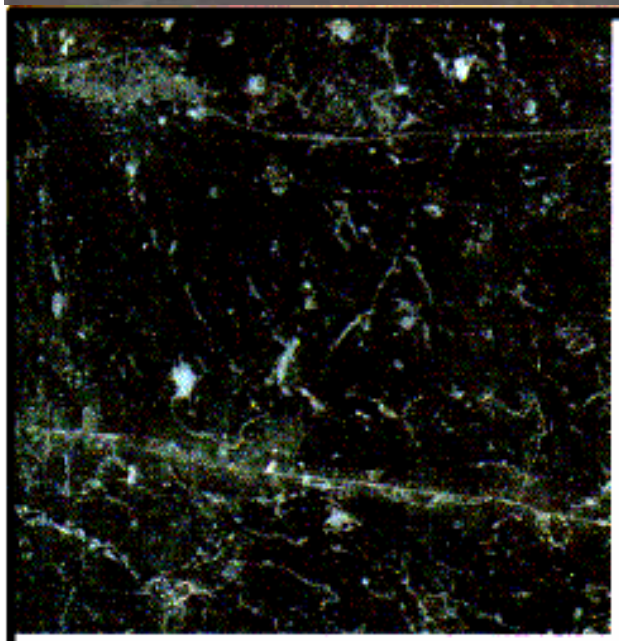


H : Rhyodacite

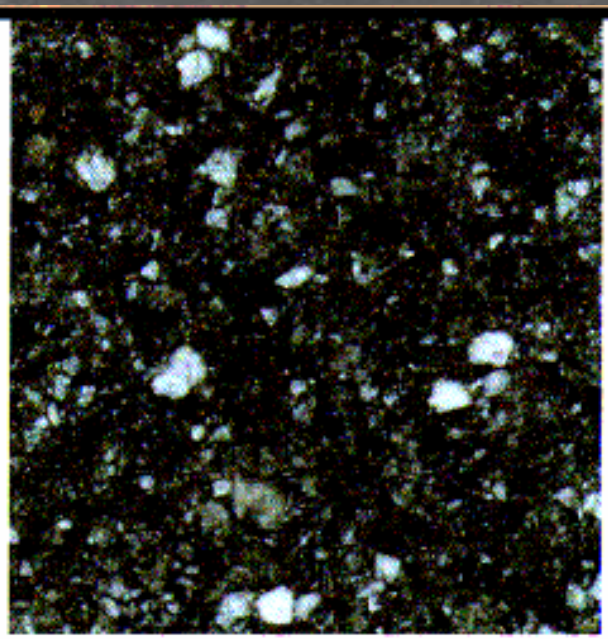


I : Dacite

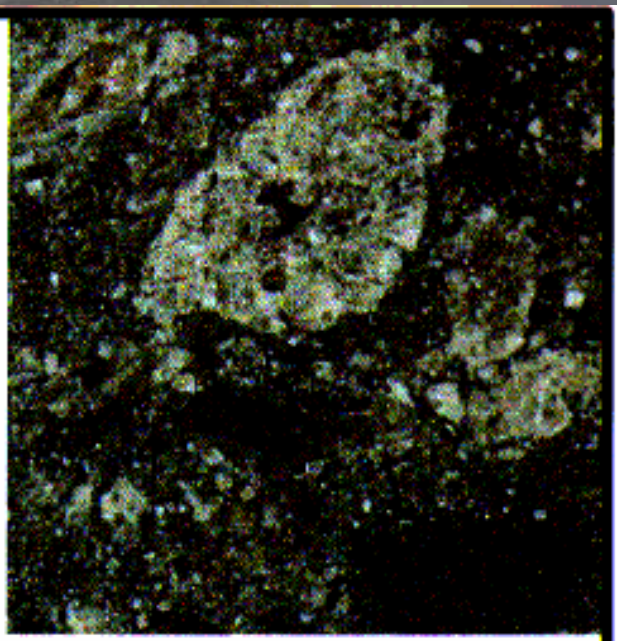
Some Common Rock Types



S: Fine Ash Tuff

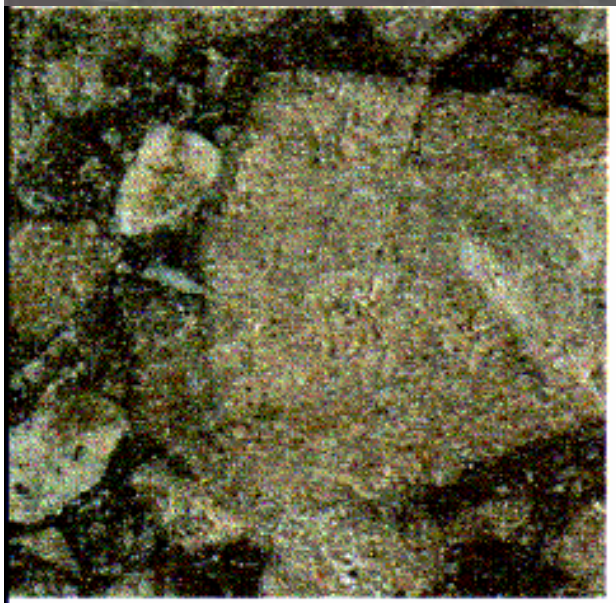


T: Coarse Ash Tuff

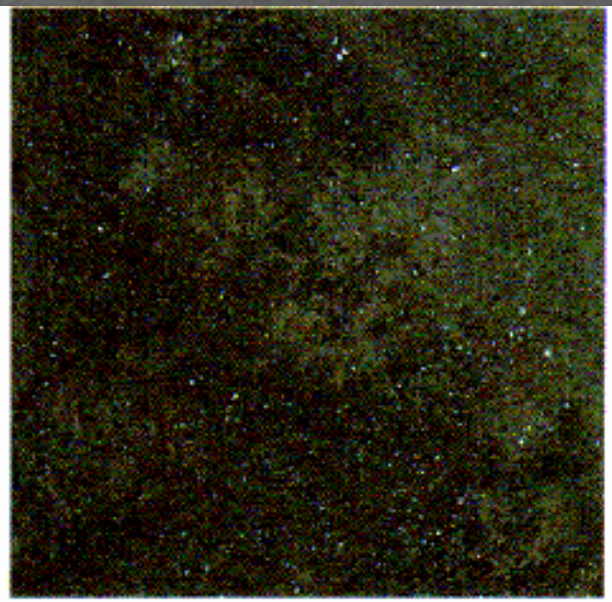


U: Lapilli Tuff

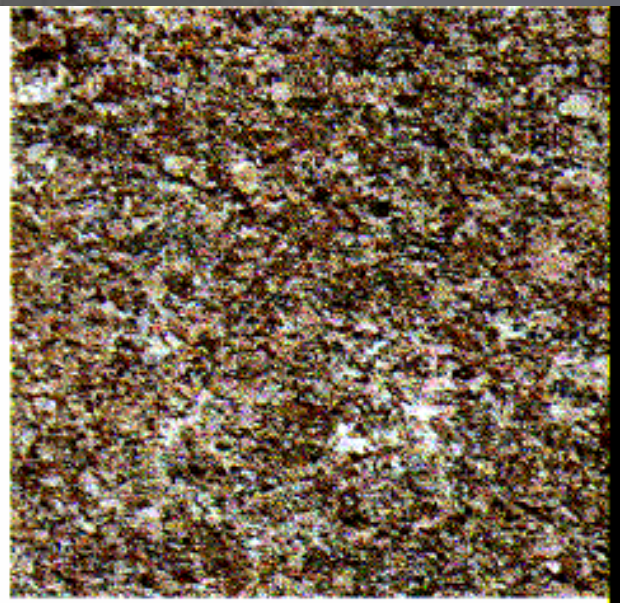
Some Common Rock Types



V: Pyroclastic Breccia (×1/2)



W: Mudstone



X: Sandstone

Some Common Rock Types

Y: Conglomerate

Z: Sedimentary Breccia

AA: Chert

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

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

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

Key Older Sedimentary Rocks (c.340Ma)

Lok Ma Chau Formation

Tai Shek Mo Member - Metasandstone with metaconglomerate

Mai Po Member - Metasiltstone with graphite schist

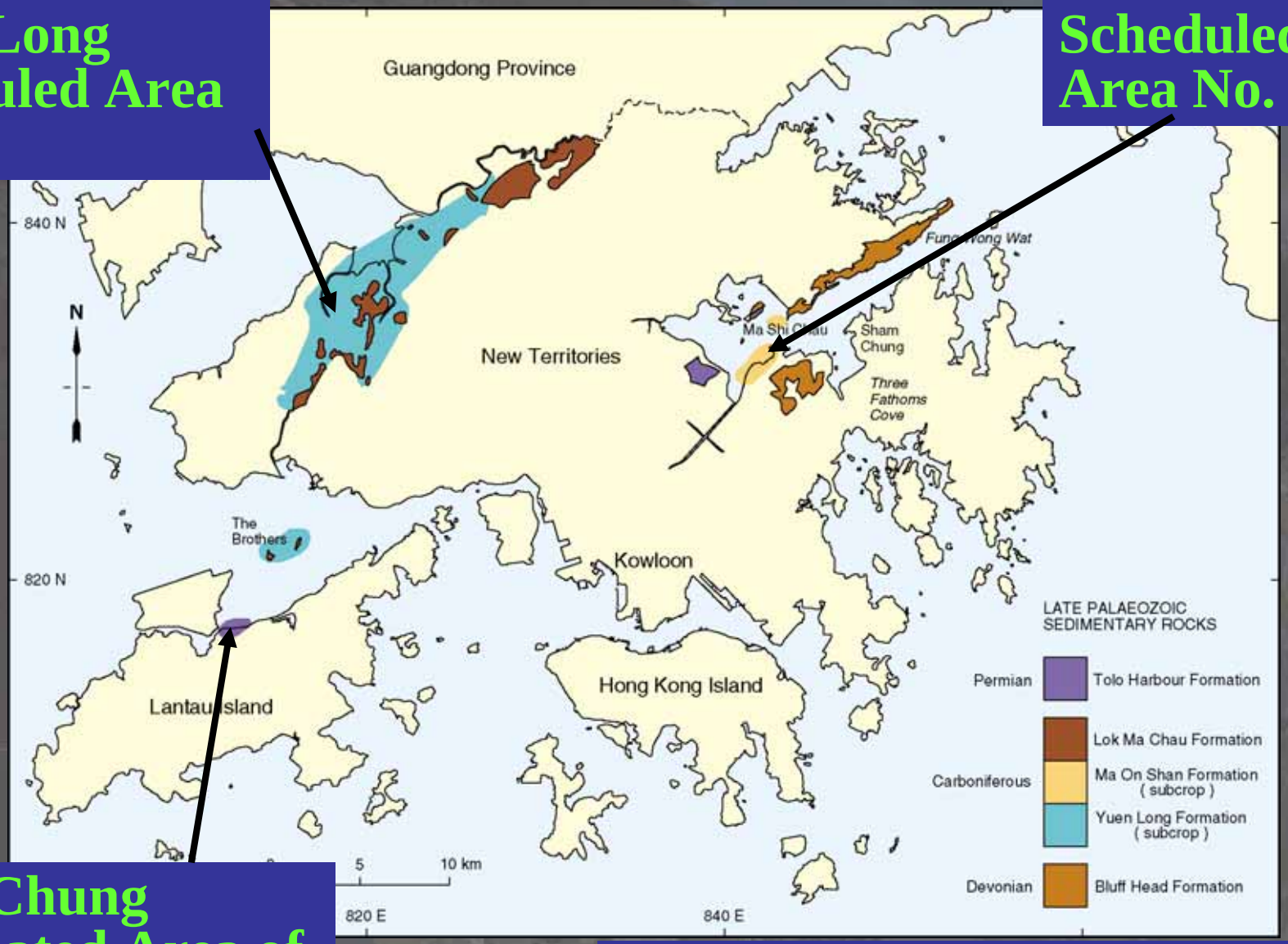
- Yuen Long and Ma On Shan Formations

Marble (>50% carbonate) + cavity/cavity-infill

Pure and Impure (up to 17% impurities)

Tin Shui Wai & Yuen Long Scheduled Area No. 2

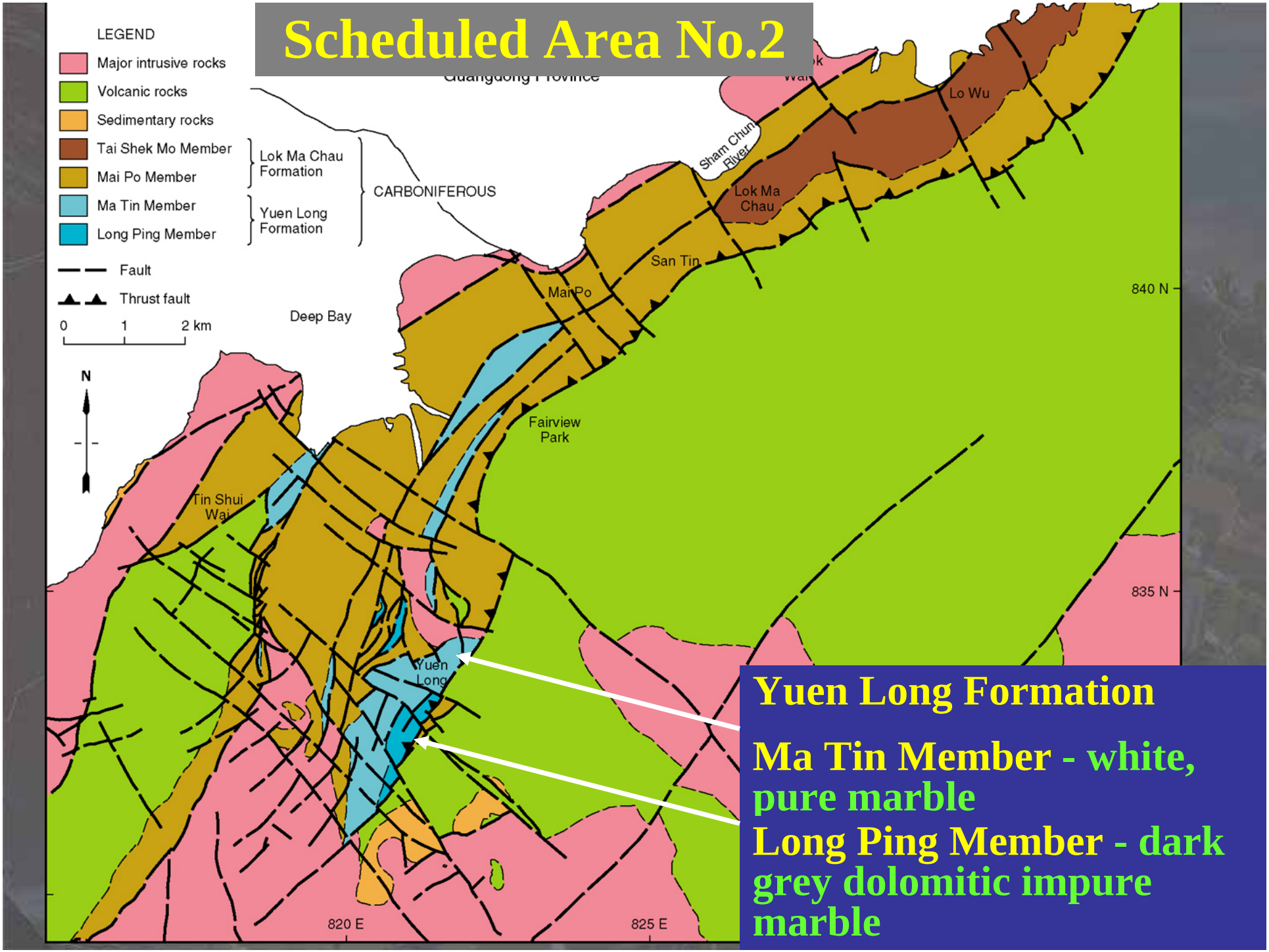
Ma On Shan Scheduled Area No. 4



Tung Chung Designated Area of Northshore Lantau

Areas of Marble Subcrop

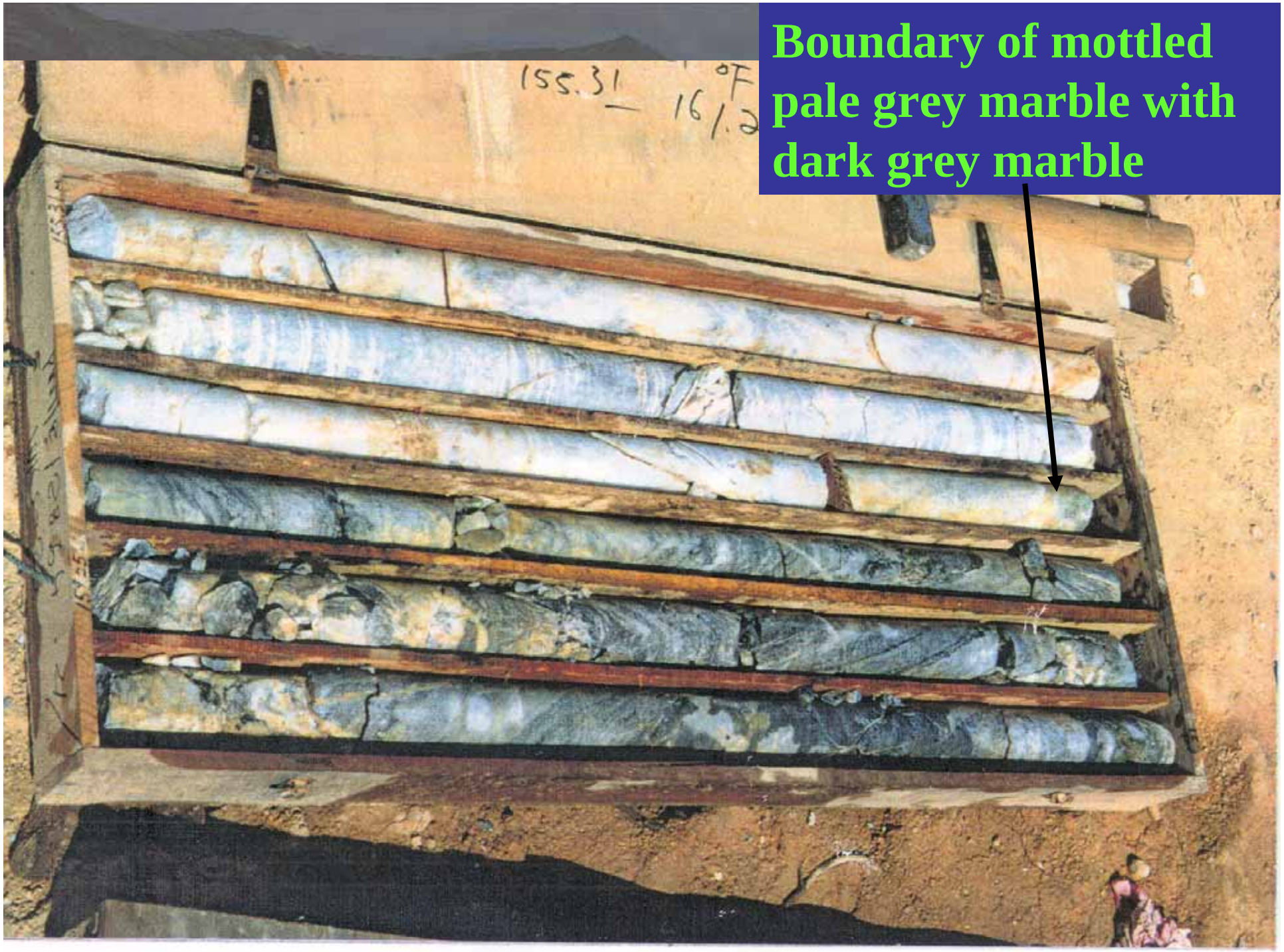
Scheduled Area No.2



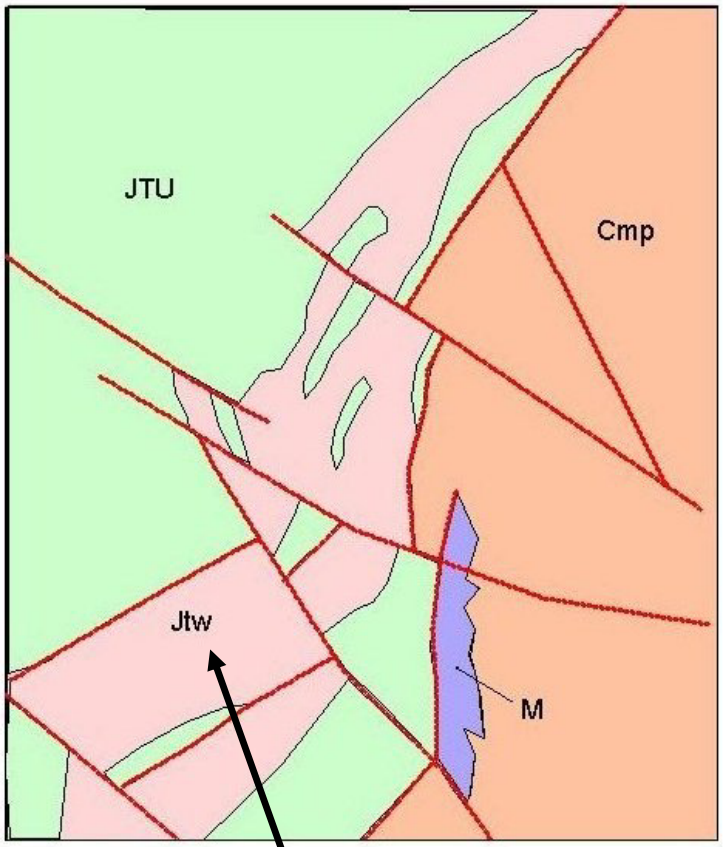
Yuen Long Formation

Ma Tin Member - white, pure marble

Long Ping Member - dark grey dolomitic impure marble


Boundary of mottled pale grey marble with dark grey marble

<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

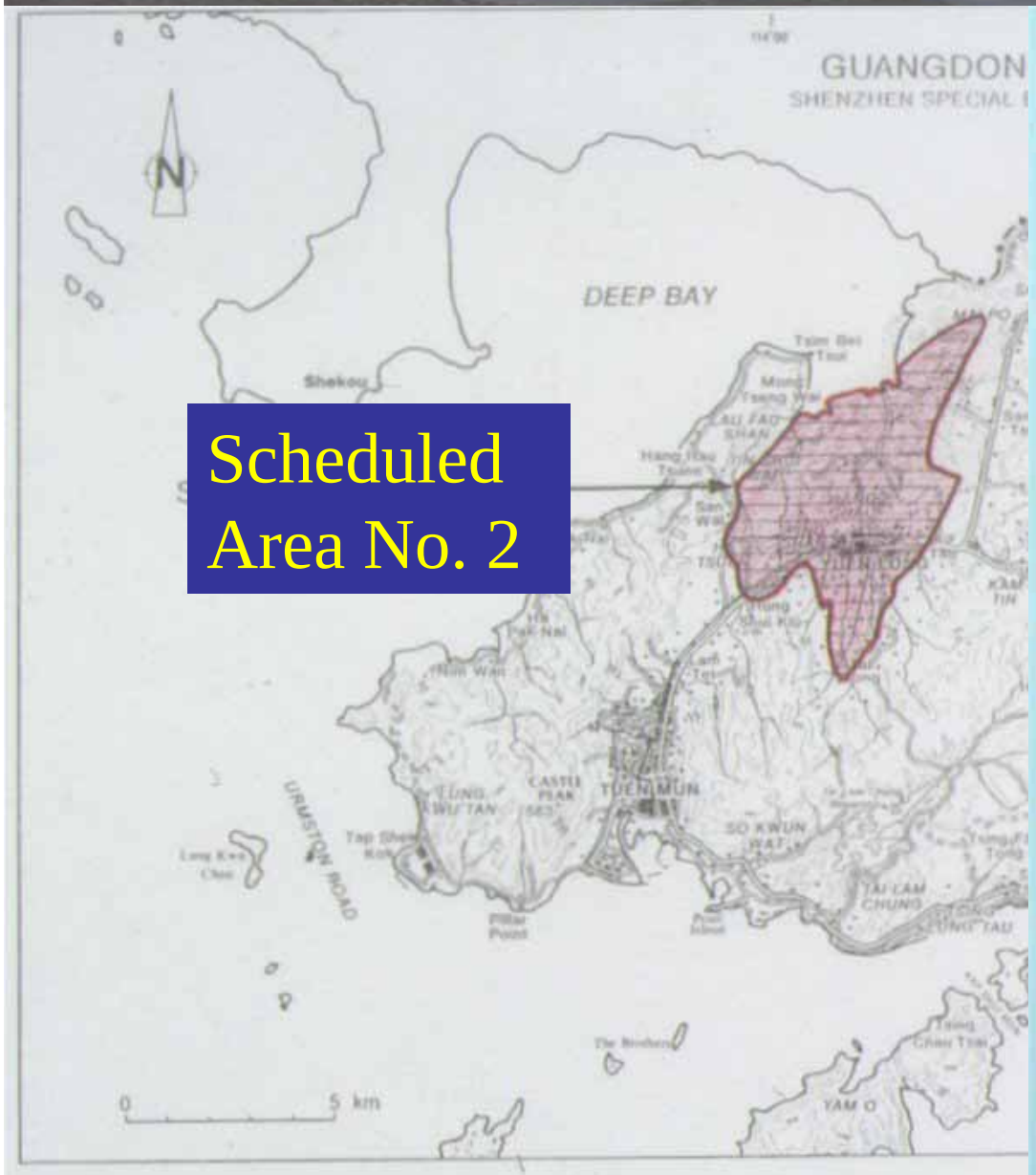


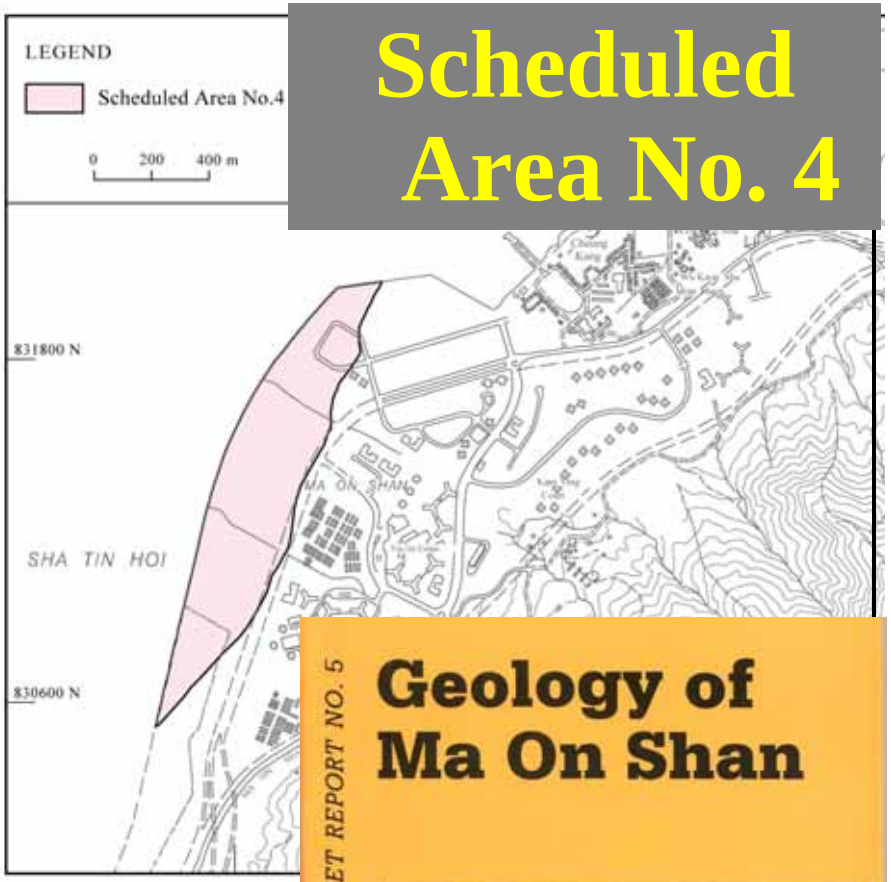
Figure 2 - The Redefined Designated Area in the Northwest New Territories (Sched

