

# Geomorphology and Landslide Hazard Models

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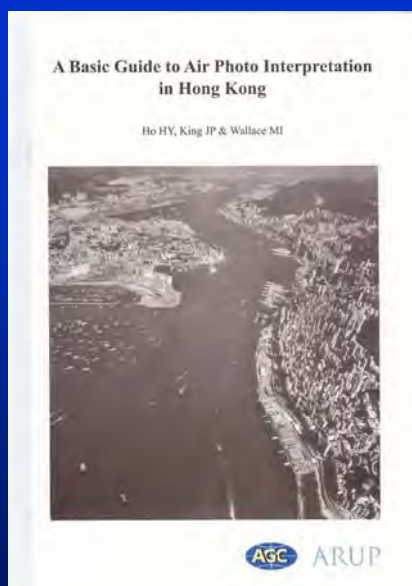


Key component of interpreting geomorphology and therefore hazard at a site is the use of API

The purpose of this talk is not to try and teach you API

Buy the AGS book – it shows the components of API. However it will not teach you how to carry out a geomorphological interpretation

That requires geomorphological training and experience



## The methodology required for NTHS is very different from LPM

Man-made Slope Assessment	Natural Slope Assessment
Site of limited extent	Sites have a large extent, often comprising multiple catchments
Ground investigation (GI) stations are closely spaced	Given large site and difficult access, GI is restricted to critical areas
Exposures are available either before, during the GI, or during construction	Exposures are limited and often restricted to drainage lines
Considerable amount of published data on geotechnical properties of materials	Relatively limited data on the behaviour of natural landslides in Hong Kong, limited data of geotechnical mass properties
It may be appropriate to use simple classification of material types e.g. "colluvium"	Simple classifications maybe inappropriate. Classifying the superficial deposits requires an understanding of landscape evolution and geomorphological processes
Well developed software for 2D slope stability analysis	Stability programmes are not appropriate for catchment wide applications

The commonly adopted "design event" approach for NTHS requires derivation of either a "conservative event" (~ 100 year return period), or a "worst credible event" (~ 1000 year return period) depending on slope geometry, facility & susceptibility.

However, these are often simply and mistakenly equated to "recent" and "relict" ENTLI features and the assessment simply becomes the adoption of the largest of the applicable landslide type within the catchment.

Whilst the ENTLI is a valuable dataset... it is just that an unverified dataset

## ENTLI

Given the project constraints (over 105,000 aerial photographs were reviewed in 16 months) the interpreters could only examine for relatively clear evidence of landslides e.g. obvious scarps, with very little time available to consider geomorphological settings, often critical with respect to the identification of older degraded and possibly landslide related features