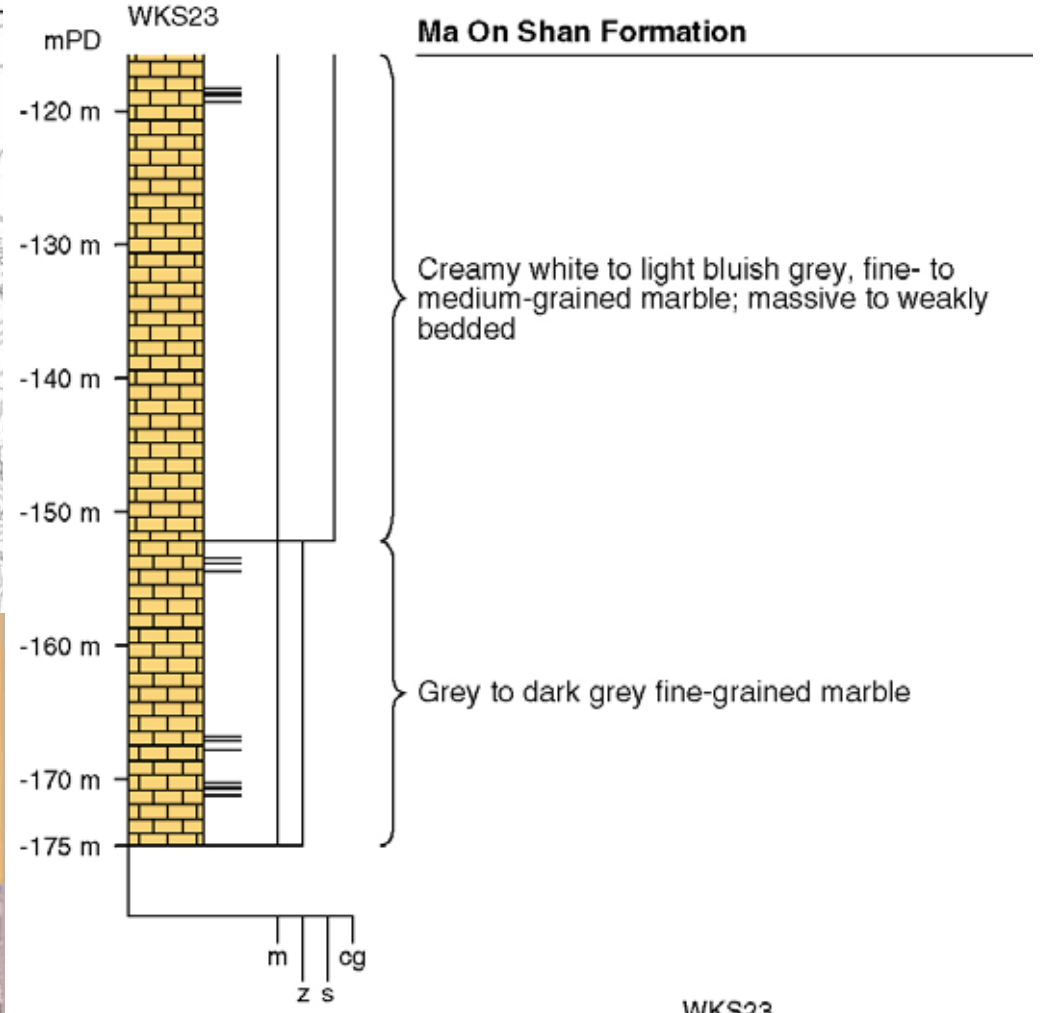
HONG KONG GEOLOGICAL SURVEY *SHEET REPORT NO. 1*

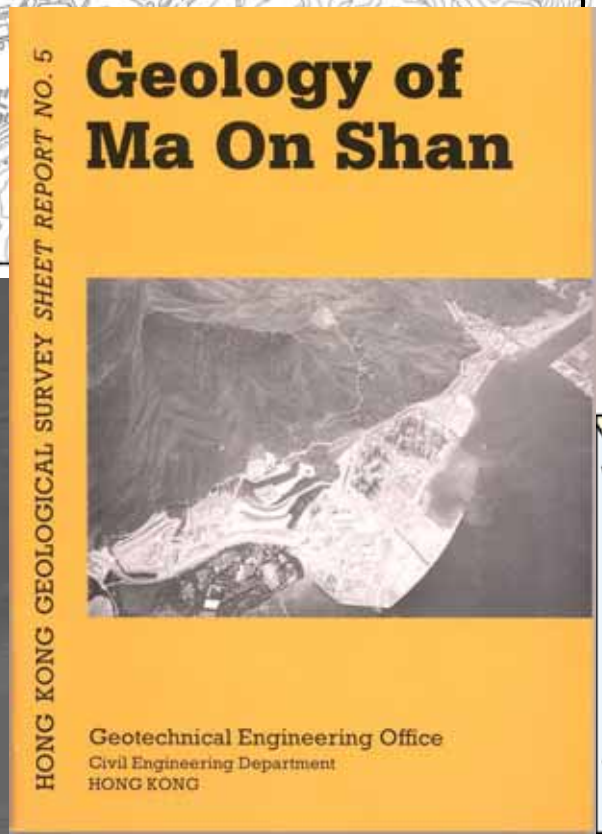
Geology of Yuen Long

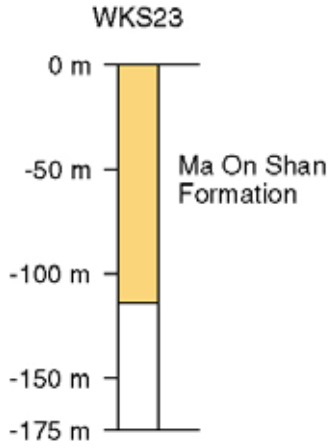
Geotechnical Engineering Office
Civil Engineering Department
HONG KONG

Scheduled Area No. 4

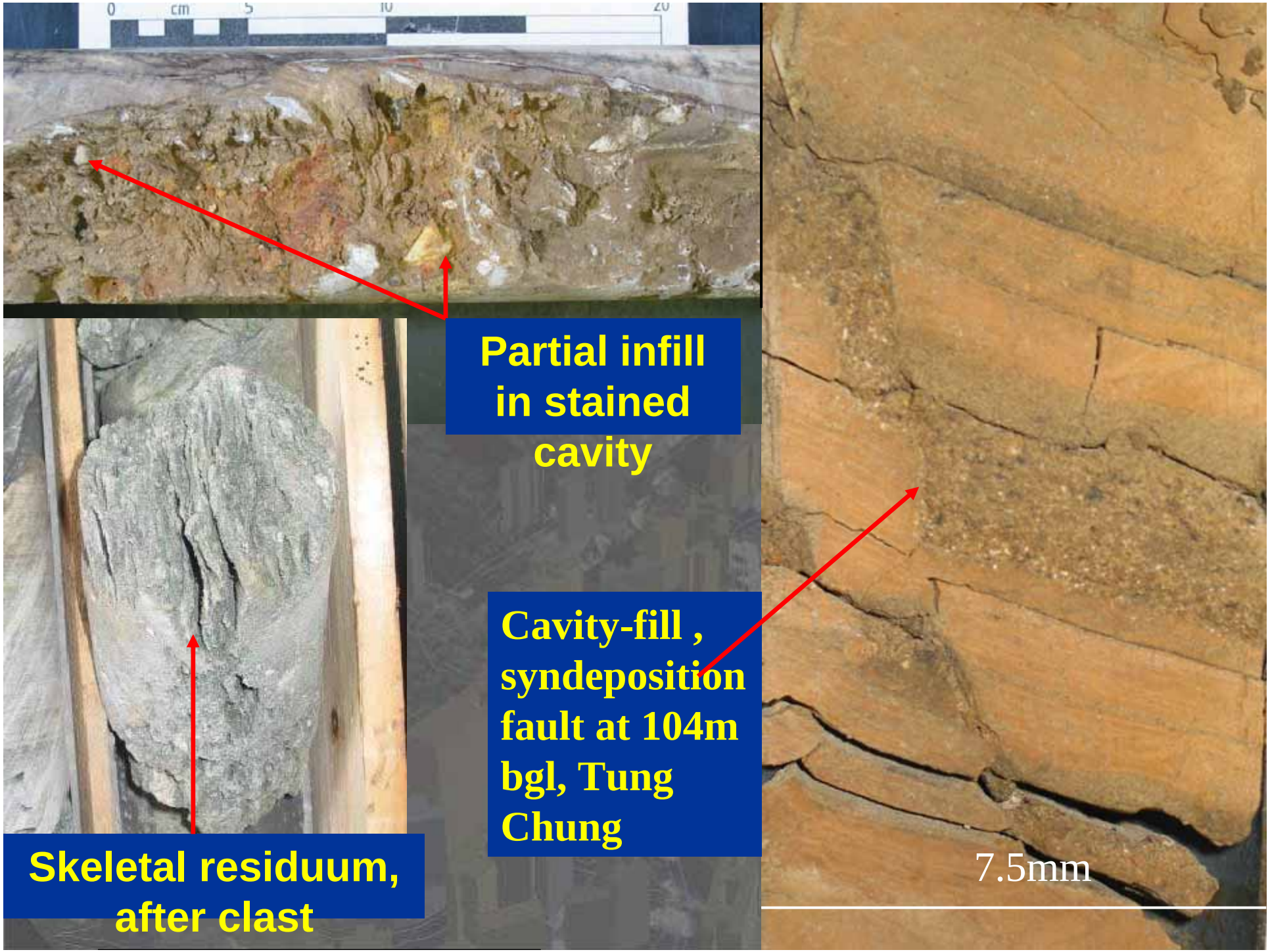






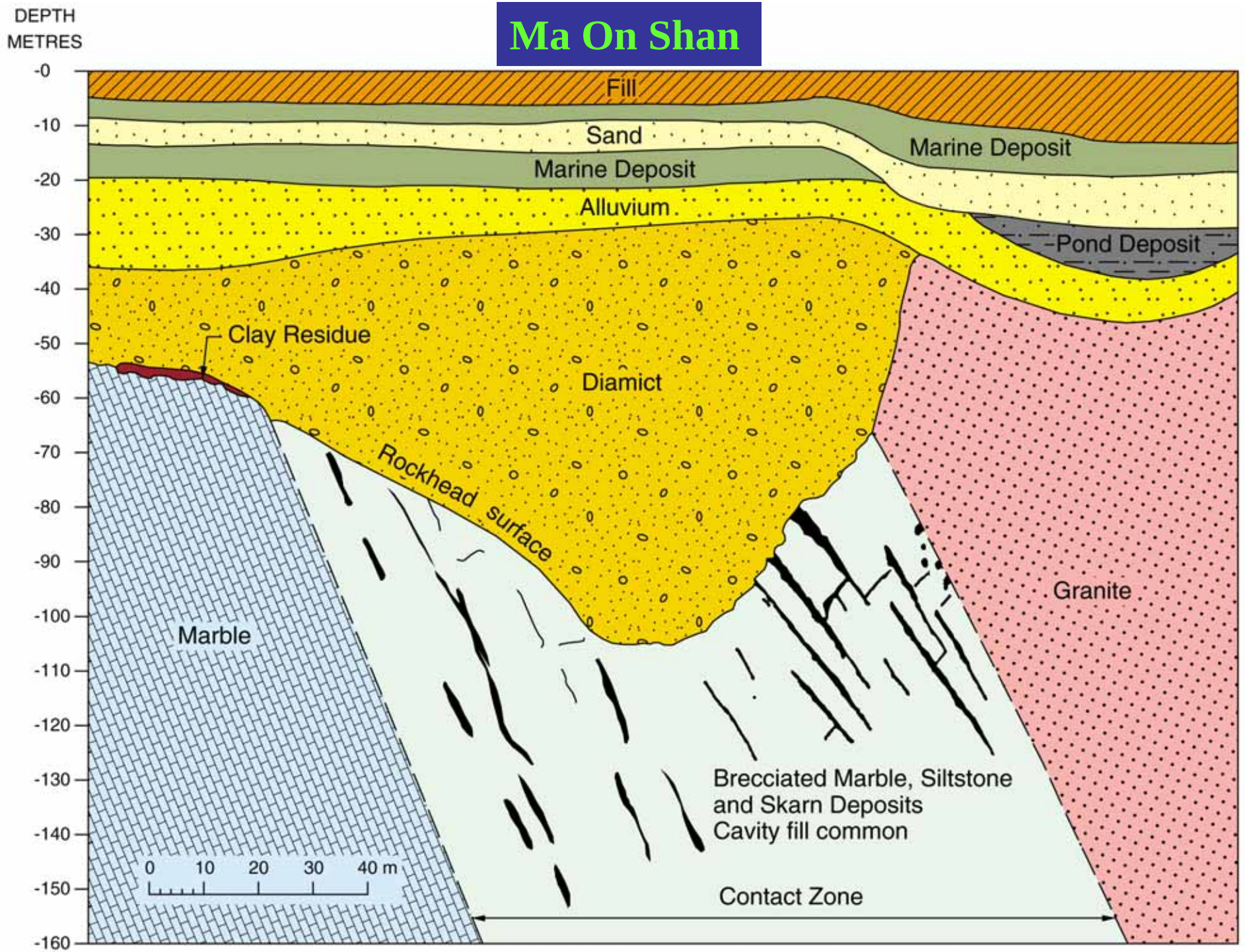


Cavity development in marble
NW New Territories

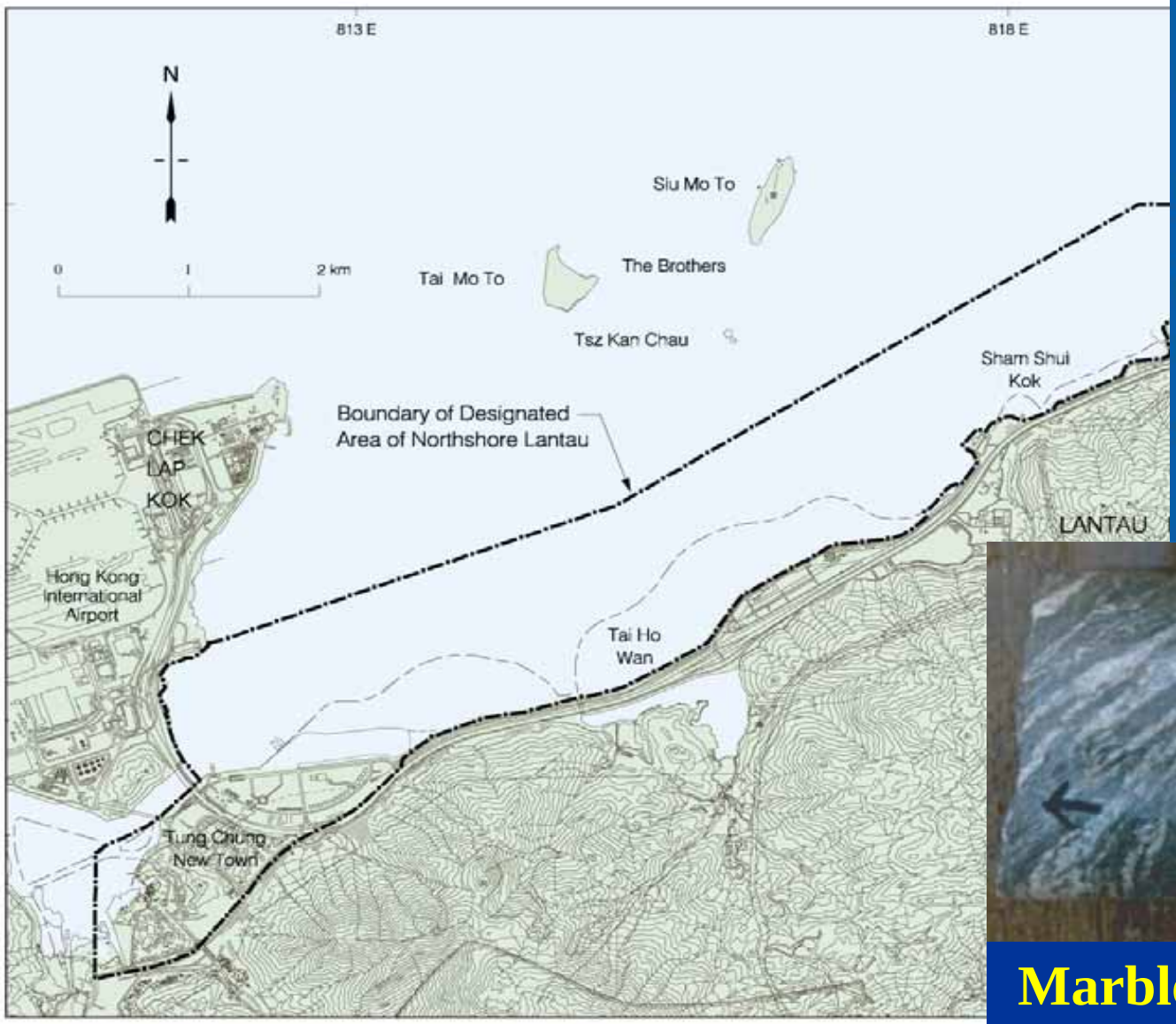

Partial infill in stained cavity
Cavity-fill , syndeposition fault at 104m bgl, Tung Chung
Skeletal residuum, after clast
7.5mm

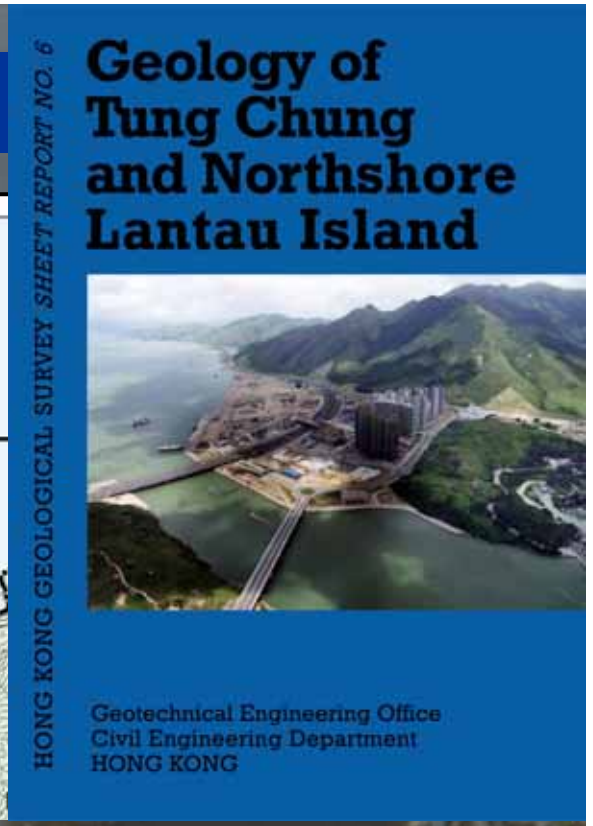

CH602 103-107.0
White marble with brown clay cavity infill, Ma On Shan

Ma On Shan


DEPTH
METRES
-0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
Fill
Sand
Marine Deposit
Marine Deposit
Alluvium
Pond Deposit
Clay Residue
Diamict
Rockhead surface
Granite
Marble
Brecciated Marble, Siltstone
and Skarn Deposits
Cavity fill common
Contact Zone
0 10 20 30 40 m

Designated Area of Northshore Lantau



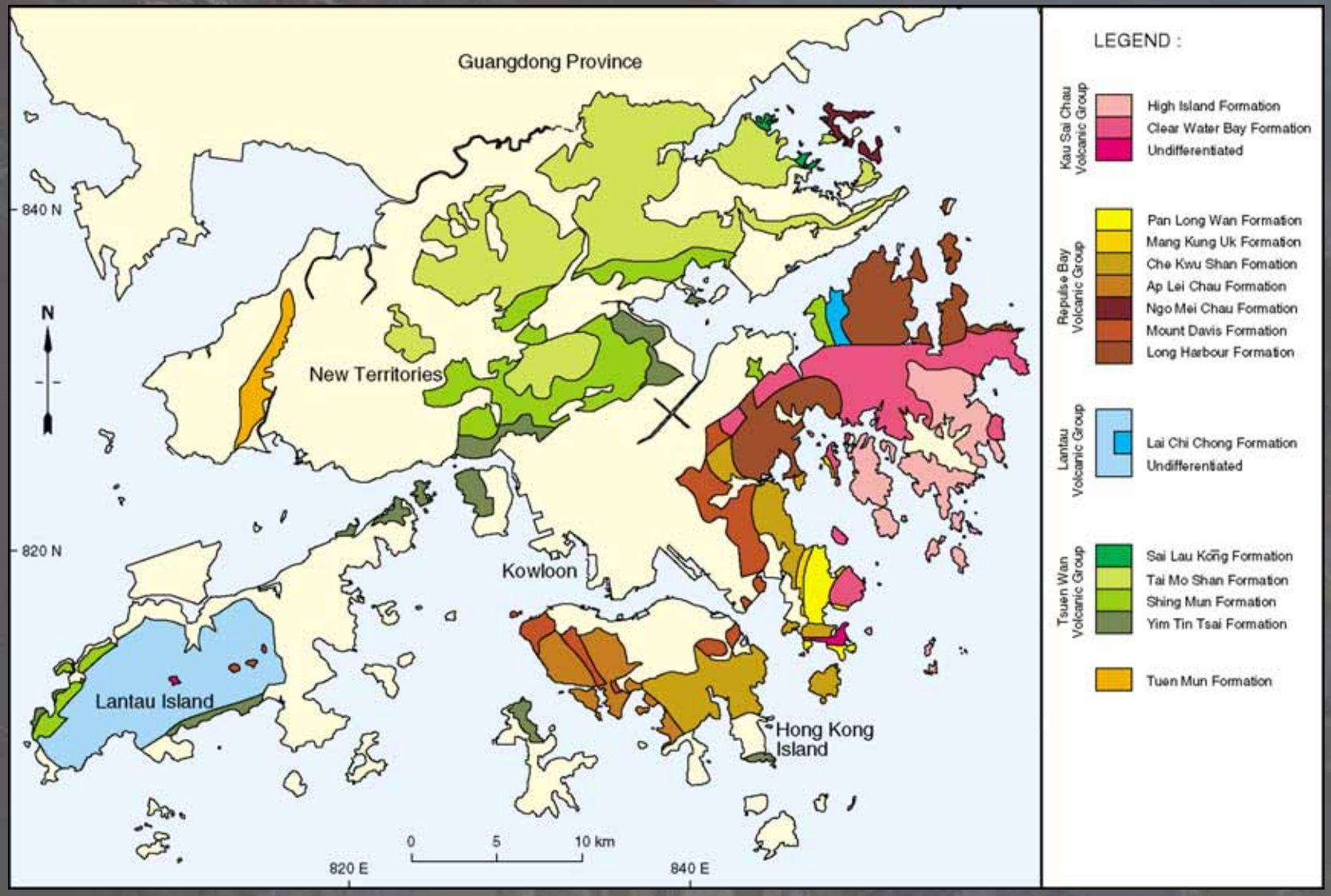


Marble (typically banded) (Tung Chung)

Volcanic & Granitic Rocks

(% land surface of Hong Kong)

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



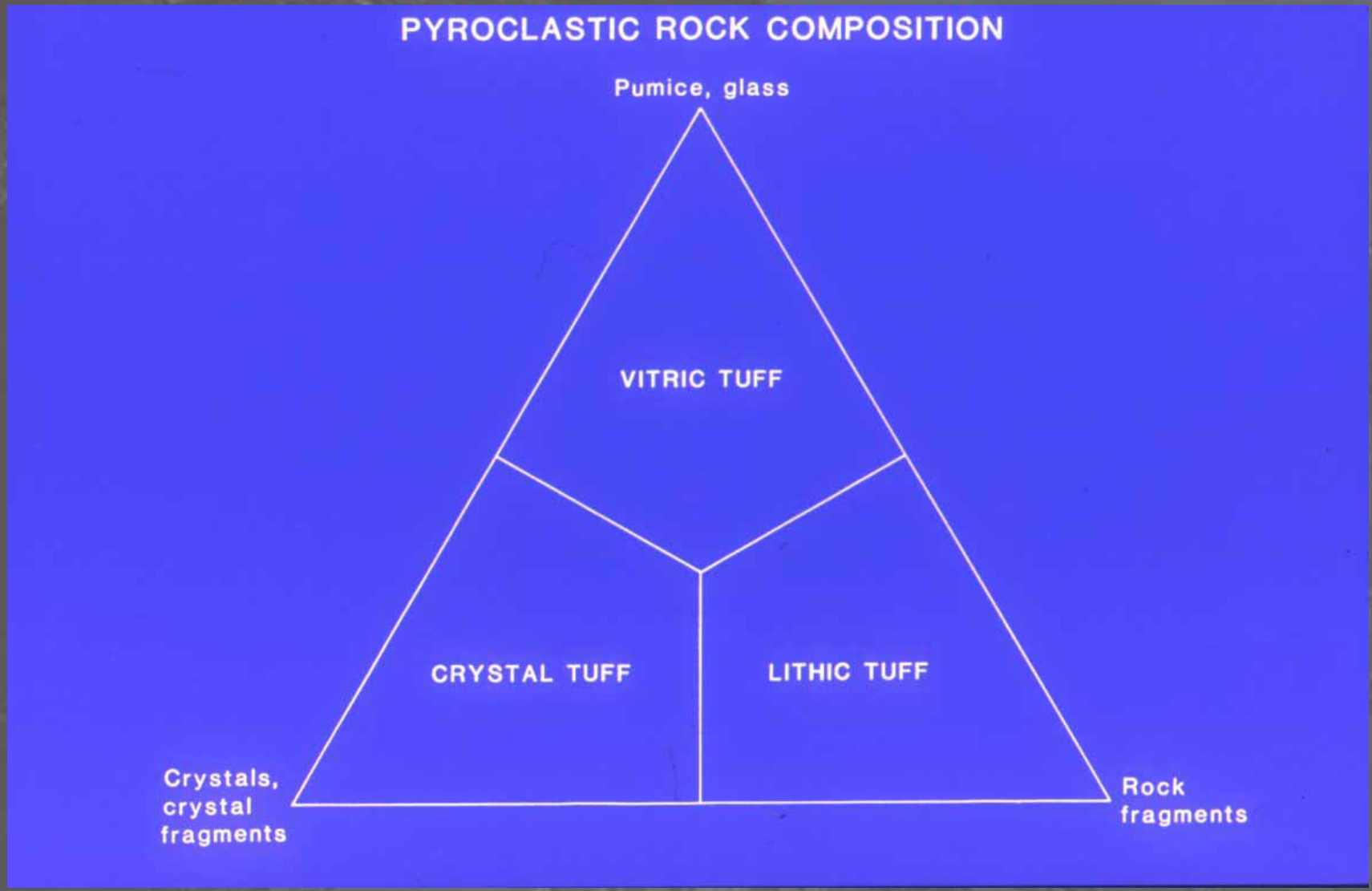
Volcanic Rocks

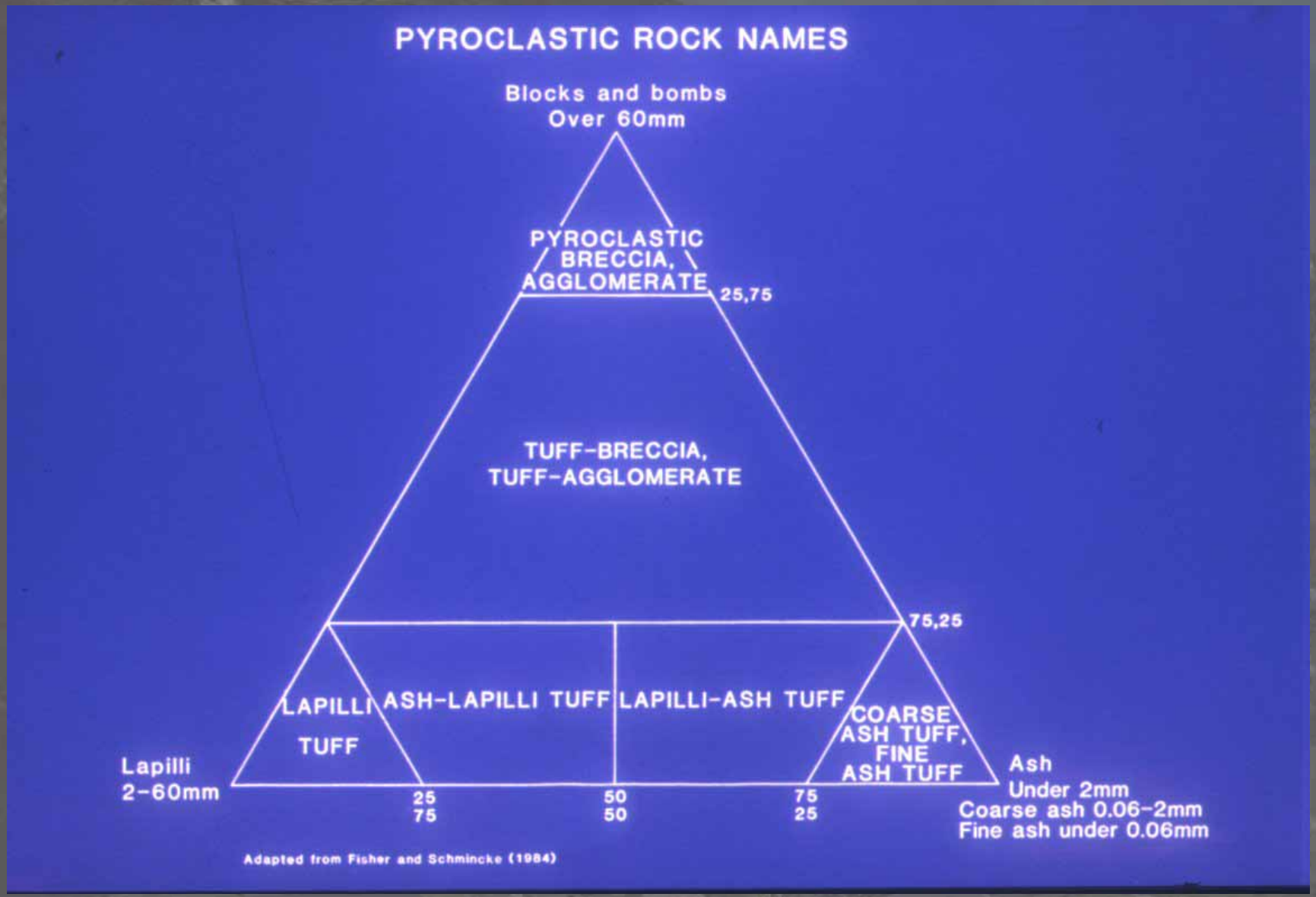
Sewell et al., 2000

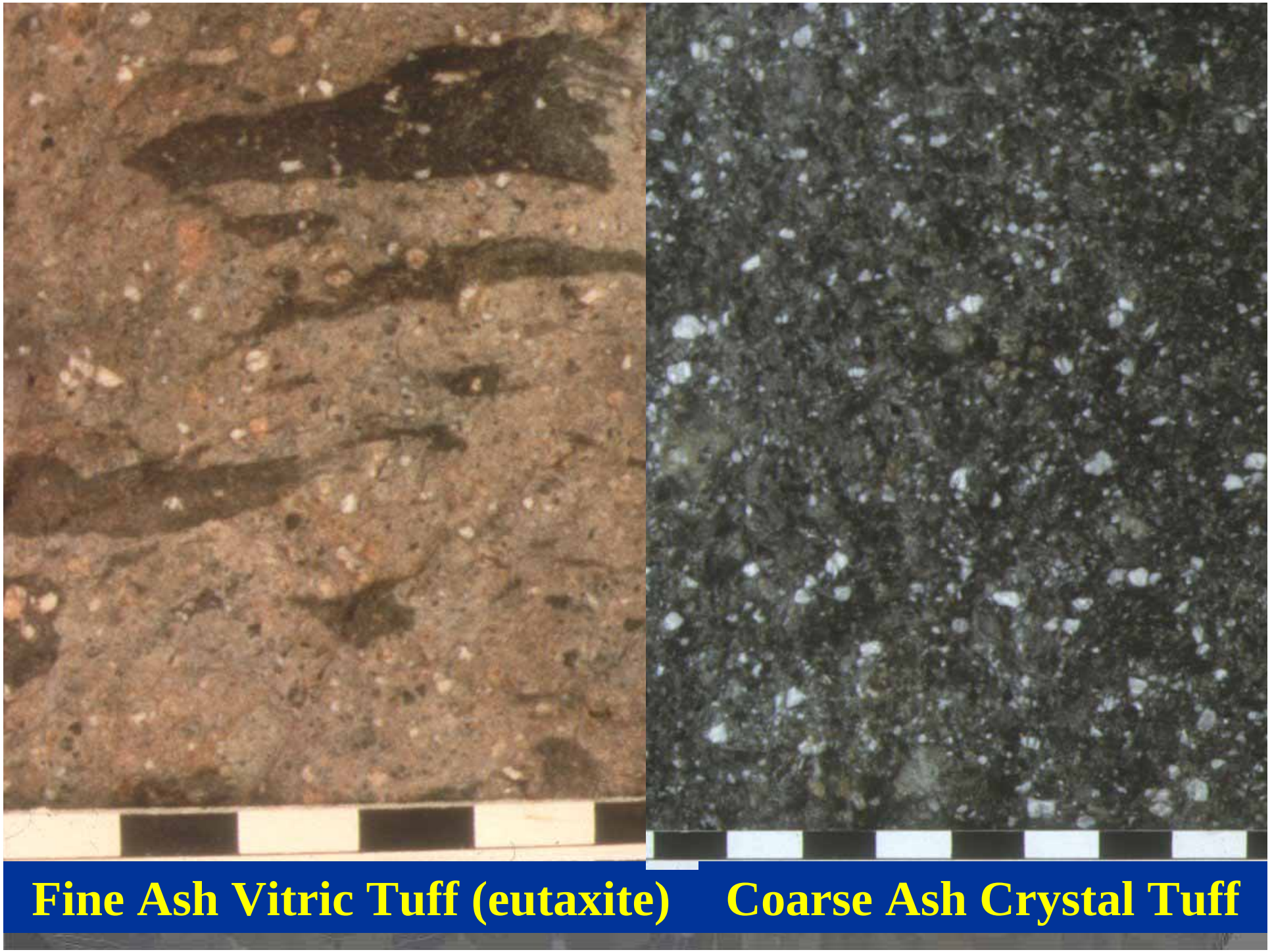
VOLCANIC ROCKS

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


PYROCLASTIC ROCK COMPOSITION
Pumice, glass
VITRIC TUFF
CRYSTAL TUFF
LITHIC TUFF
Crystals, crystal fragments
Rock fragments


PYROCLASTIC ROCK NAMES
Blocks and bombs
Over 60mm
PYROCLASTIC
BRECCIA,
AGGLOMERATE
25,75
TUFF-BRECCIA,
TUFF-AGGLOMERATE
75,25
LAPILLI
TUFF
ASH-LAPILLI TUFF
LAPILLI-ASH TUFF
COARSE
ASH TUFF,
FINE
ASH TUFF
Lapilli
2-60mm
25
75
50
50
75
25
Ash
Under 2mm
Coarse ash 0.06-2mm
Fine ash under 0.06mm
Adapted from Fisher and Schmincke (1984)



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

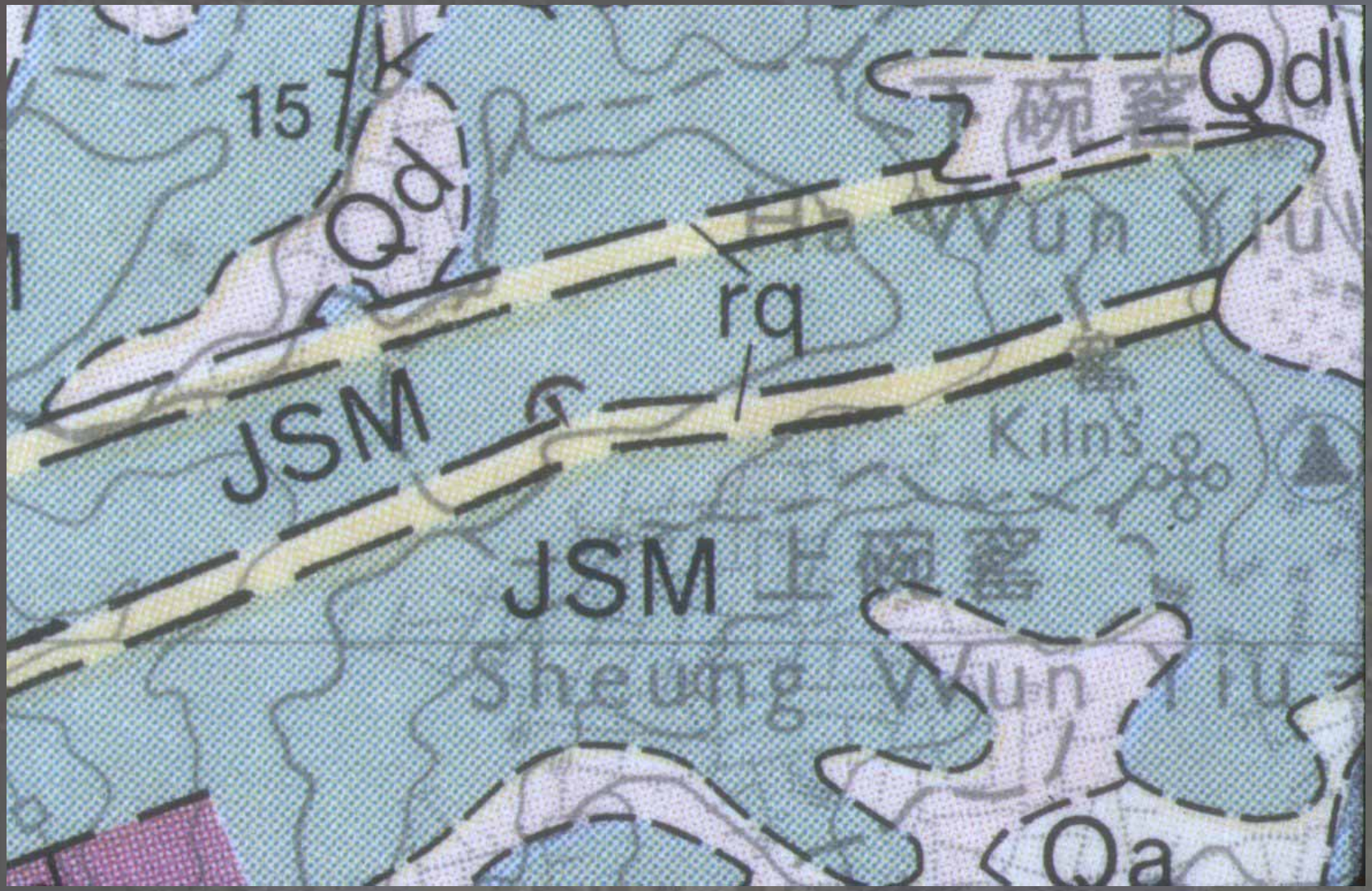
- Four groups of 'rhyolitic' formations (same age /chemistry) each of similar characteristics – may be equivalent to formations in Guangdong = suitable level of classification for engineering

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

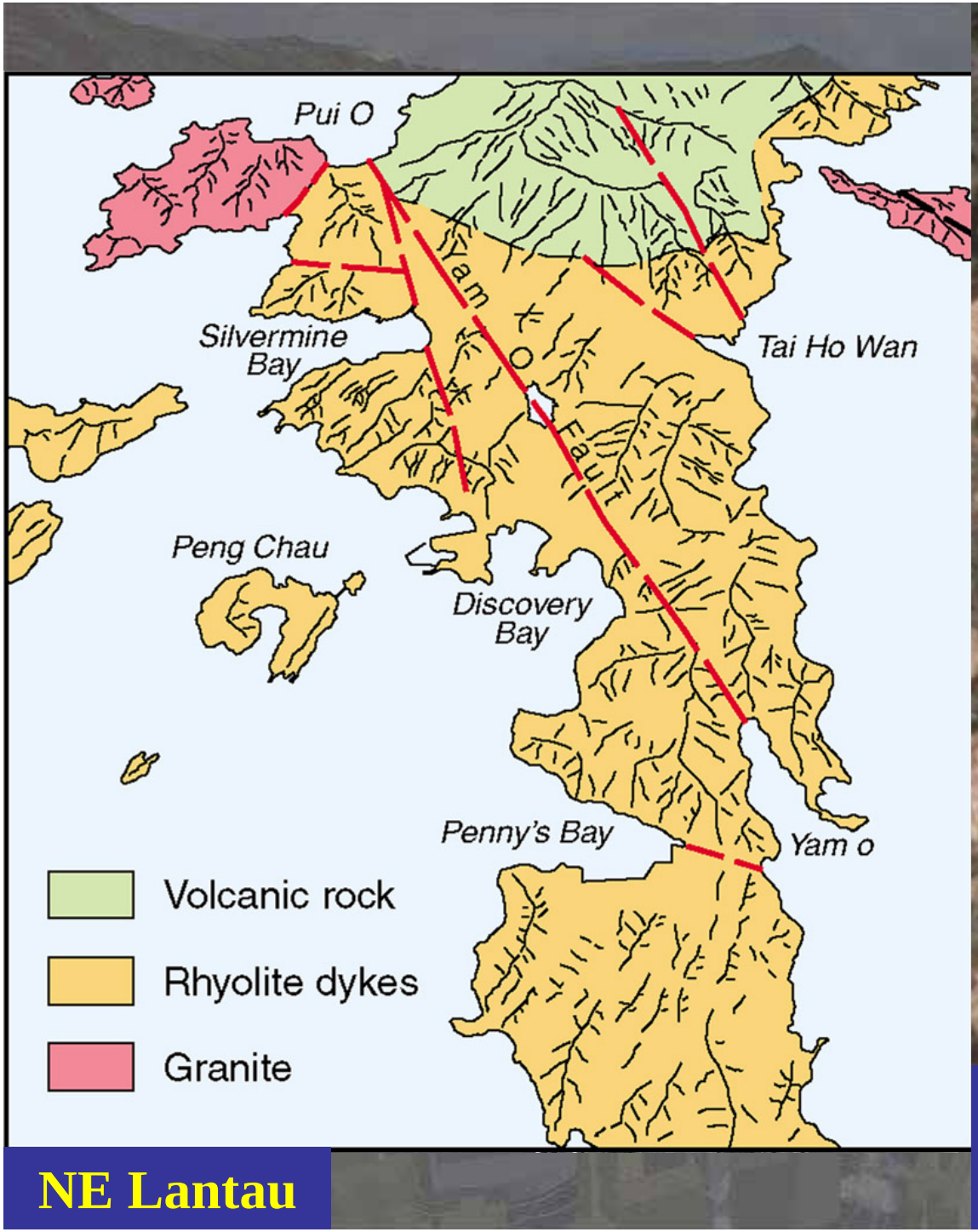
DYKE ROCKS - Classified on basis of composition, grain size, dominant crystals

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

GEO, CED 1986



Dykes are generally under-represented on maps



NE Lantau

DYKE ROCK

Feldsparphyric Rhyolite

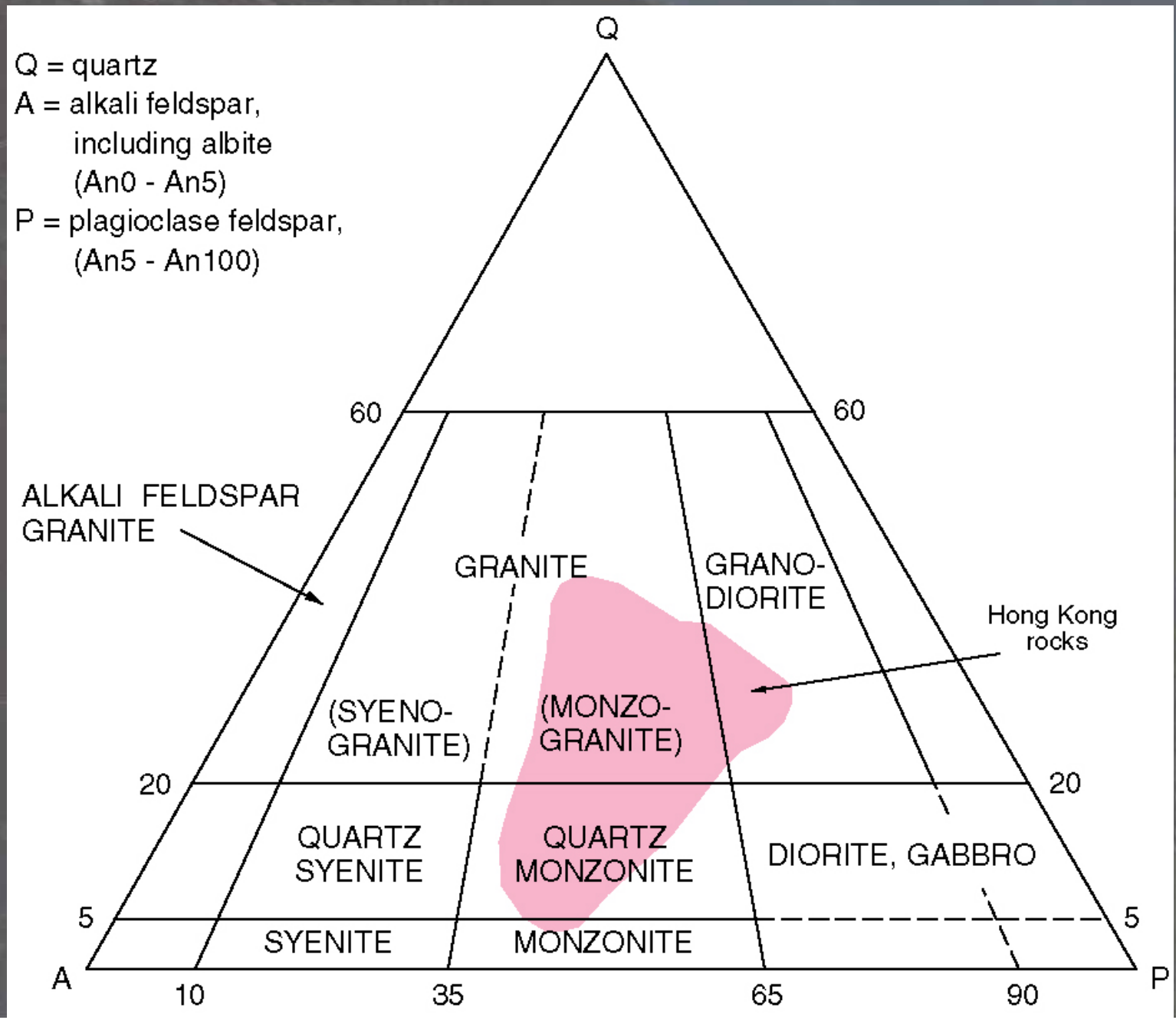
Classification Scheme for Granitic Rocks

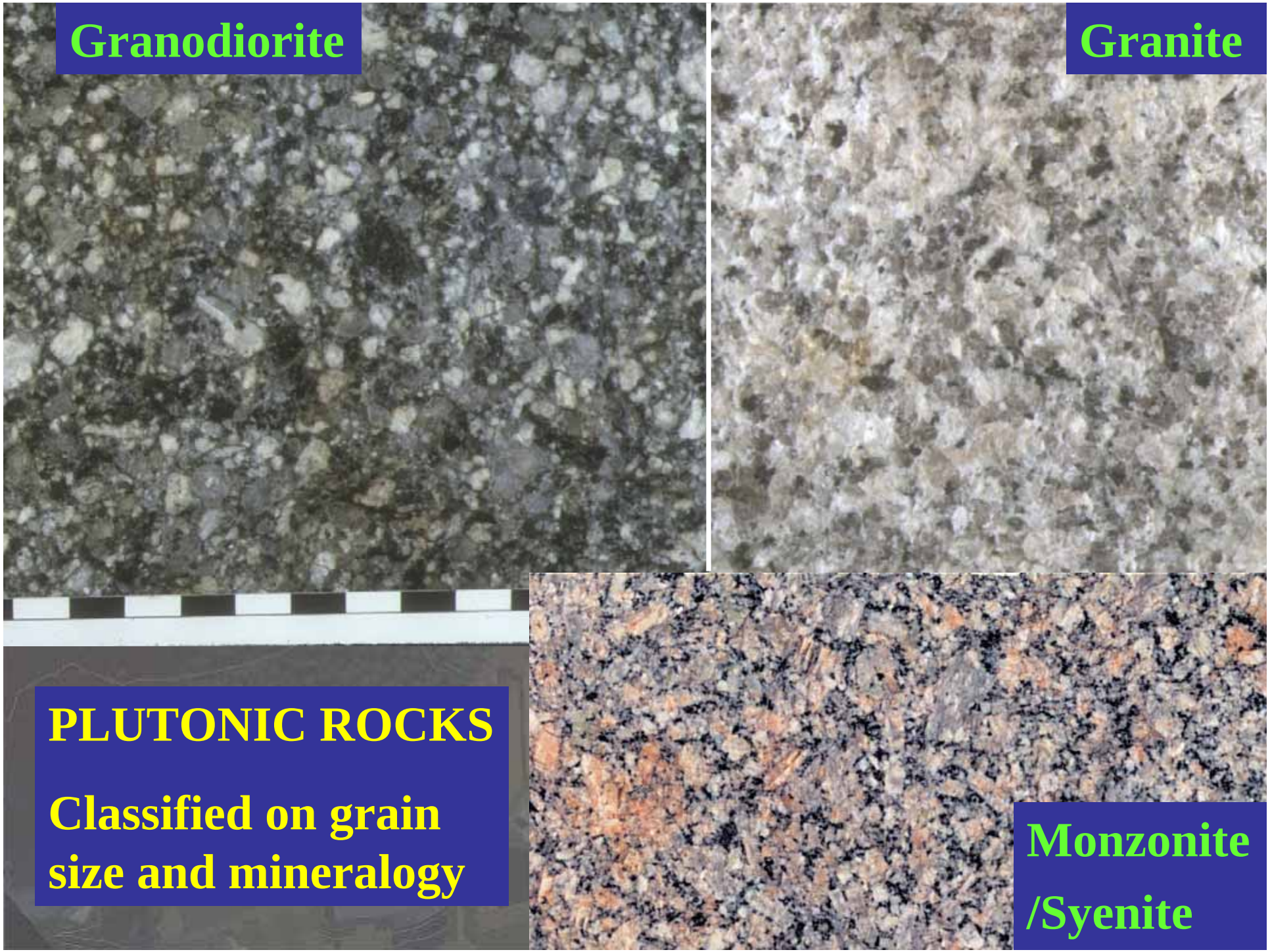
Based on measurable grain size and mineral (chemical) composition