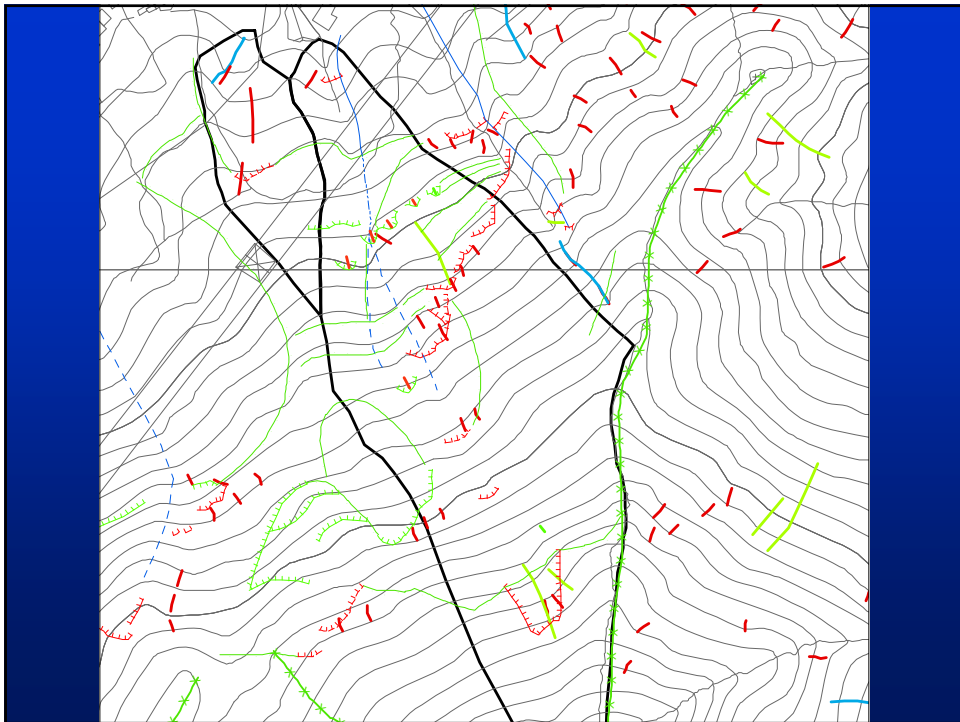
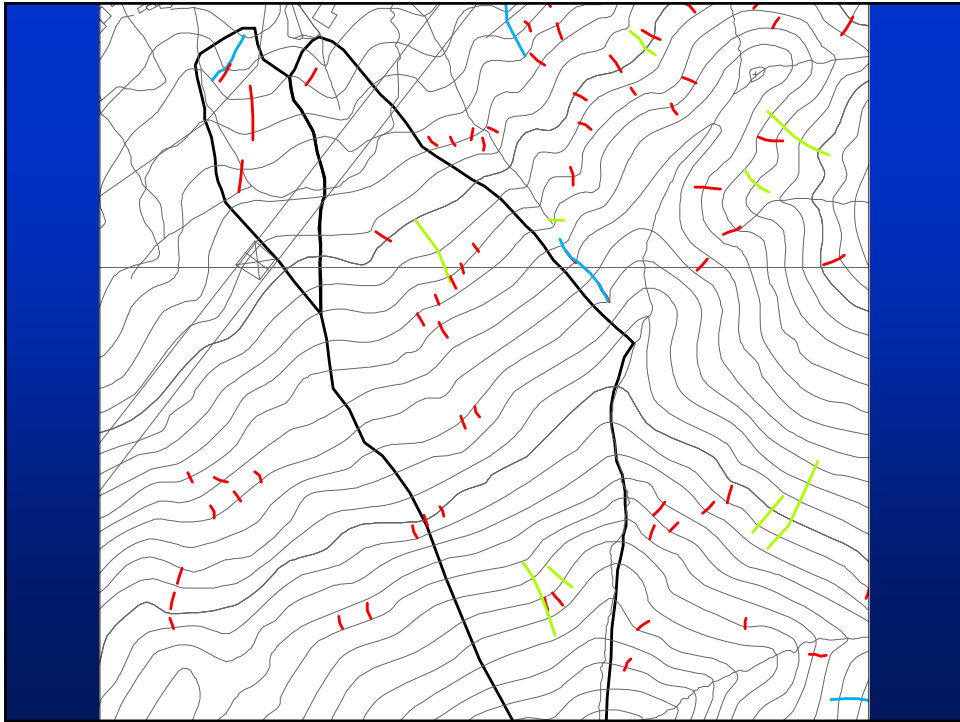
None of the features were field verified