- **Grain size**
  - **Coarse-grained >6mm**
  - **Medium-grained >2mm - <6mm**
  - **Fine-grained <2mm**

- **Mineralogy – proportions of quartz (Q) alkali feldspar (A) and plagioclase (P)**

Mineralogical Classification



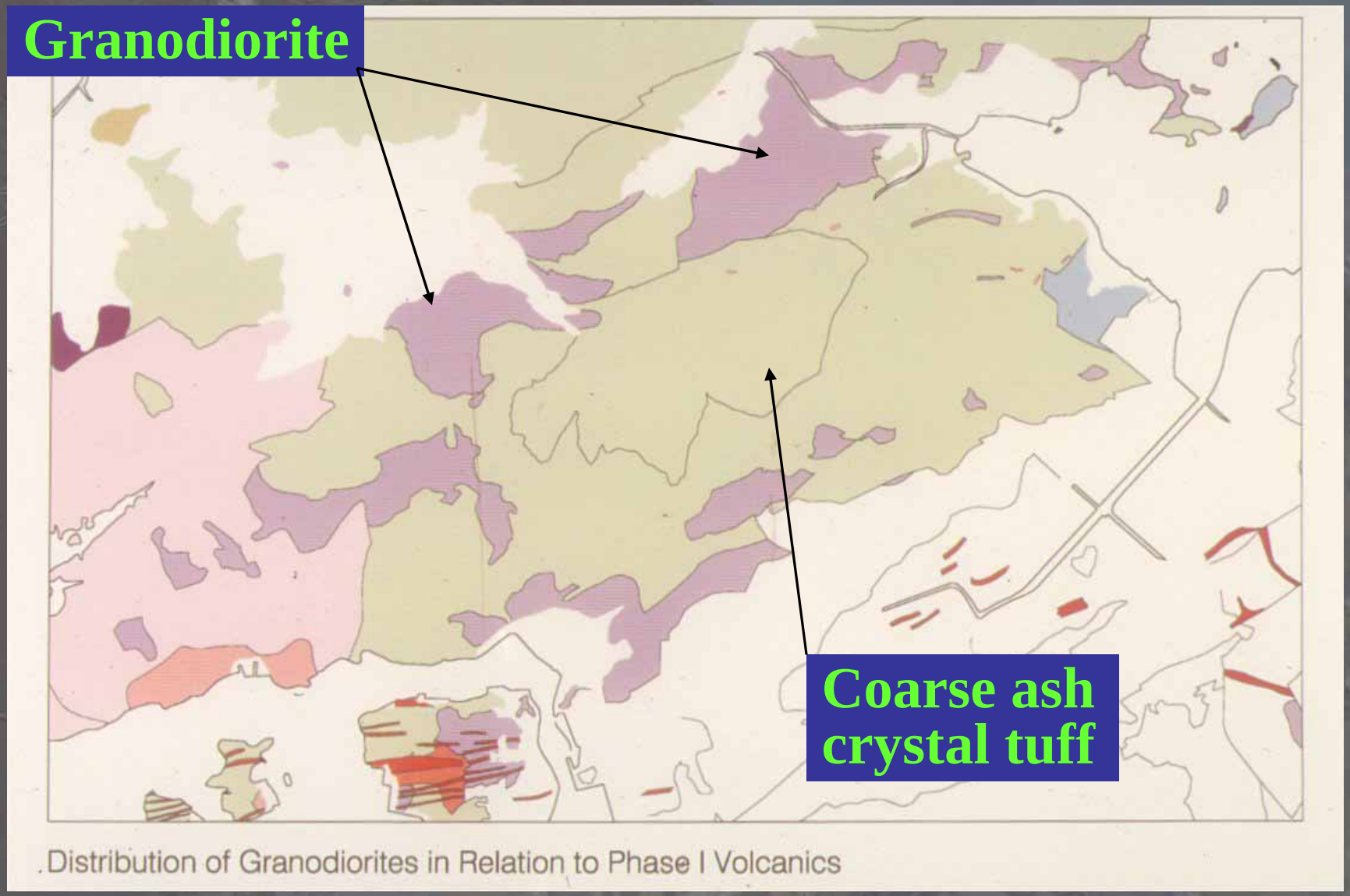

Granodiorite
Granite
PLUTONIC ROCKS
Classified on grain size and mineralogy
Monzonite /Syenite

Granitic Rocks

- As with volcanic rocks, many individual intrusions (units)

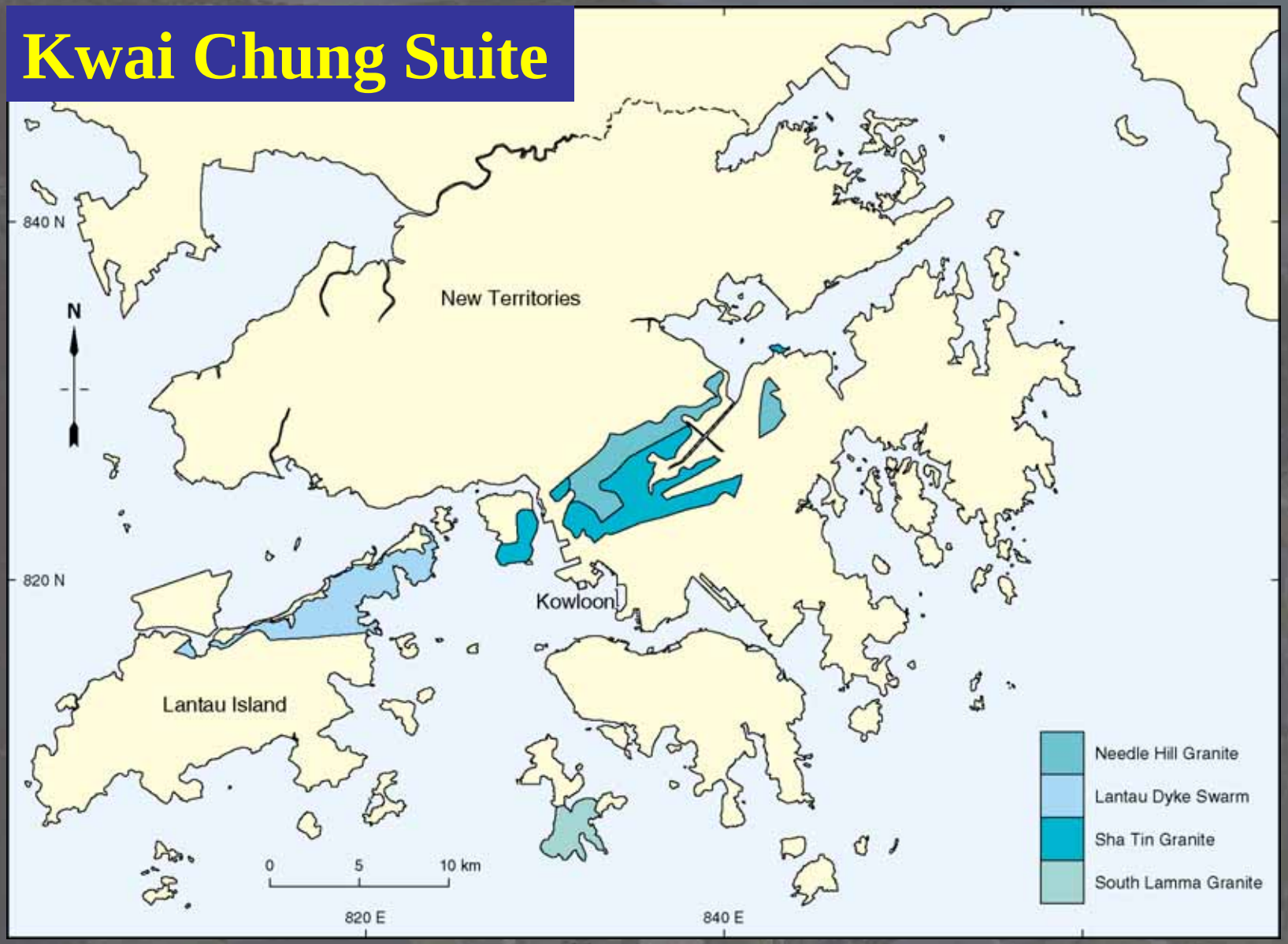
- Granitic rocks are grouped (chemistry/age) into four suites, each with their own similar characteristics

- Lamma, Kwai Chung, Cheung Chau and Lion Rock suites

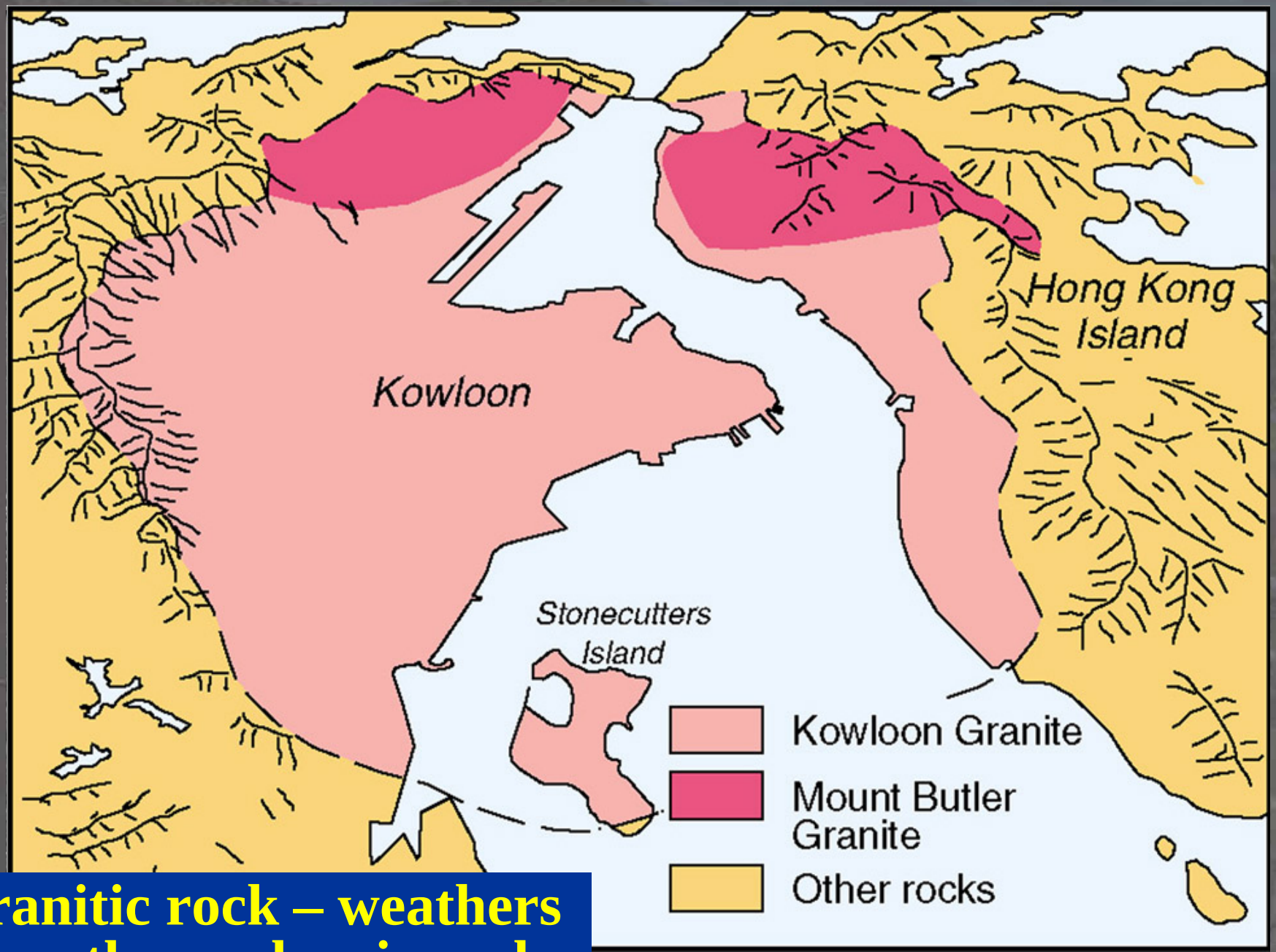


Tai Mo Shan Area

Kwai Chung Suite



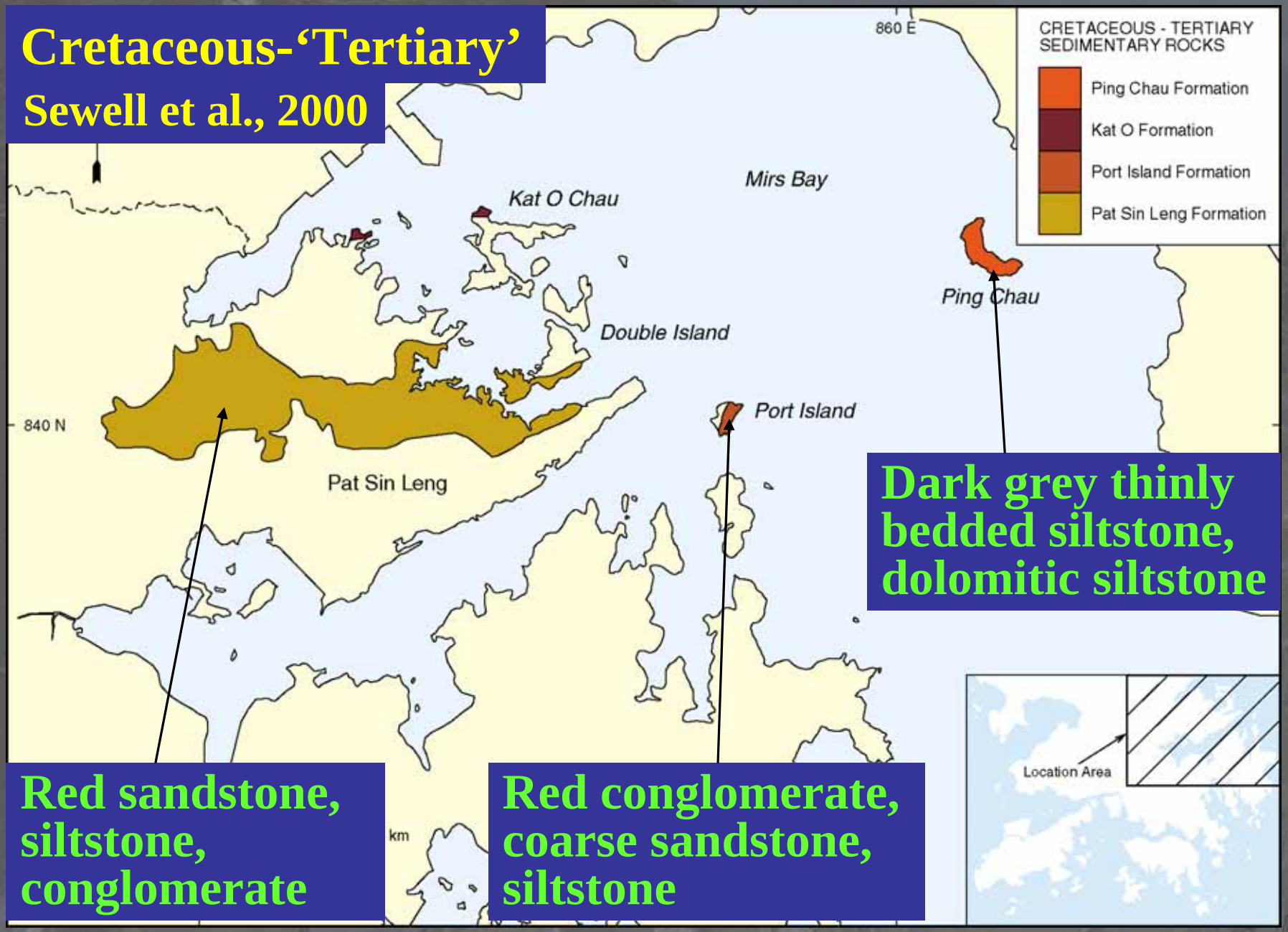
Sewell et al., 2000



Granitic rock – weathers more than volcanic rocks

Cretaceous-'Tertiary'

Sewell et al., 2000



Dark grey thinly bedded siltstone, dolomitic siltstone

Red sandstone, siltstone, conglomerate

Red conglomerate, coarse sandstone, siltstone

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.**

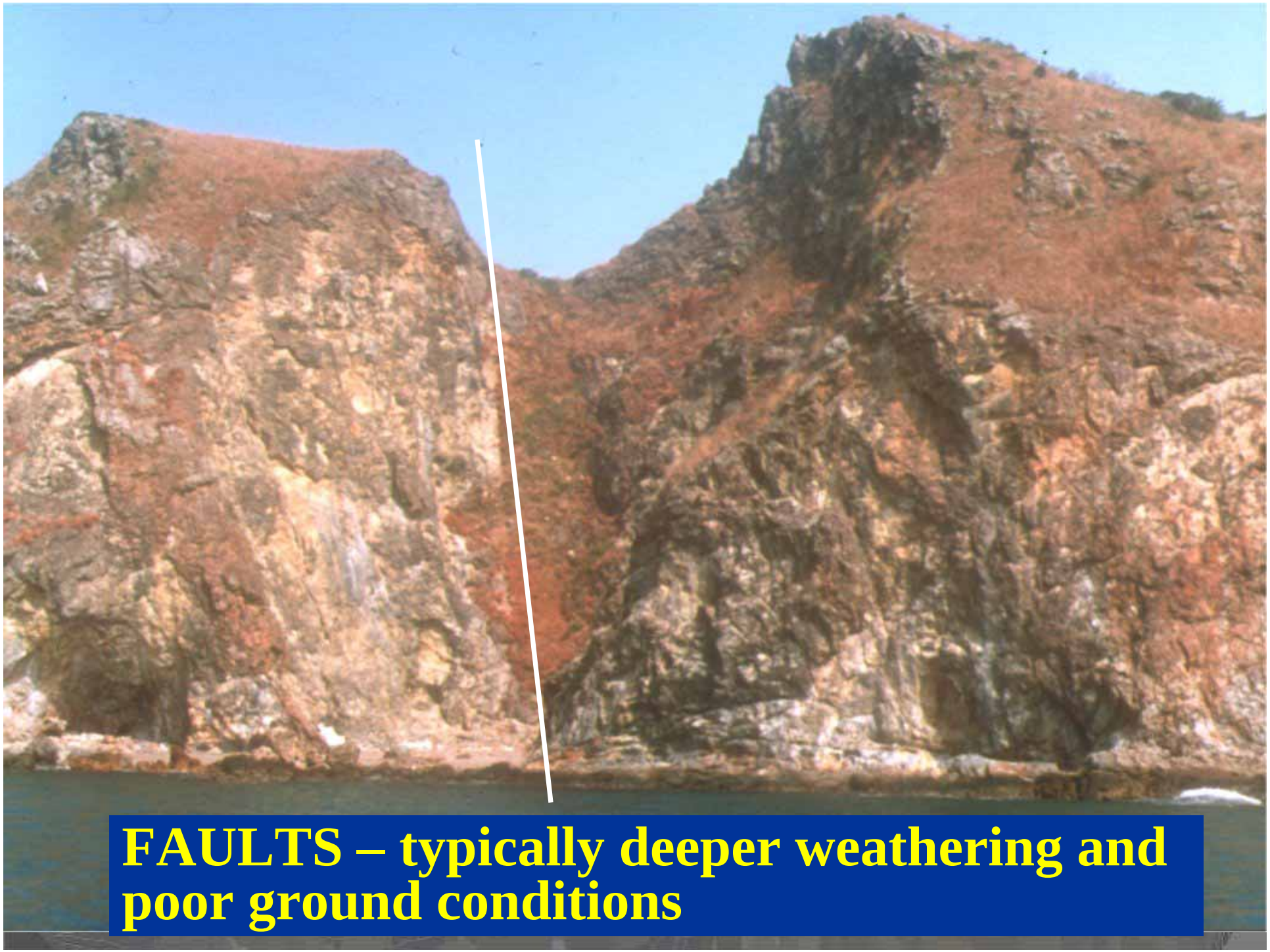
HONG KONG STRUCTURES

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

HONG KONG STRUCTURES
Importance to engineers

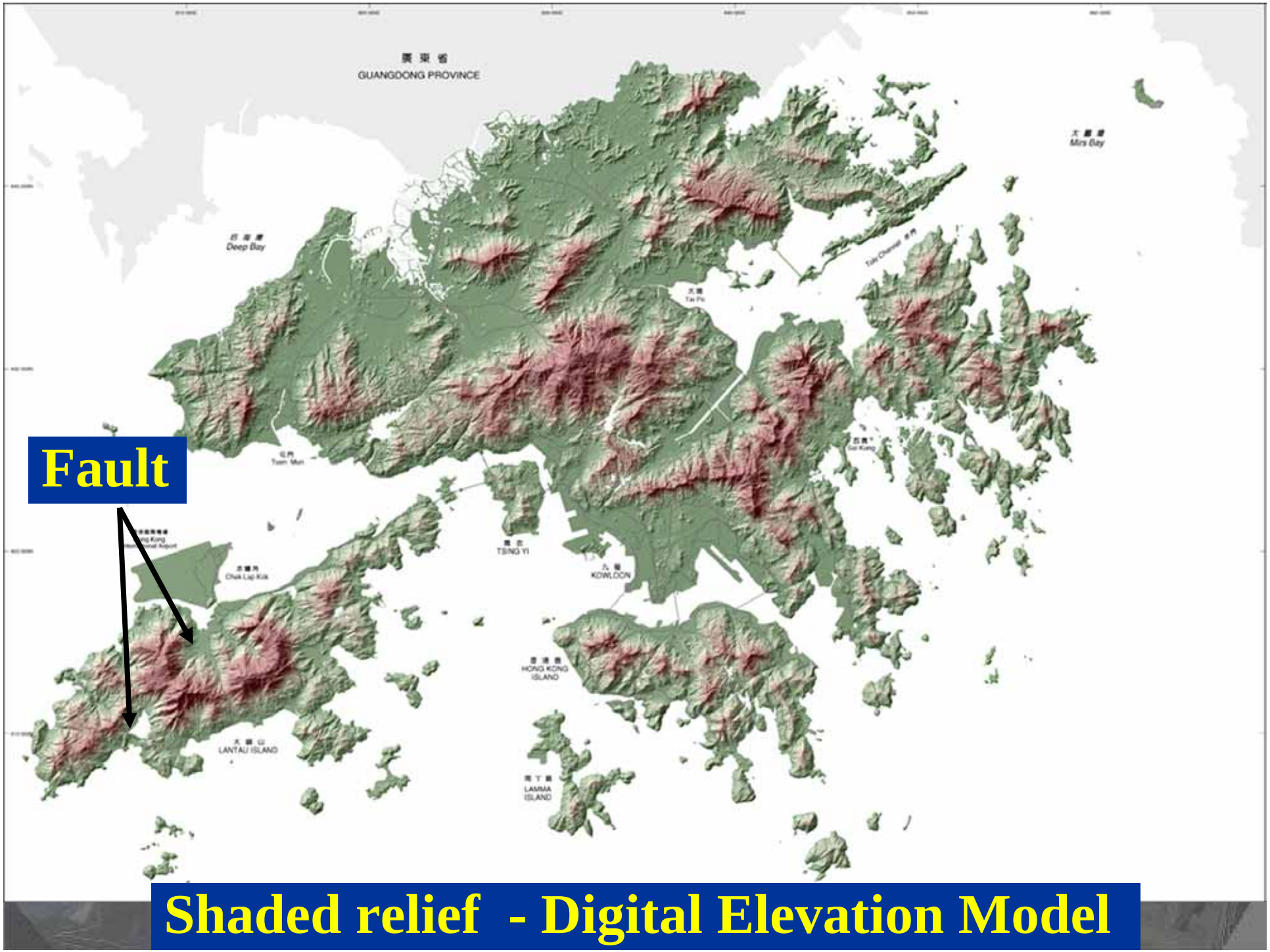
- Define areas/zones of contrasting material type (lithology, strength)
- Control material weathering grades, rock mass weathering characteristics (PW zones) and rockhead depth and form
- Influence hydrogeology
- Influence instability etc.

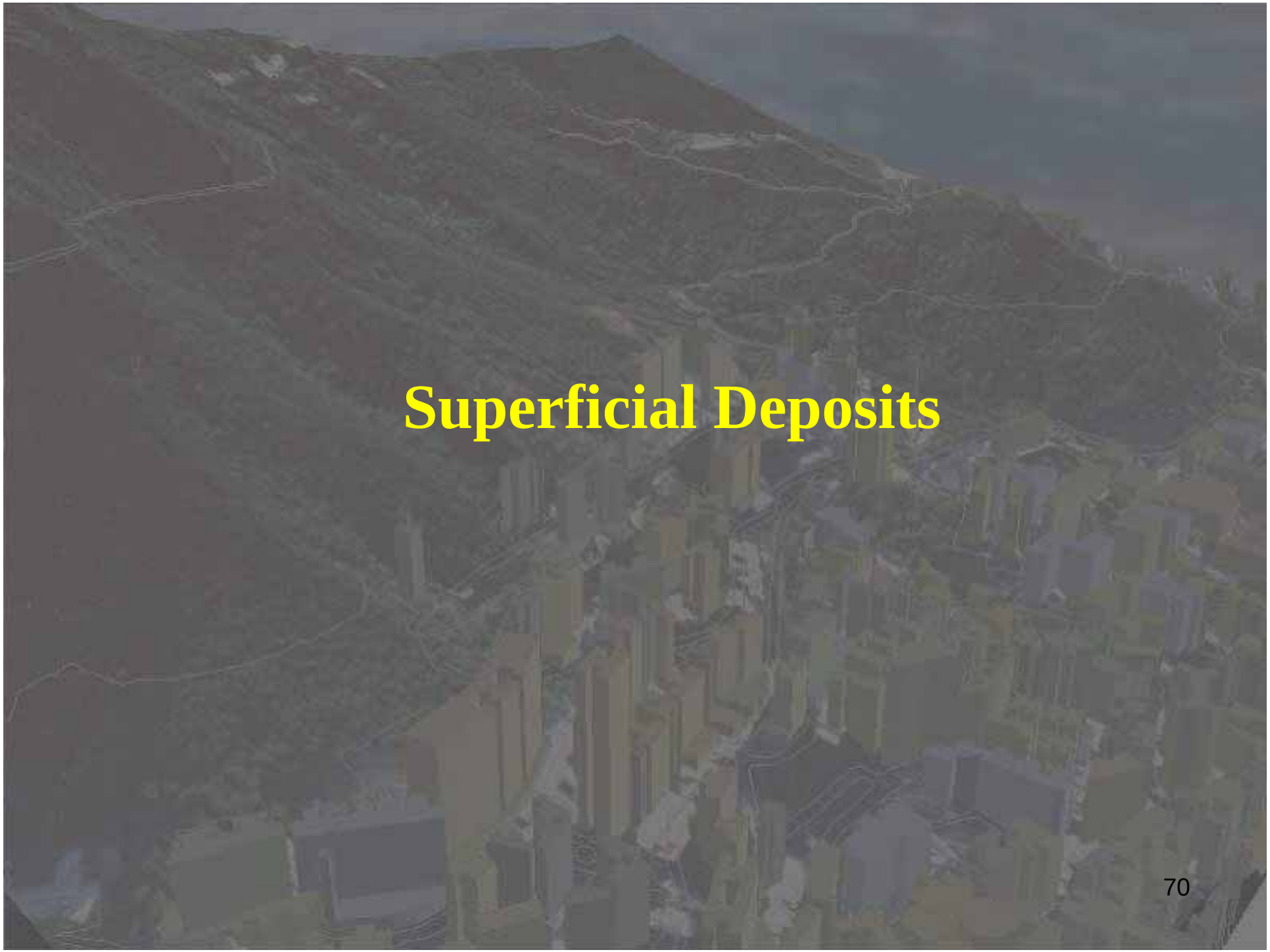
Maybe structures more important to the engineer than rock type? - in rock? - in soil?



FAULTS – typically deeper weathering and poor ground conditions

Tai Lam Fault

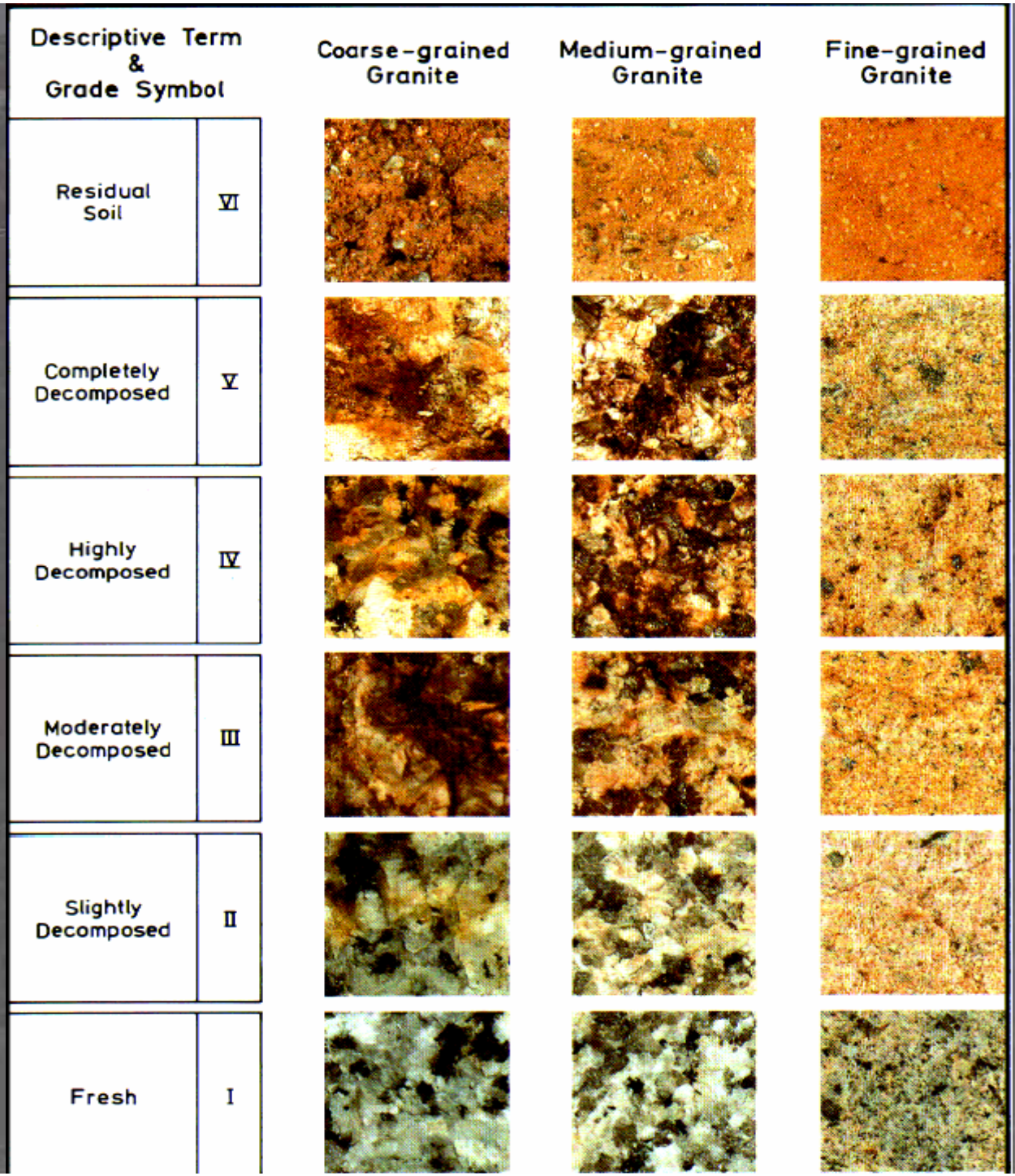

GUANGDONG PROVINCE
Deep Bay
Mirs Bay
Tai Po
Tsuen Mun
TSING YI
KOWLOON
Chek Lap Kok
HONG KONG ISLAND
LANTAU ISLAND
LAMMA ISLAND
Fault
Shaded relief - Digital Elevation Model

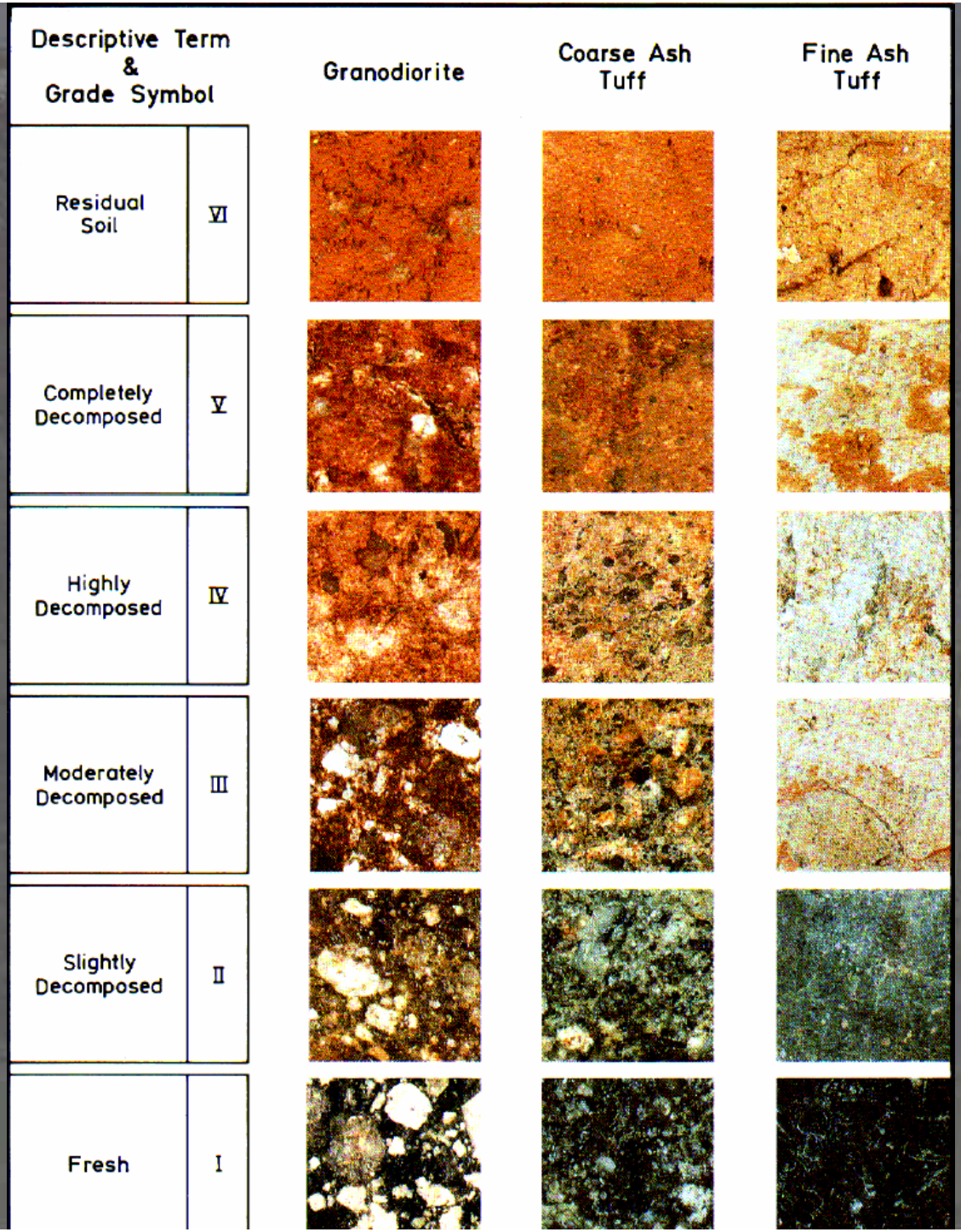


Superficial Deposits

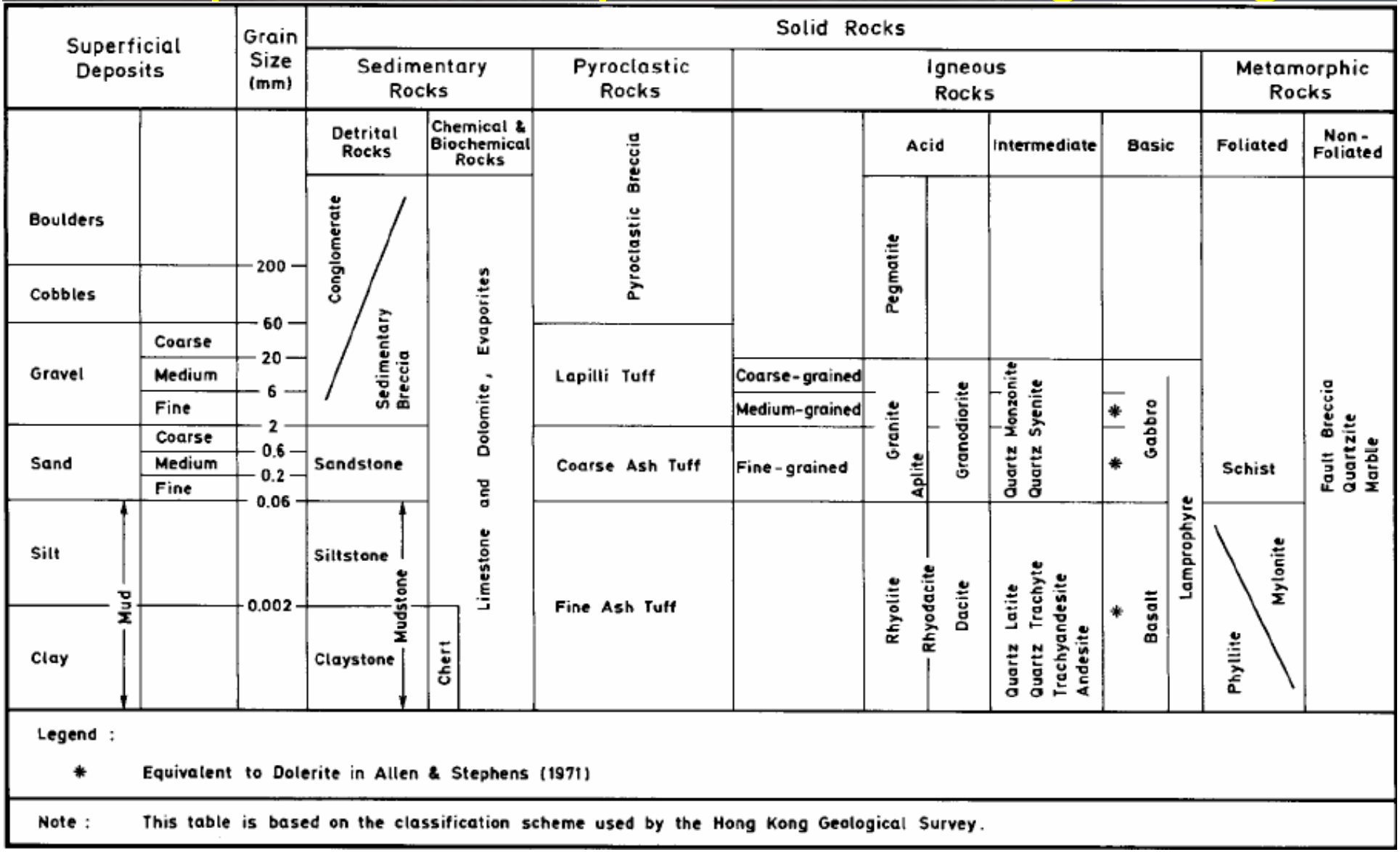
Classification of Rock Material Decomposition Grades

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	Reddish brown Feldspars completely destroyed Quartz is only remaining primary mineral; usually dull, etched or pitted and reduced in size compared with fresh condition	Dark reddish brown Feldspars completely destroyed Quartz only remaining primary mineral; grains reduced in size compared with fresh condition	Brown or reddish brown Quartz only remaining primary mineral	Yellowish brown
Completely Decomposed	V	Original rock texture preserved Can be crumbled by hand and finger pressure into constituent grains Easily indented by point of geological pick Slakes when immersed in water Completely discoloured compared with fresh rock	Yellowish brown to reddish brown Feldspars powdery to soft Hand penetrometer shear strength index <250 kPa Zero rebound from N Schmidt hammer	Yellowish brown to reddish brown Plagioclase feldspars powdery to soft, very easily grooved by pin Orthoclase feldspars gritty, less easily grooved Zero rebound from N Schmidt hammer	Brown to reddish brown Slakes slowly in water Mafic minerals soft, dull, dark green to brown, difficult to distinguish	Yellowish brown Slakes readily in water
Highly Decomposed	IV	Can be broken by hand into smaller pieces Makes a dull sound when struck by geological hammer Not 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 Hand penetrometer shear strength index >250 kPa Positive N Schmidt rebound value <25	Yellowish brown to yellowish orange/brown Plagioclase feldspars powdery to gritty N Schmidt rebound value 15 - 30	Yellowish brown Mafic minerals 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 Biotite not shiny N Schmidt rebound value 25 - 45	Yellowish brown Plagioclase feldspars party decomposed to gritty small pieces N Schmidt rebound value 25 - 50	Yellowish grey Mafic minerals generally not shiny, soft, black 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 Fresh rock colours generally retained but stained near joint surfaces	Feldspars hard to slightly gritty Orthoclase feldspars often pink Biotite slightly stained and dull around edges N Schmidt rebound value >45	Plagioclase feldspars slightly gritty Biotite and hornblende slightly stained and dull N Schmidt rebound value 45 - 70	Light grey or greenish grey Mafic minerals shiny, hard, black, may be slightly stained and dull around edges	Grey, light grey or greenish grey Cloudy 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 Biotite shiny, not stained Quartz colourless or grey, glassy	Overall rock colour grey Feldspars hard and shiny Biotite and hornblende shiny; not stained Quartz colourless or grey, glassy N Schmidt rebound value >60	Overall rock colour ranges from light greenish grey (JSM) to grey (JSM, JYT) Feldspars hard and shiny Mafic minerals shiny, hard, 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 strength in the fresh state is moderately strong or less (see Table 2). Alternative classifications may be more appropriate for such materials (see Section 2.3.4). (2) Use of geological hammer applicable mainly to materials confined in a field exposure.	(3) Based on Moye (1955), Hencher & Martin (1982) and unpublished work by the GCO. (4) Assessments of minerals applicable to medium and coarse-grained granite; may be difficult or impossible to assess in fine-grained granites.	(5) Based on Irfan & Powell (1985a,b).	(6) Based on unpublished work by the GCO. (7) JYT = Yim Tin Tsai Formation JSM = Shing Mun Formation (see HKGS maps and memoirs). (8) Mafic minerals referred to are biotite and hornblende.	(9) Based on unpublished work by the GCO.
Notes on Index Tests		(10) Slake test: samples already close to saturation moisture content are less likely to slake. (11) Feldspar alteration test: Hard = cannot be cut by knife or grooved by pin; Gritty = can be 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 very easily to clay in fingers. (12) N Schmidt hammer test: rebound values are for hammer held perpendicular to rock face: take initial 'seating' blows to ensure good contact and record average value from a minimum of five consecutive impacts, ignoring unusually low readings. (13) Hand penetrometer test: press instrument head slowly and smoothly into sample, take an average of ten values and divide by two to give shear strength index; test may be impractical on very small samples. (14) Test results in general may be affected by sample moisture content and degree of microfracturing.				


Descriptive Term & Grade Symbol
Coarse-grained Granite
Medium-grained Granite
Fine-grained Granite
Residual Soil
VI
Completely Decomposed
V
Highly Decomposed
IV
Moderately Decomposed
III
Slightly Decomposed
II
Fresh
I


Descriptive Term & Grade Symbol
Granodiorite
Coarse Ash Tuff
Fine Ash Tuff
Residual Soil
VI
Completely Decomposed
V
Highly Decomposed
IV
Moderately Decomposed
III
Slightly Decomposed
II
Fresh
I

Classification of Solid Rocks and Superficial Deposits in Hong Kong



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

Basic Soil Type

		Particle Size (mm)	Visual Identification
Very Coarse Soils	BOULDERS	200	Only seen complete in pits or exposures.
	COBBLES	60	Often difficult to recover from boreholes.
Coarse Soils (over 65% sand and gravel sizes)	GRAVELS	Coarse 20	Easily visible to naked eye; particle shape can be described; grading can be described.
		Medium 6	Well-graded: wide range of grain sizes, well distributed. Poorly-graded: not well graded. (May be uniform: size of most particles lies between narrow limits; or gap-graded: an intermediate size of particle is markedly under-represented.)
		Fine 2	
	SANDS	Coarse 0.6	Visible to naked eye; very little or no cohesion when dry; grading can be described.
		Medium 0.2	Well-graded; wide range of grain sizes. Poorly-graded: not well graded. (May be uniform: size of most particles lies between narrow limits; or gap-graded: an intermediate size of particle is markedly under-represented.)
		Fine 0.06	
Fine Soils (over 35% silt and clay sizes)	SILTS	Coarse 0.02	Only coarse silt barely visible to naked eye; exhibits little plasticity and marked dilatancy; slightly granular or silky to the touch. Disintegrates in water; lumps dry quickly; possess cohesion but can be powdered easily between fingers.
		Medium 0.006	
		Fine 0.002	
	CLAYS	MUD	Dry lumps can be broken but not powdered between fingers; they also disintegrate under water but more slowly than silt; smooth to the touch; exhibits plasticity but no dilatancy; sticks to fingers and dries slowly; shrinks appreciably on drying, usually showing cracks. Intermediate and high plasticity clays show these properties to a moderate and high degree, respectively.
Organic Soils	ORGANIC CLAY, SILT or SAND	Varies	Contains substantial amounts of organic vegetable matter. Often has noticeable smell and changes colour on oxidation.
	PEATS	Varies	Predominantly plant remains; usually dark brown or black in colour, often with distinctive smell; low bulk density.

Particle Shape and Plasticity

Particle Shape

Form
Equidimensional
Flat
Elongate
Flat and elongate

Angularity
Angular
Subangular
Subrounded
Rounded

Surface Texture
Smooth
Rough
Glassy
Honeycombed
Pitted
Striated

Plasticity

Non-plastic or low plasticity	
Intermediate plasticity (Lean clay)	
High plasticity (Fat clay)	

Composite Soil Types (Mixtures of Basic Soil Types)

Scale of Secondary Constituents with Coarse Soils

Term		% of Silt or Clay
Slightly silty / Slightly clayey	GRAVEL or SAND	< 5
- silty / - clayey	GRAVEL or SAND	5 - 15
Very silty / Very clayey	GRAVEL or SAND	15 - 35

Coarse fraction may also be subdivided to give additional secondary constituent where applicable (Table 15).
For composite types described as:
clayey : fines are plastic, cohesive;
silty : fines are non-plastic or of low plasticity

Scale of Secondary Constituents with Fine Soils

Term		% of Gravel or Sand
Slightly gravelly / Slightly sandy	SILT or CLAY	< 35
- gravelly / - sandy	SILT or CLAY	35 - 65

Full explanation of the use of secondary constituents in Composite Soils is given in Tables 15 and 16.

Strength (Compactness & Consistency)

Strength Term	Field Test
Loose	By inspection of voids and particle packing
Dense	
Loose	Can be excavated with spade; 50mm wooden peg can be easily driven.
Dense	Requires pick for excavation; 50mm wooden peg hard to drive.
Very soft	Exudes between fingers when squeezed in hand.
Soft	Moulded by light finger pressure.
Firm	Can be moulded by strong finger pressure.
Stiff	Cannot be moulded by fingers. Can be indented by thumb.
Very stiff	Can be indented by thumb nail.
Compact	Fibres already compressed together.
Spongy	Very compressible and open structure.
Plastic	Can be moulded in hand, and smears fingers.

Structure and Weathering

Structural Term	Field Identification
Homogeneous	Deposit consists essentially of one type.
Inter-stratified (interbedded or inter-laminated)	Alternating layers of varying types or with bands or lenses of other materials. Quantitative scale for bedding spacing may be used.
Heterogeneous	A mixture of types.
Fissured	Breaks into polyhedral fragments along fissures. Quantitative scale for spacing of discontinuities may be used.
Intact	No fissures.
Homogeneous	Deposit consists essentially of one type.
Inter-stratified (interbedded or inter-laminated)	Alternating layers of varying types. Interval scale for thickness of layers may be used.
Fibrous	Plant remains recognizable and retain some strength.
Amorphous	No recognizable plant remains.

Scale of Bedding Spacing

Term	Mean Spacing (mm)
Very thickly-bedded	> 2000
Thickly-bedded	600 - 2000
Medium-bedded	200 - 600
Thinly-bedded	60 - 200
Very thinly-bedded	20 - 60
Thickly-laminated	6 - 20
Thinly-laminated	< 6

Scale of Spacing of Other Discontinuities

Term	Mean Spacing (mm)
Extremely widely-spaced	> 6000
Very widely-spaced	2000 - 6000
Widely-spaced	600 - 2000
Medium-spaced	200 - 600
Closely-spaced	60 - 200
Very closely-spaced	20 - 60
Extremely closely-spaced	< 20

Discontinuities (General)

For full description of individual discontinuities, use methods and terms given in Section 2.4.3

Weathering

In fine soils : describe discolouration where evident
In coarse soils : describe overall discolouration of soil and degree of decomposition of gravel and larger fragments

Colour

Lightness
Light
Dark

Chroma

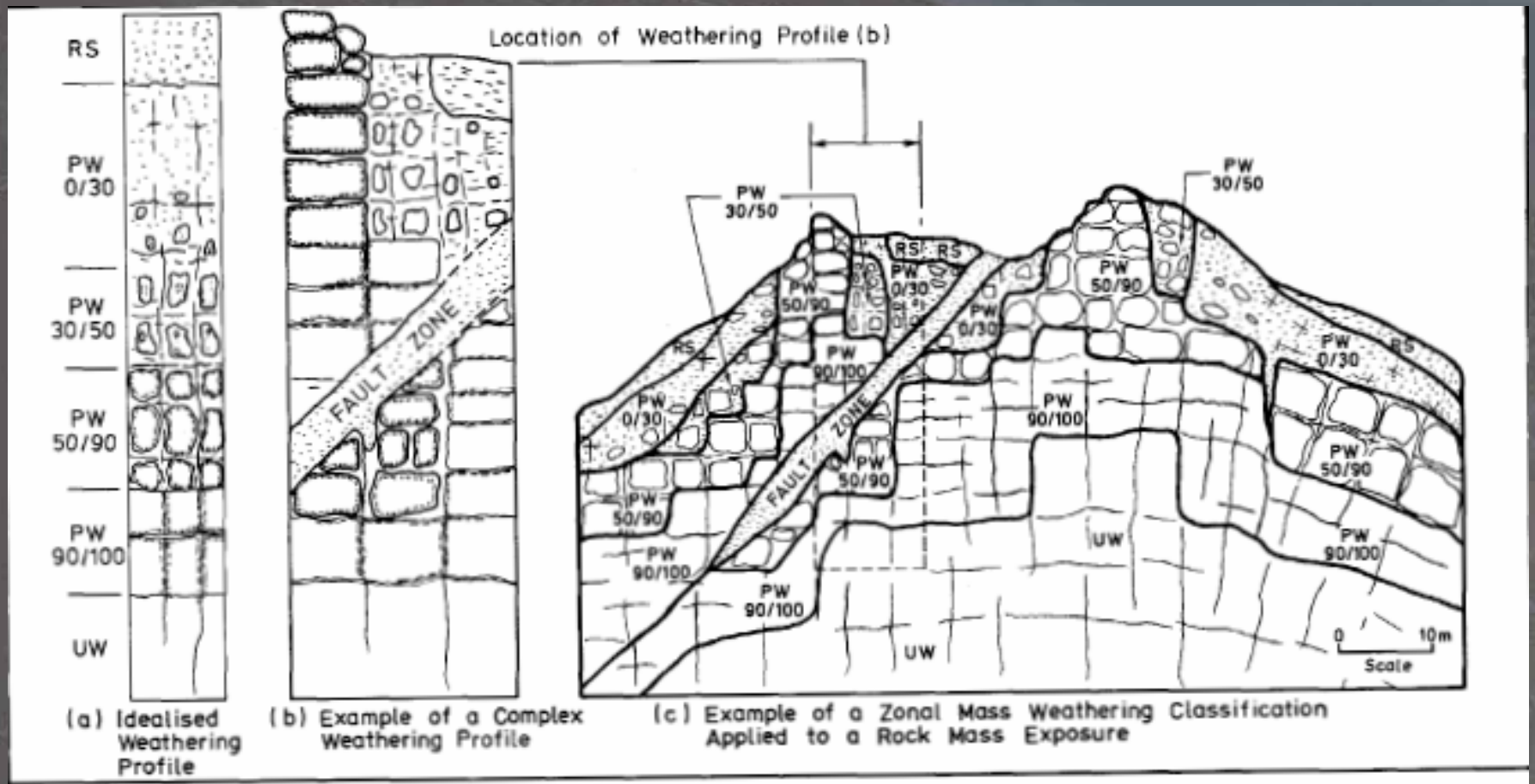
Hue
Pinkish
Reddish
Yellowish
Orangish
Brownish
Greenish
Bluish
Purplish
Greyish

Pink
Red
Yellow
Orange
Brown
Green
Blue
Purple
White
Grey
Black

Non-uniform Distribution
Spotted
Mottled
Dappled
Streaked
Striped

Select one value of lightness, chroma and hue as required, qualified by a term for non-uniform distribution where appropriate. See Table 3.

Classification of Rock Mass Weathering Zones



(a) Idealised Weathering Profile

(b) Example of a Complex Weathering Profile

(c) Example of a Zonal Mass Weathering Classification Applied to a Rock Mass Exposure

Legend :

UW	Unweathered Rock	PW50/90	Partially Weathered 50/90% Rock	PW0/30	Partially Weathered 0/30% Rock
PW90/100	Partially Weathered 90/100% Rock	PW30/50	Partially Weathered 30/50% Rock	RS	Residual Soil

Note : For definitions of terms, see Table 10.

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

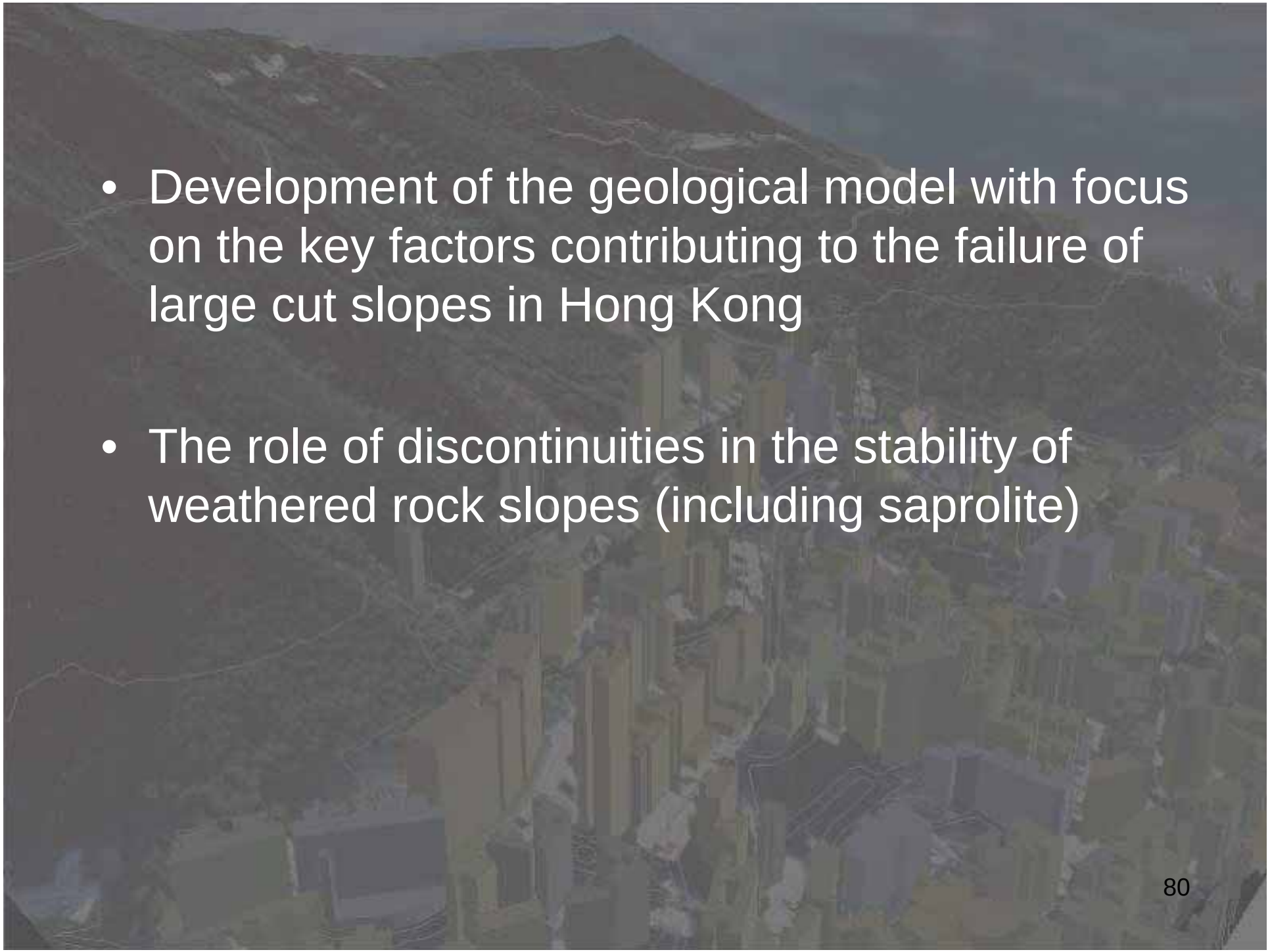
Classification of Rock Mass Weathering Zones

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 the material is finer than 0·06mm)	GRAVELS (more than 50% of coarse material is of gravel size (coarser than 2mm))	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 (finer than 2mm))	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 the material is finer than 0·06mm)	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



- 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)

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.

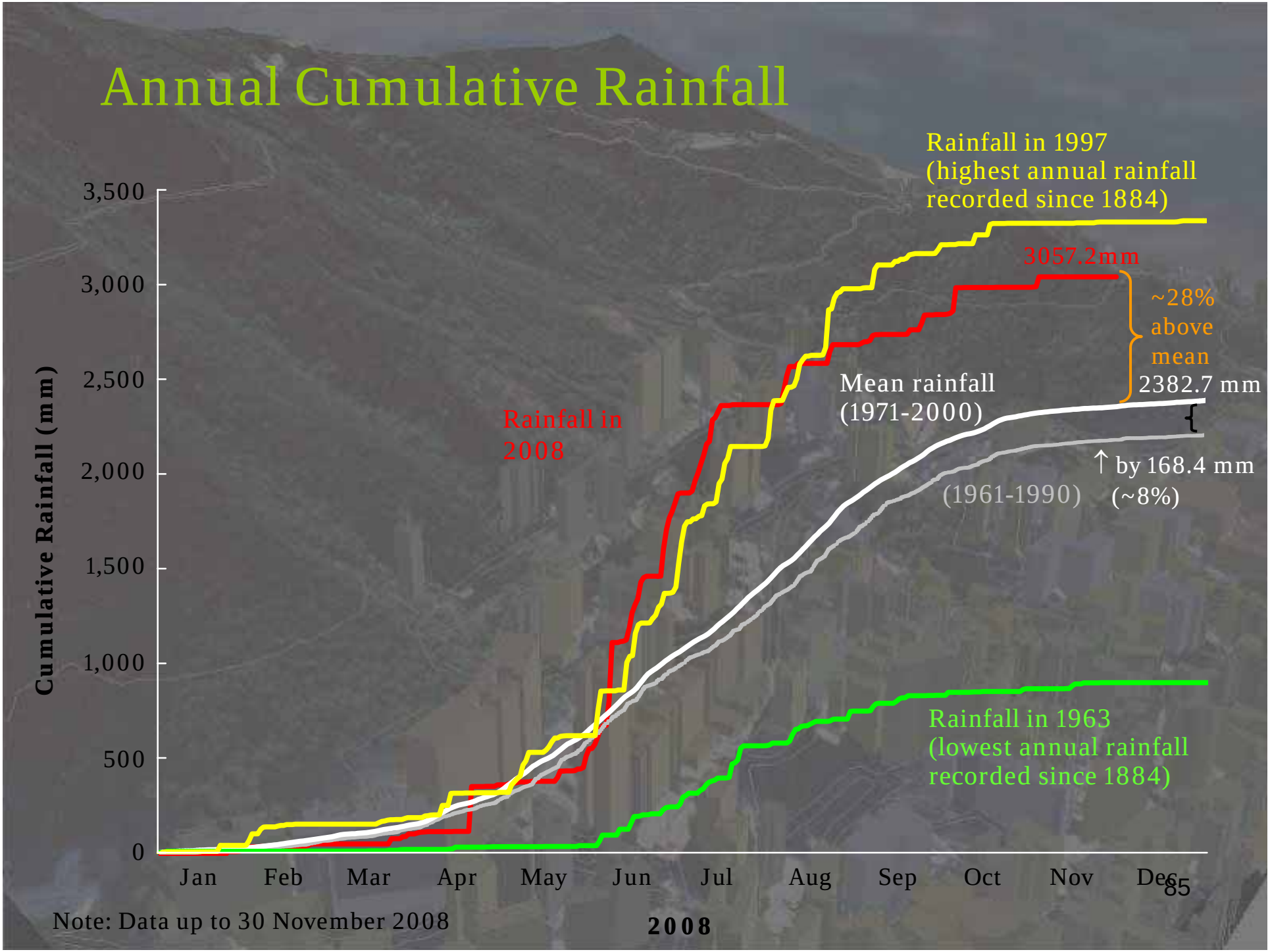
The geological model in slope and landslide studies is targeted towards facilitating geotechnical risk assessments, slope designs and investigations into the causes of landslides.


Questions?


BREAK

Rainfall in 2008

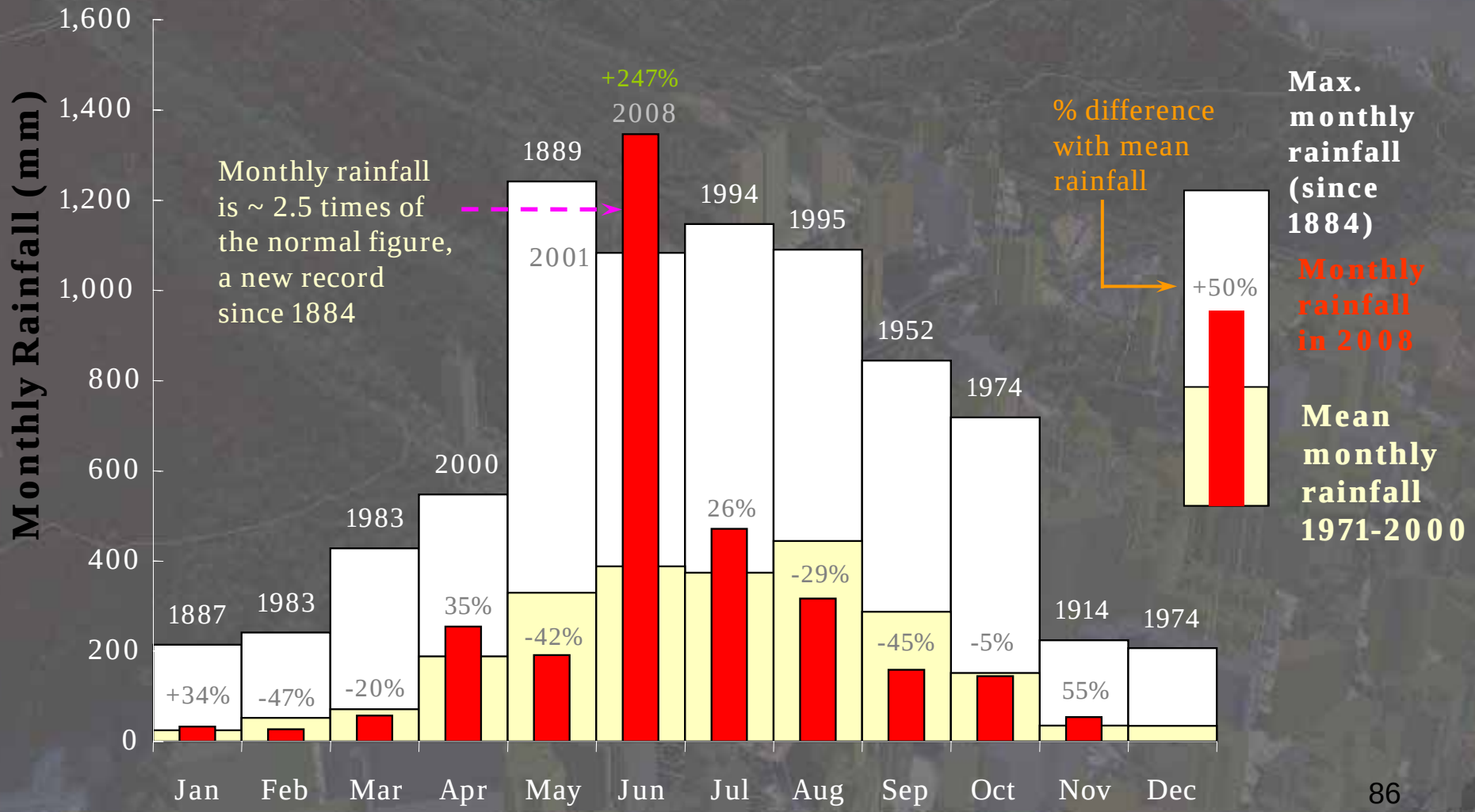
Annual Cumulative Rainfall



Note: Data up to 30 November 2008

Monthly Rainfall in 2008

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



Note: Data up to 30 November 2008

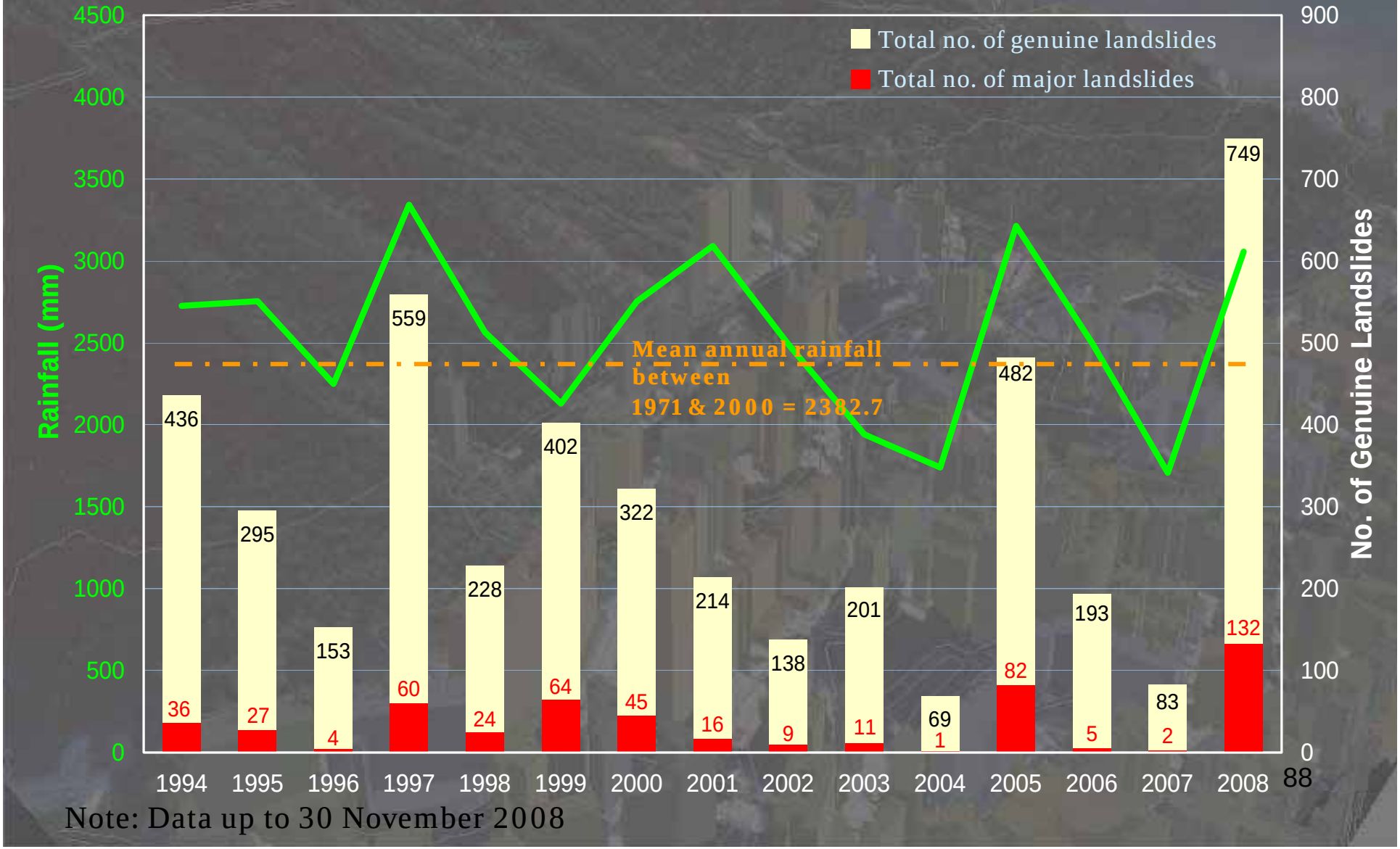
Warnings Issued

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**

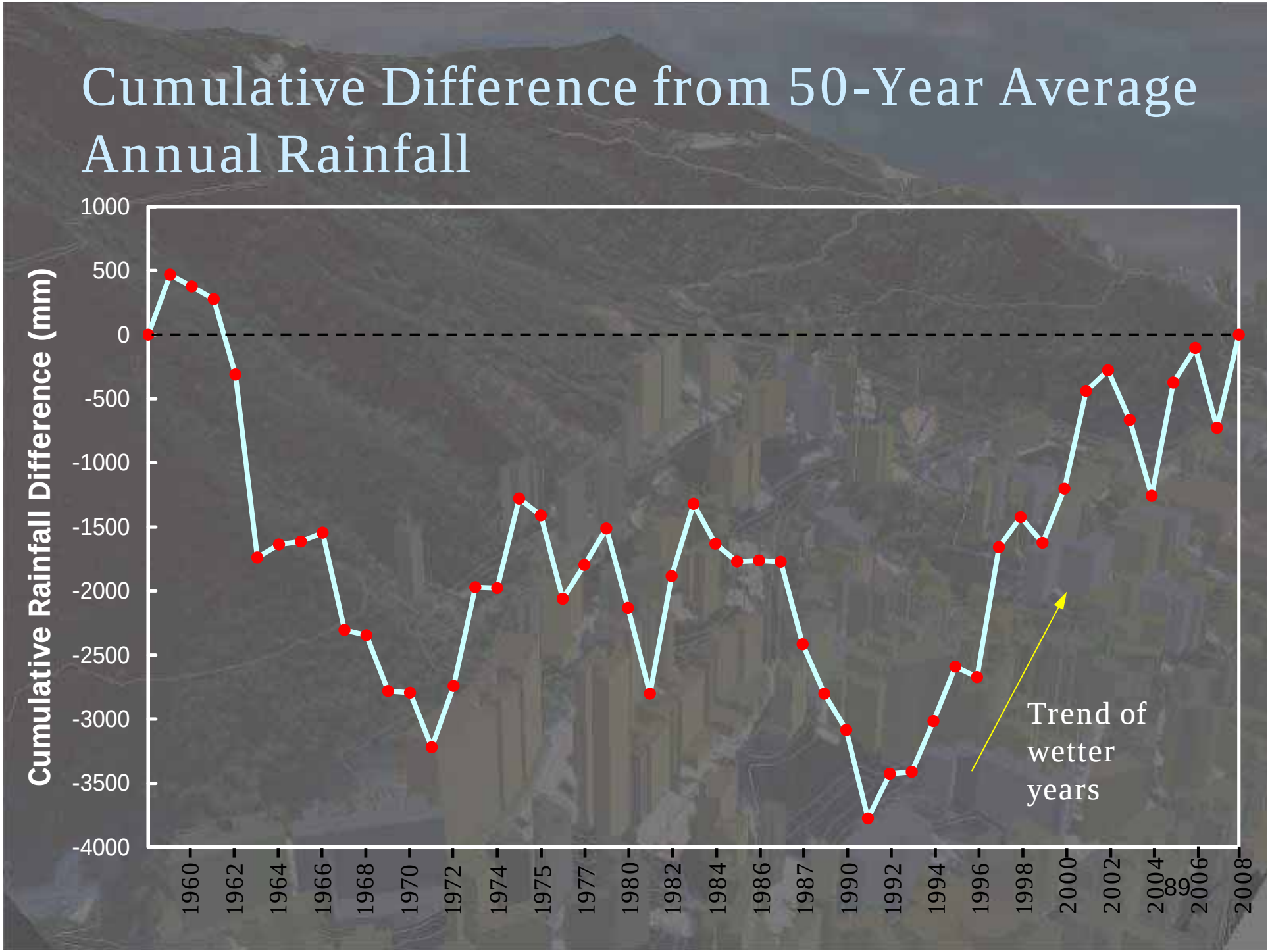
Note: * denotes Tropical Cyclone Signal No. 8 or above hoisted

Rainfall and Landslides for the Past 15 Years



Note: Data up to 30 November 2008

Cumulative Difference from 50-Year Average Annual Rainfall




Rainstorms in 2008

- Five rainstorms in 2008 triggered the issue of the Landslip Warnings

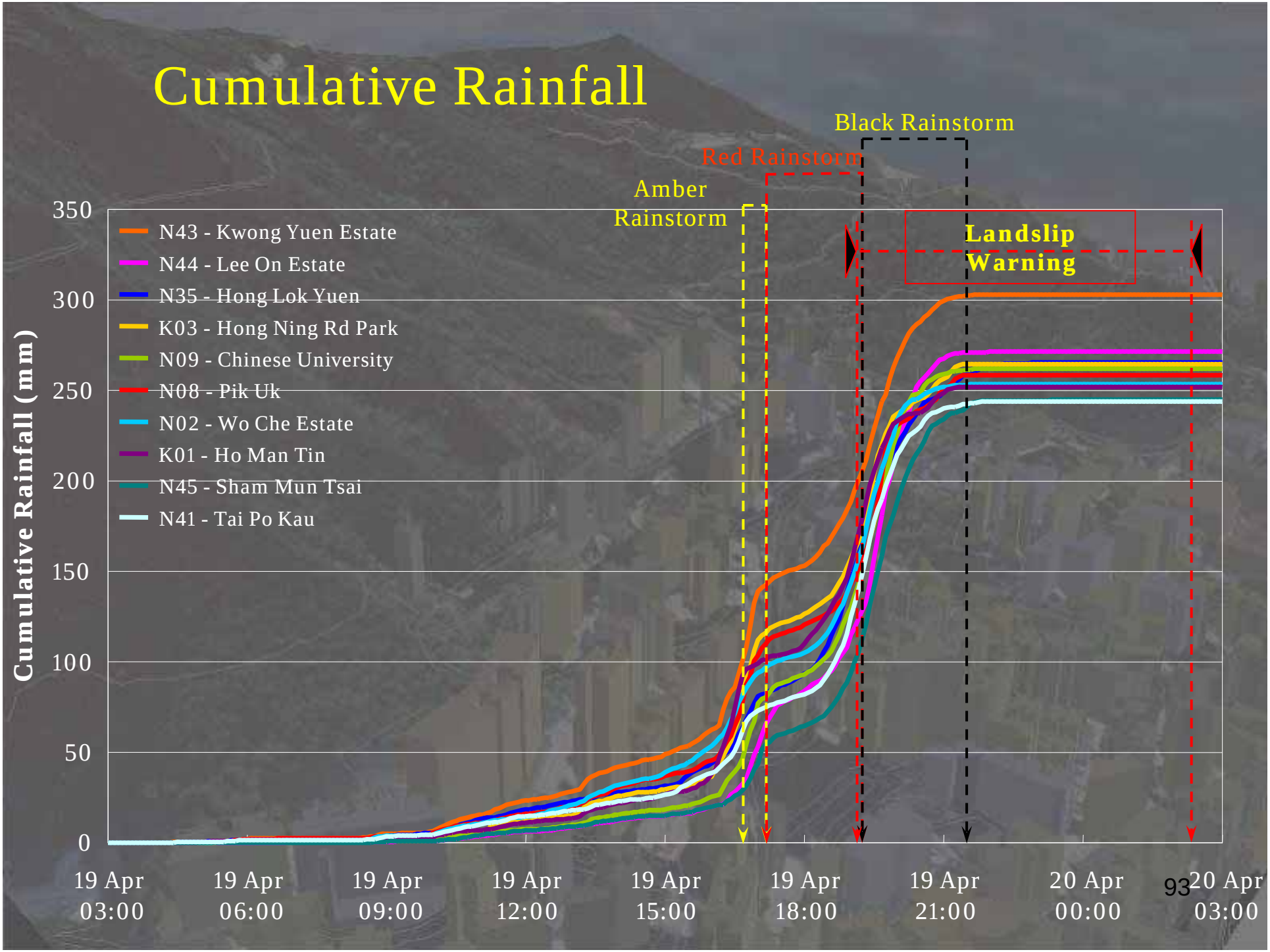
- The Landslide Potential Index (LPI) for these rainstorms are :

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

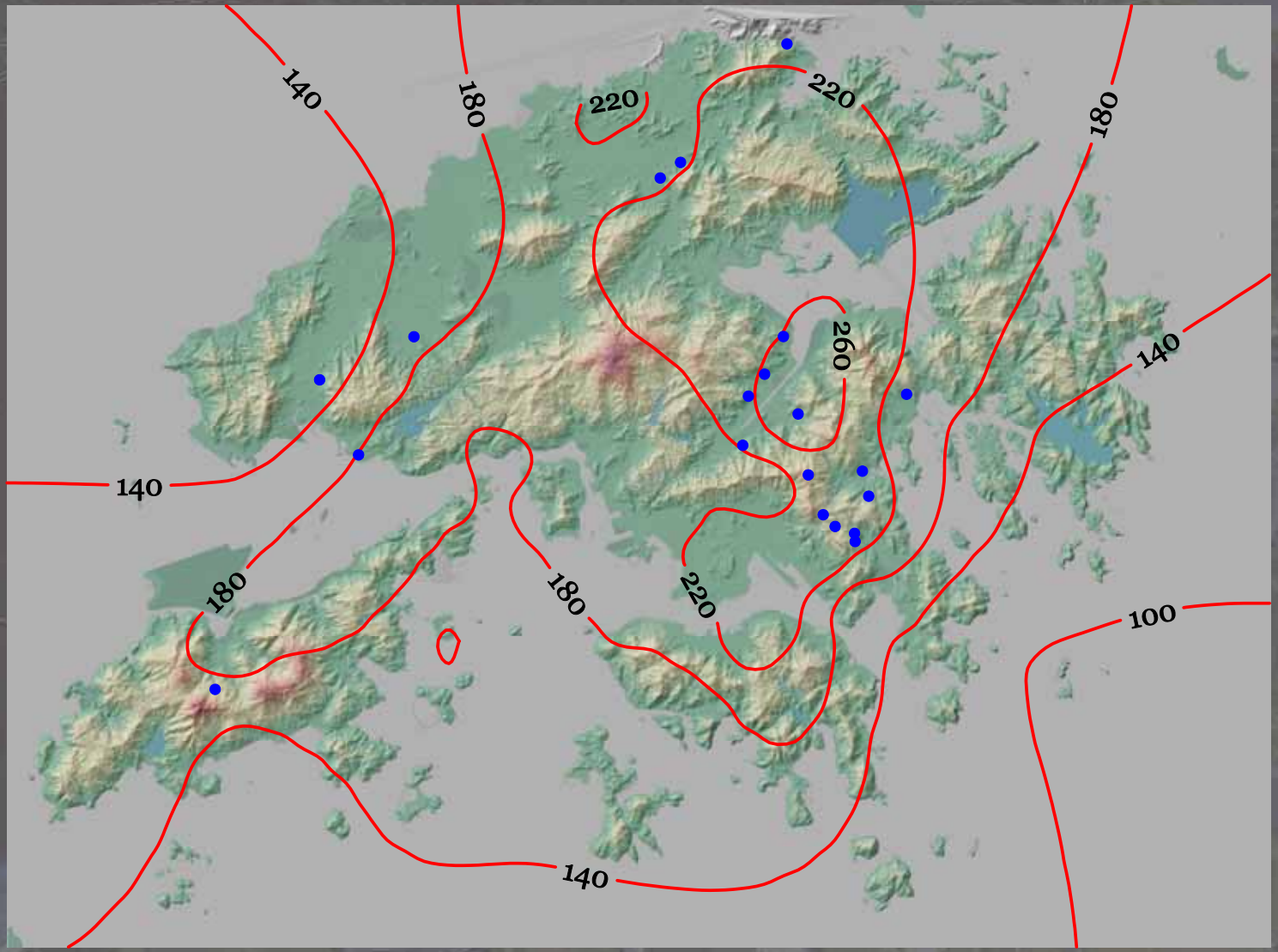
- The LPI depicts the relative severity of a rainstorm with respect to its potential to cause landslides. For comparison, the LPI of the rainstorm in late July 1994, which led to 5 deaths at Kwun Lung Lau, is set to be 10.

Rainstorm of 19 April 2008

Cumulative Rainfall



Maximum Rolling 24-hour Rainfall

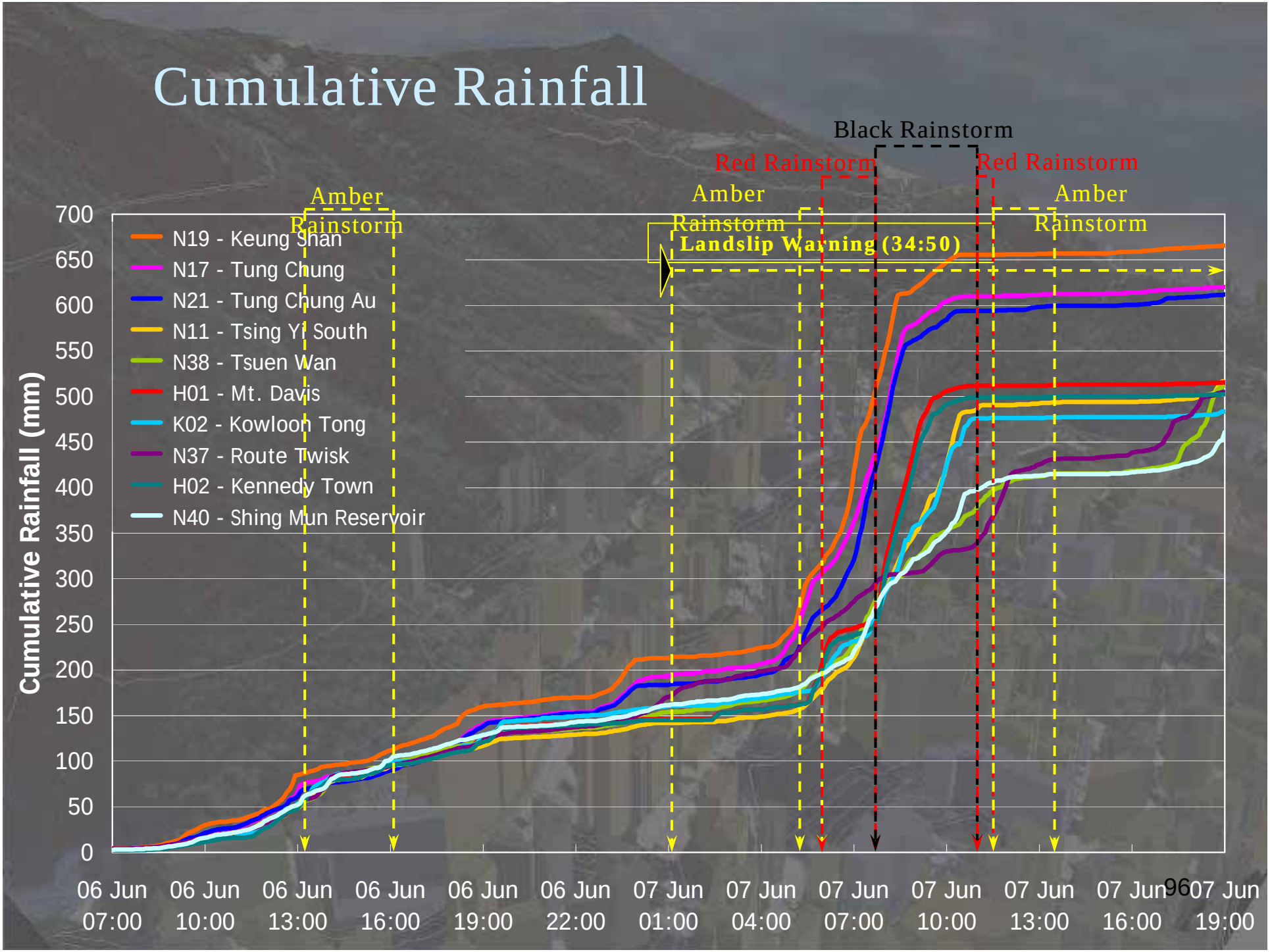


No. of reported landslides

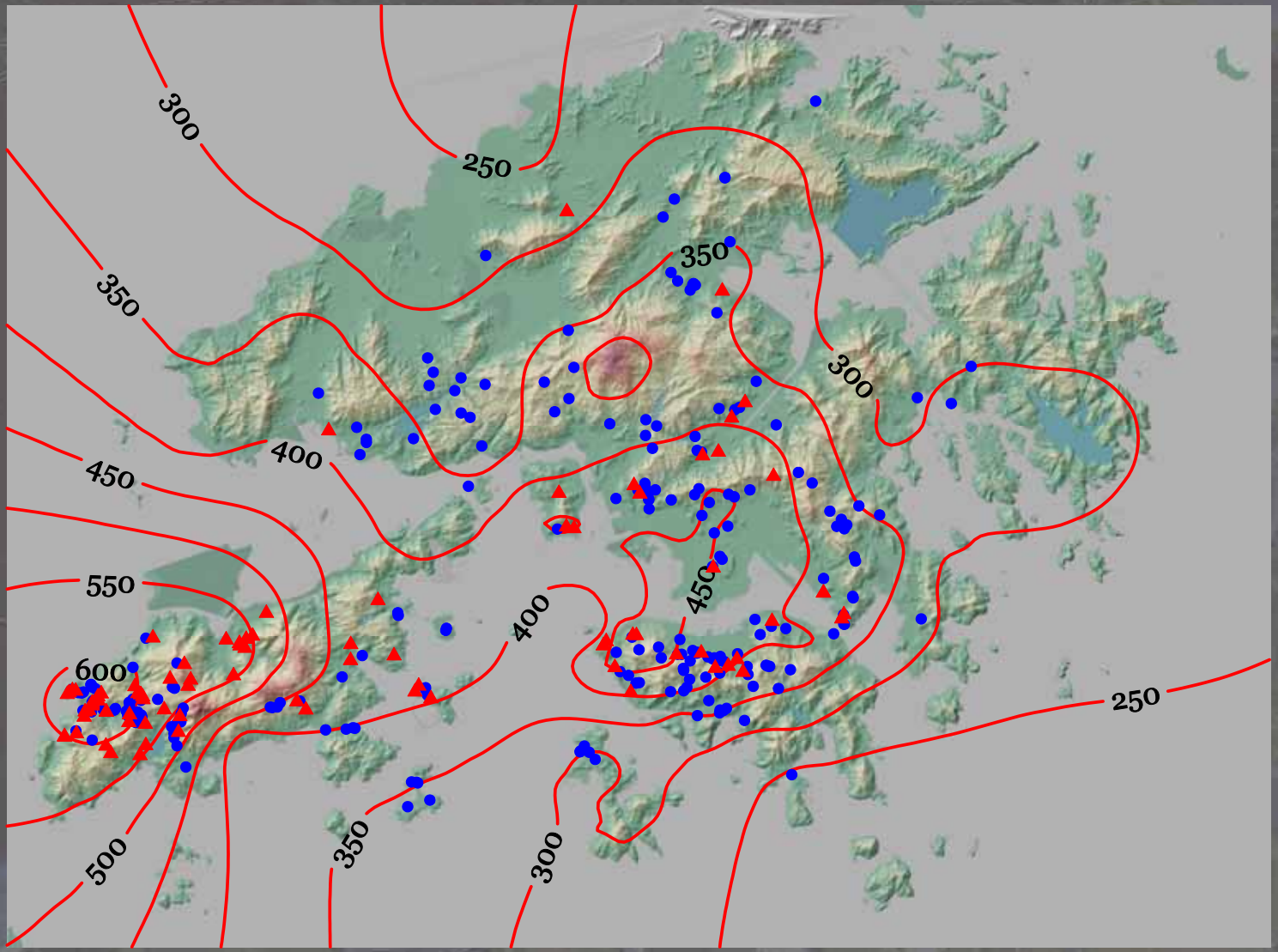
- 20 minor
- No major

Rainstorm of 7 June 2008

Cumulative Rainfall



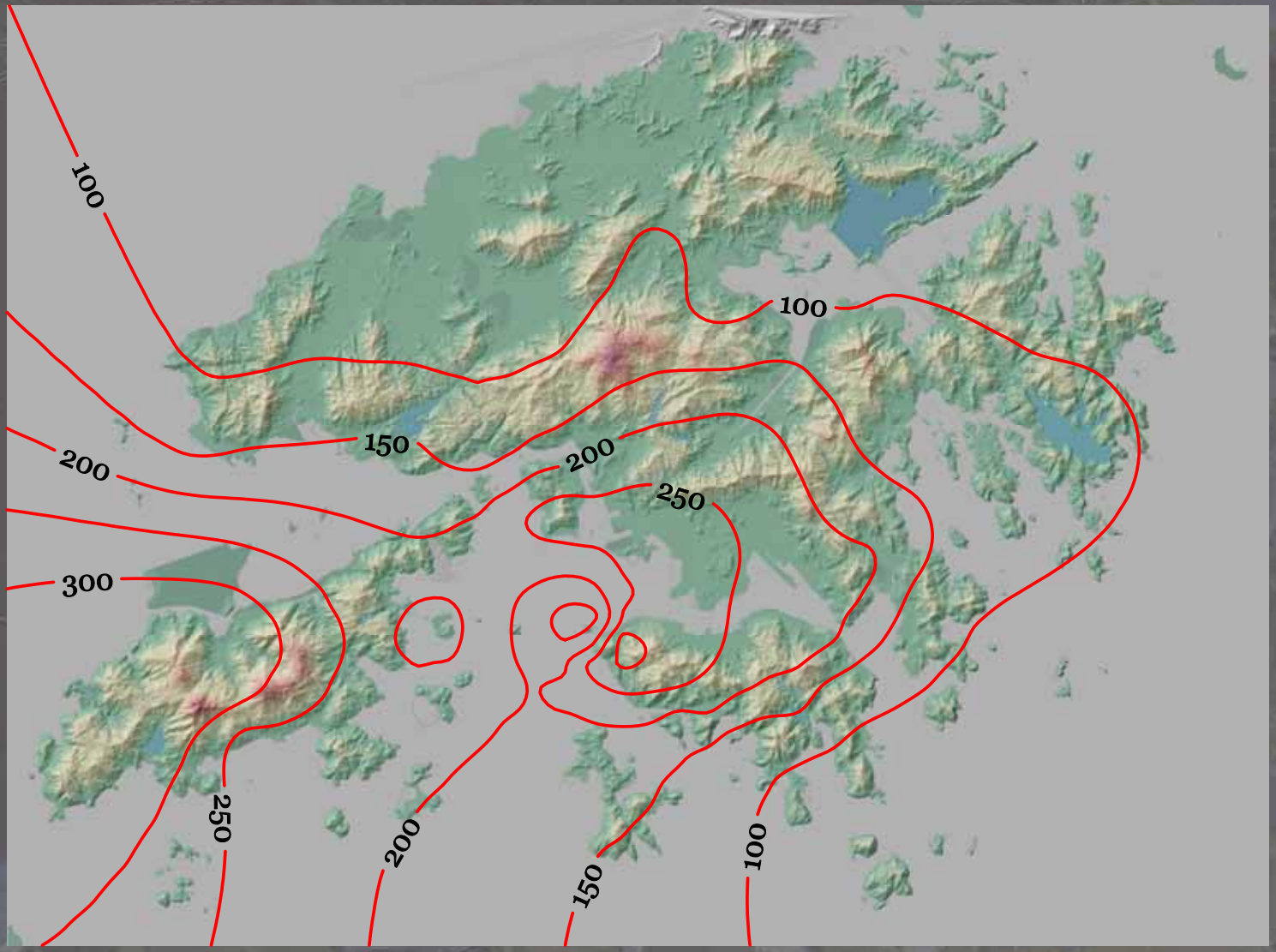
Maximum Rolling 24-hour Rainfall



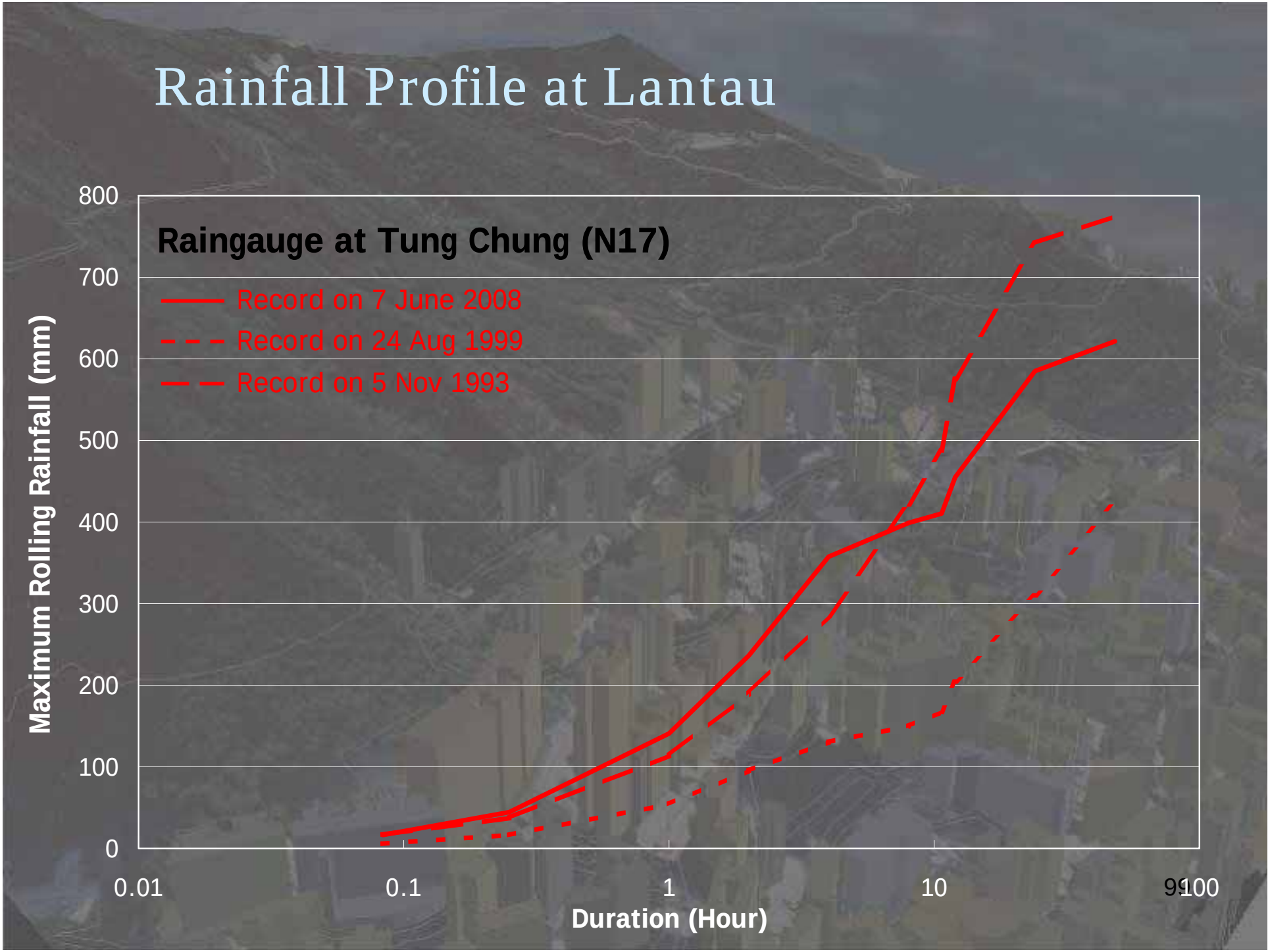
No. of reported landslides

- 274 minor
- 100 major

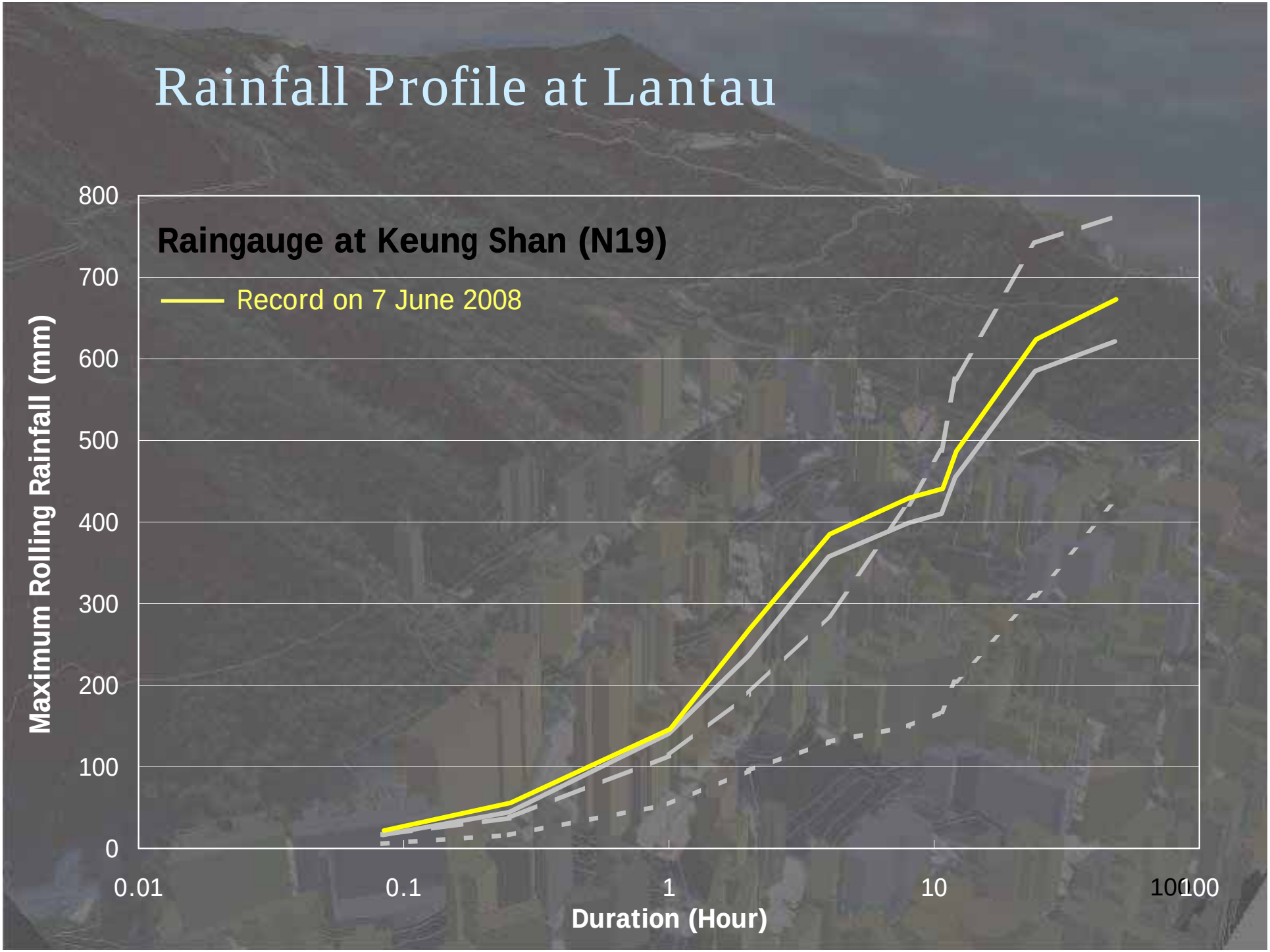
Maximum Rolling 4-hour Rainfall



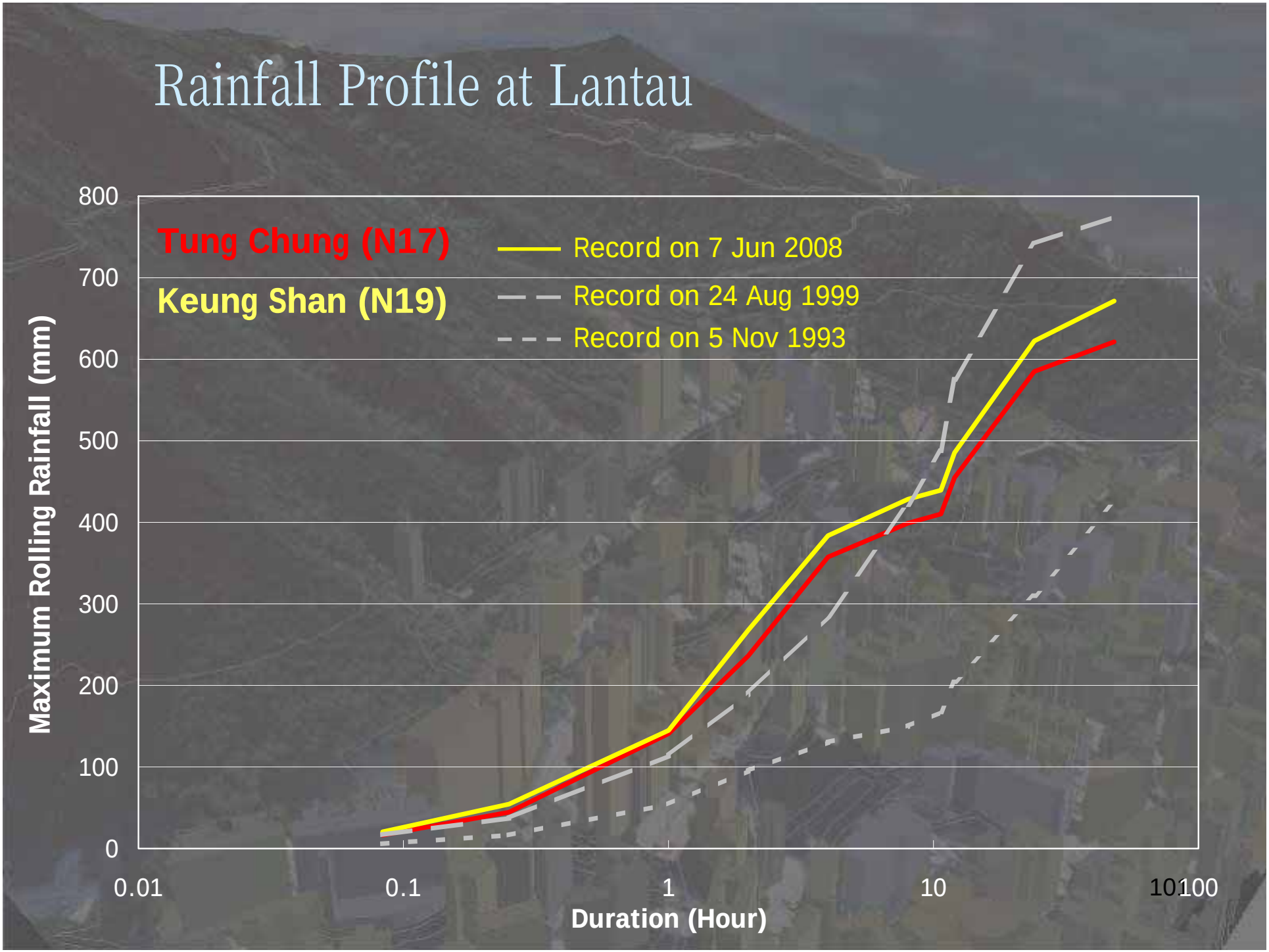
Rainfall Profile at Lantau



Rainfall Profile at Lantau

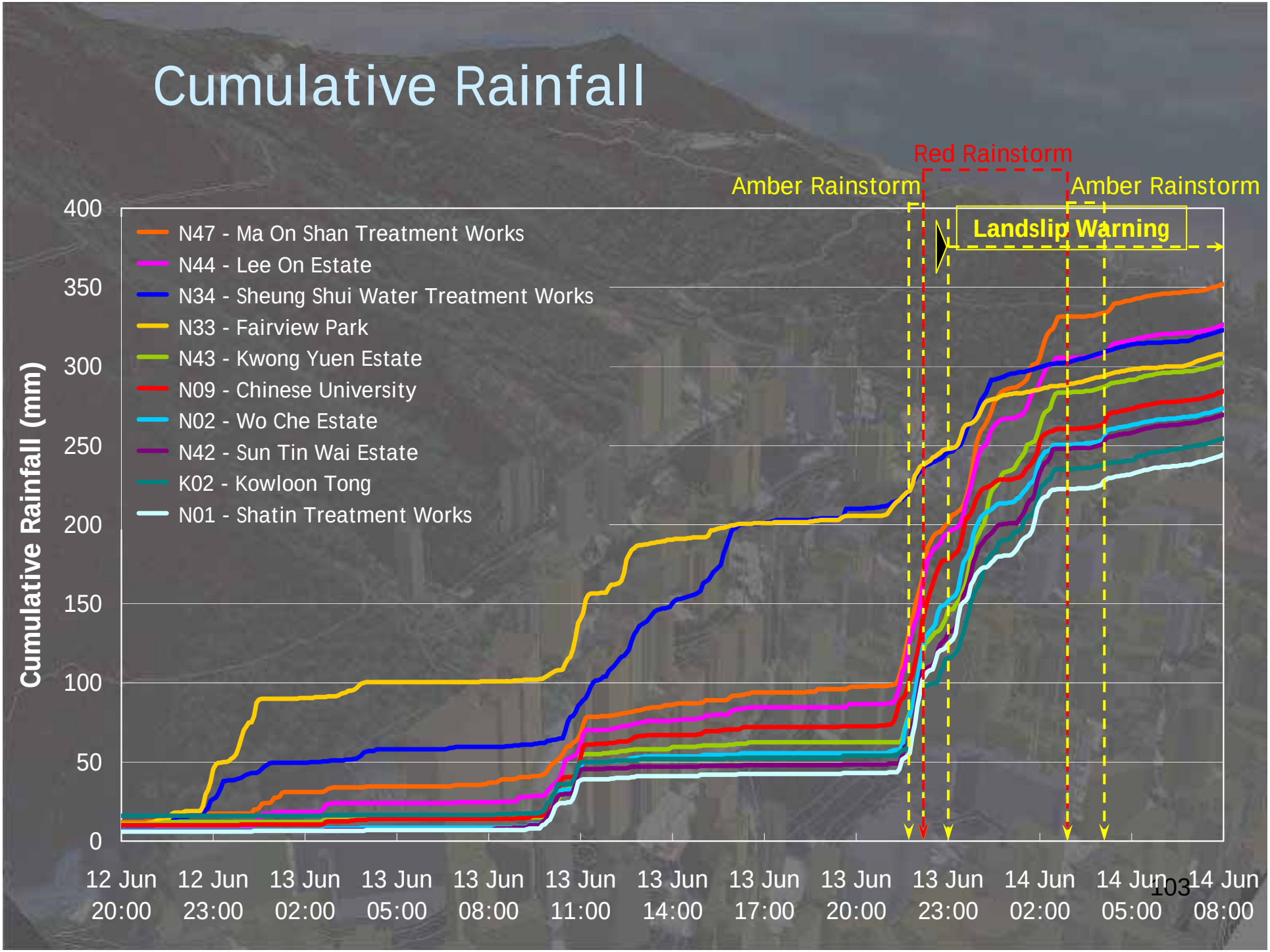


Rainfall Profile at Lantau

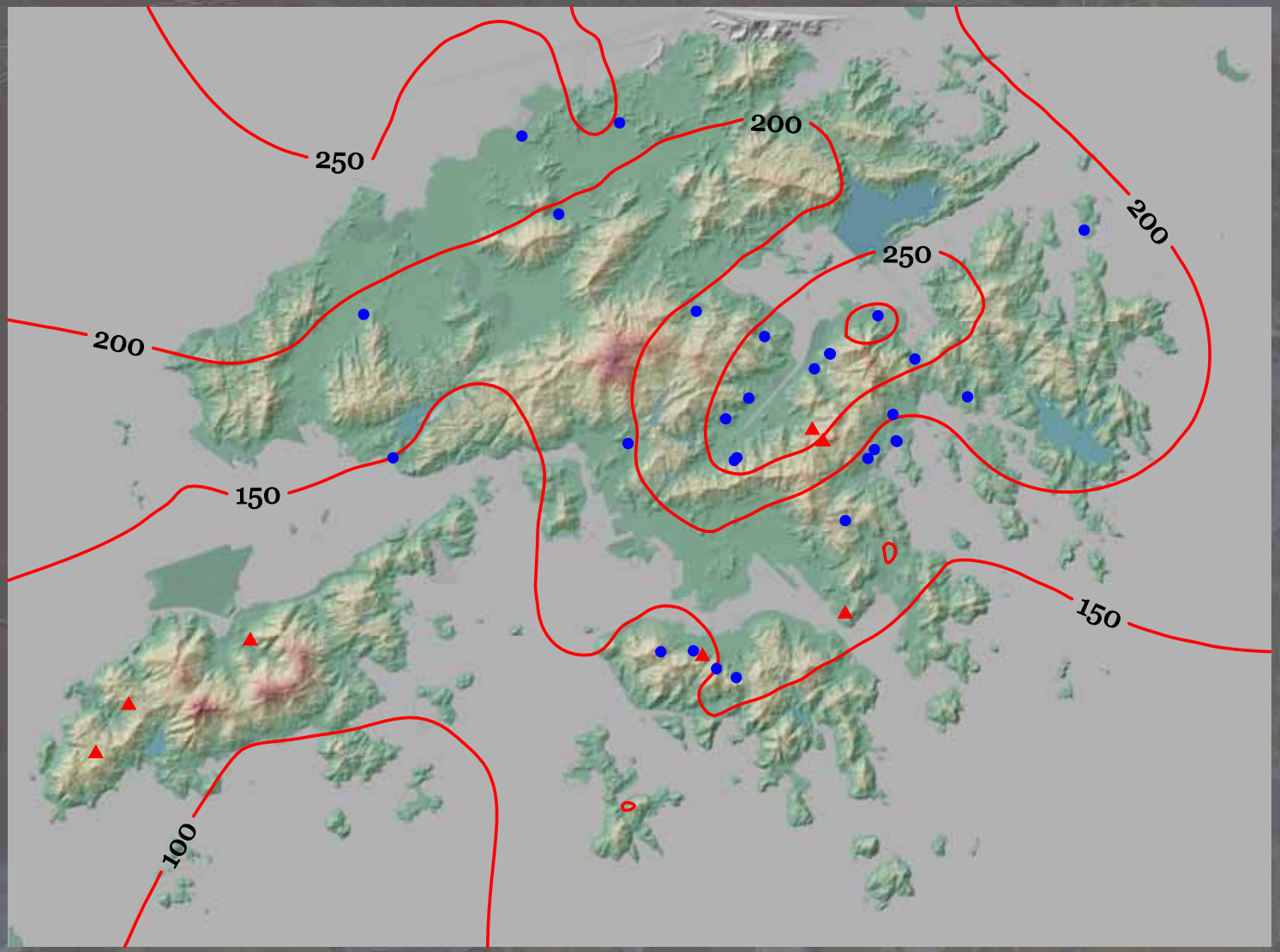


Rainstorm of 13 June 2008

Cumulative Rainfall



Maximum Rolling 24-hour Rainfall



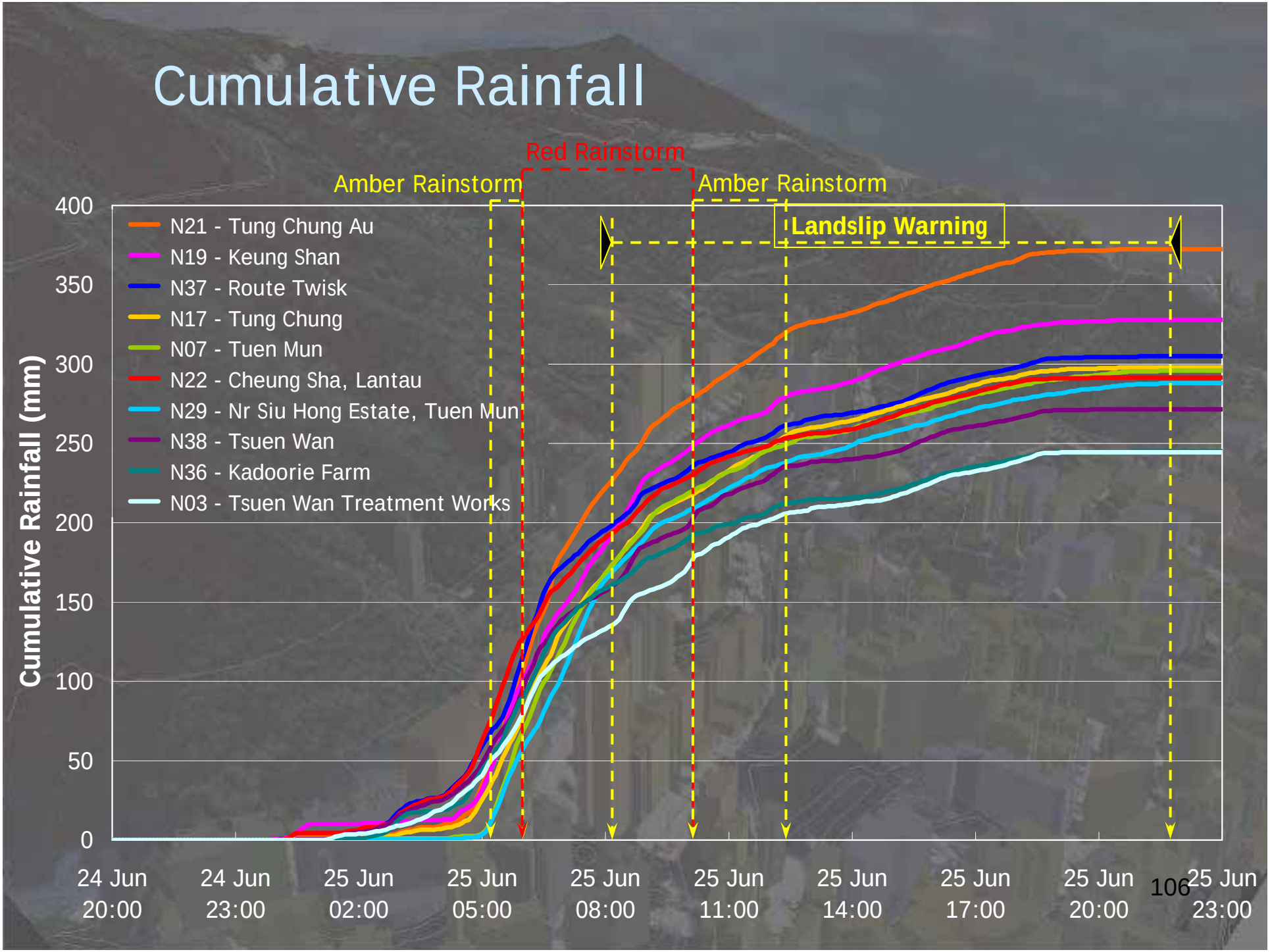
No. of reported landslides

29 minor

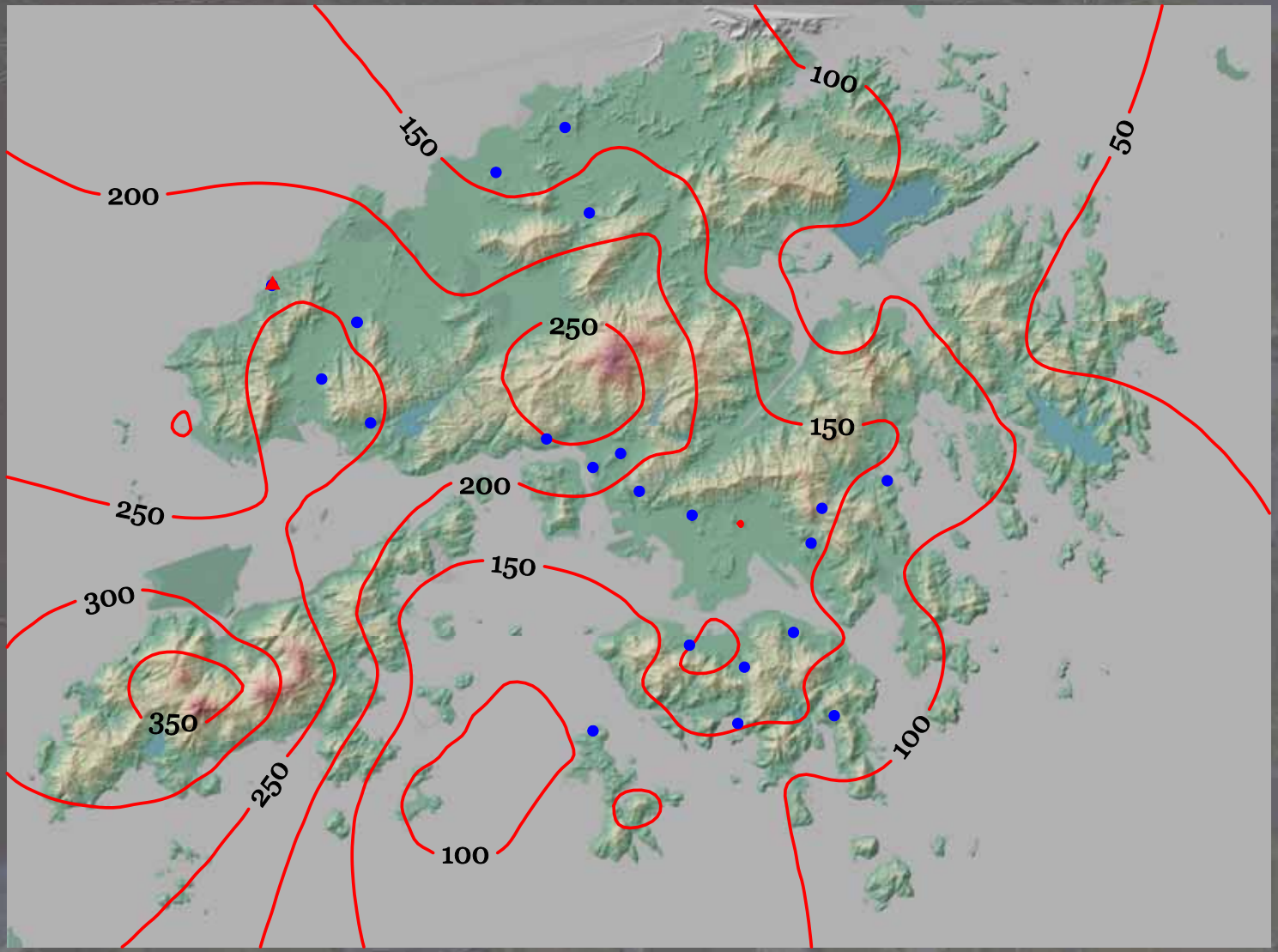
7 major

Rainstorm of 25 June 2008

Cumulative Rainfall



Maximum Rolling 24-hour Rainfall

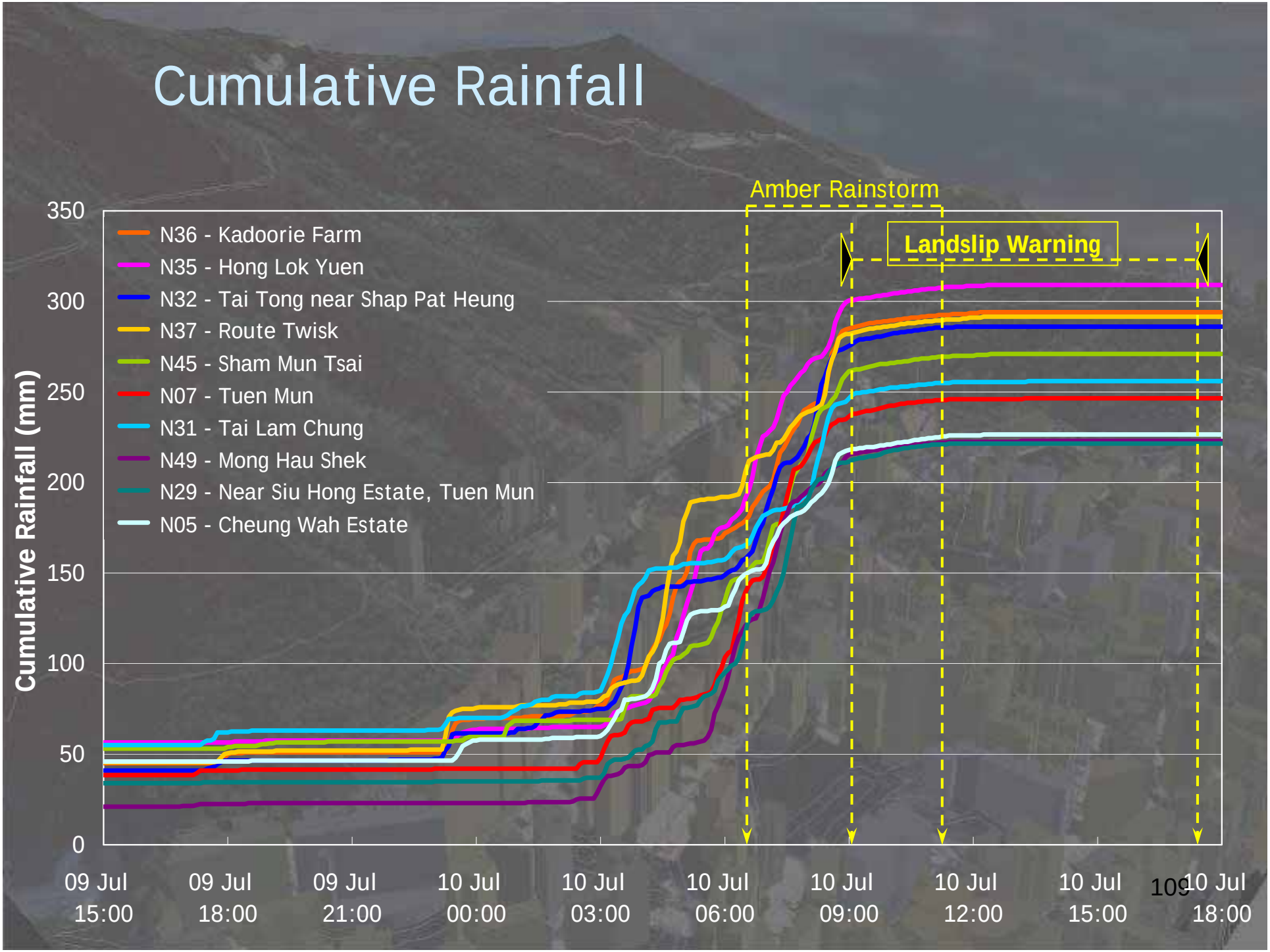


No. of reported landslides

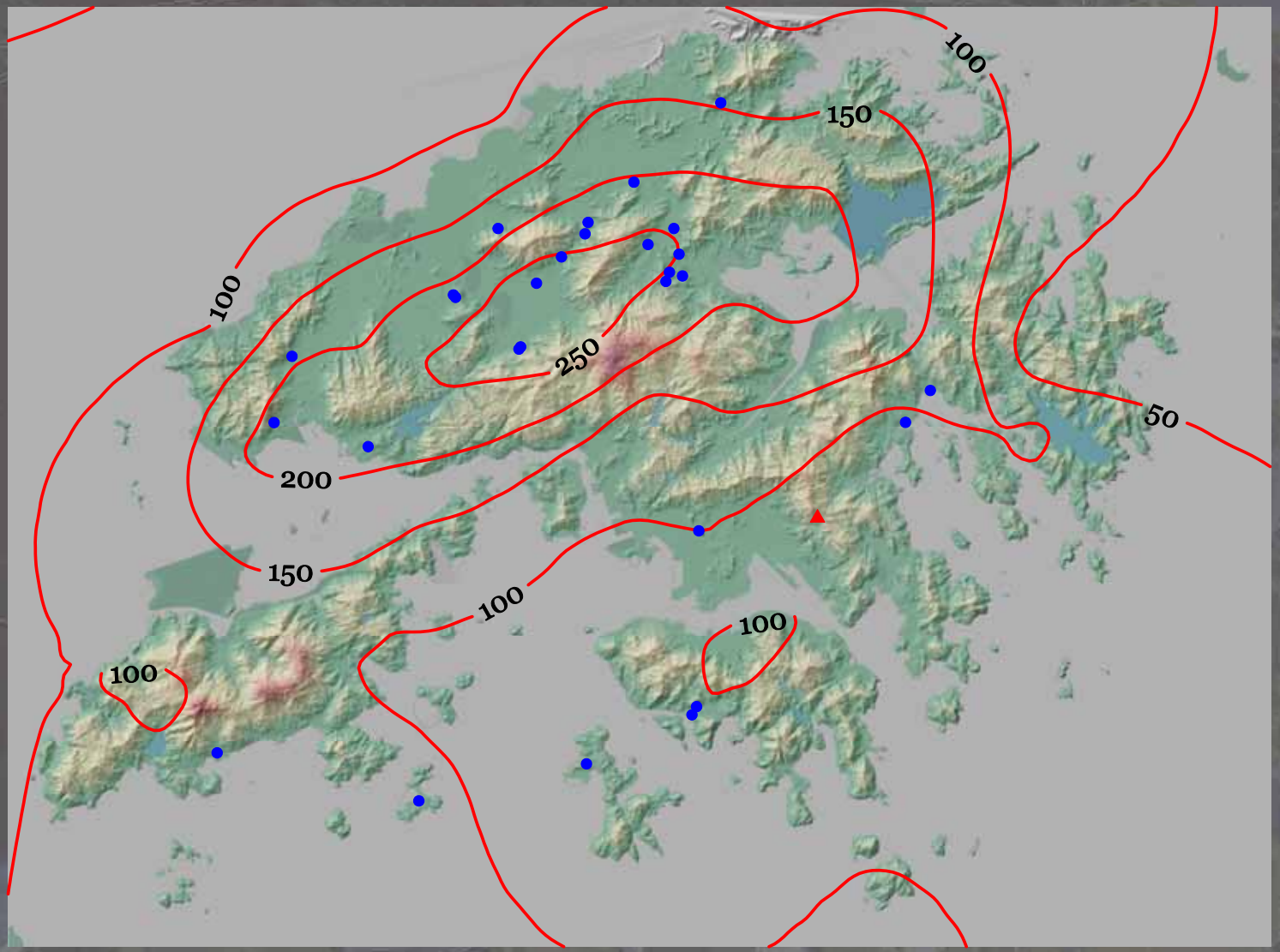
- 24 minor
- 1 major

Rainstorm of 10 July 2008

Cumulative Rainfall



Maximum Rolling 24-hour Rainfall



No. of reported landslides

28 minor

1 major

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


Questions?


Thank You