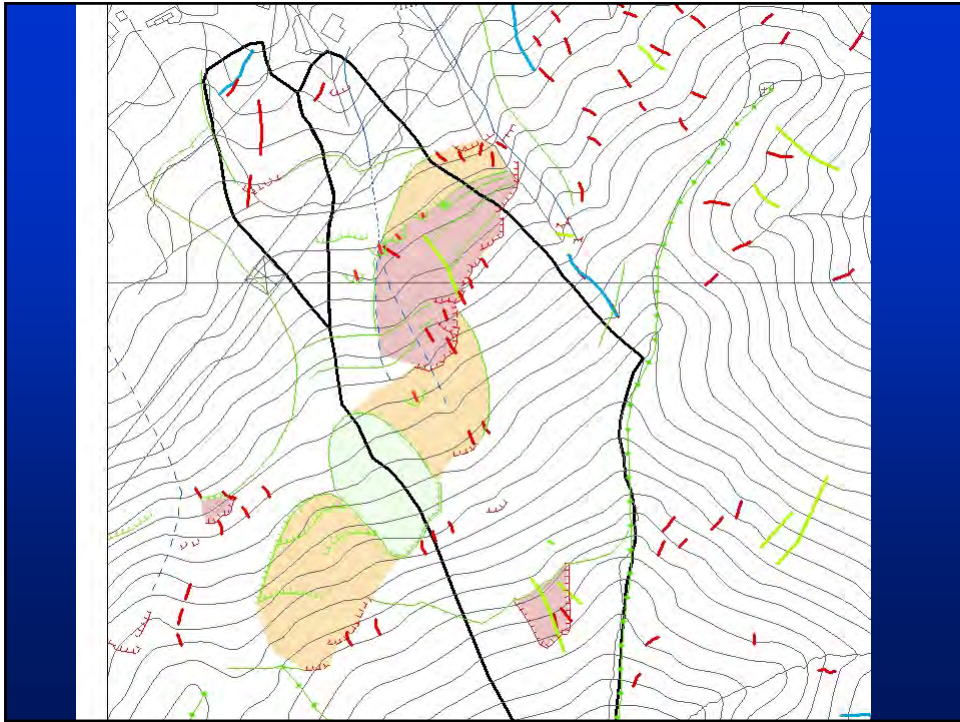
## “Relict” landslides

It should be noted that some of the large “relict” landslides are possible 10s of thousands of years old i.e. considerably outside the required 1:1000-yr event requirement

Even absolute dating can be problematic. A landslide at Tsing Shan was age dated which gave a range of ages from 44,000 to 1200 BPyears.

However, field mapping subsequently confirmed that it is an active slow-moving, landslide







### “Recent” ENTLI features

Even recent landslides can be problematic for identification from API

A number of landslides which appeared to be long run out landslides were in fact the result of scouring of the drainage line due to an abrasive mix of water and soil i.e. debris flood. Whilst landslides were associated with such features only limited amounts of debris left the source area. Based on API alone such features would have been classified as long run out landslides



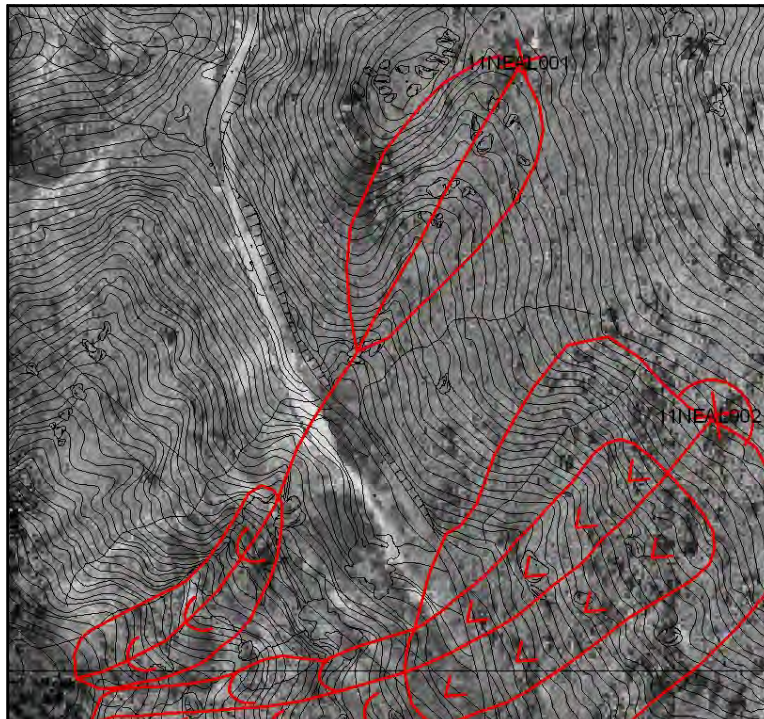
## OTHER DATASETS

In addition to the ENTLI there is the Large Landslide Database

This was generated primarily by aerial photograph interpretation (API) and targeted landslides >20m in width.

During a regional natural terrain hazard study some 11 out of 23 landslides from this database were reassessed, again by API, as not being large landslides

It is unclear whether this discrepancy reflects the experience of the interpreters as the original large landslide database was compiled by experienced overseas interpreters with little local experience whilst the regional study was undertaken by less experienced but local interpreters









## What is “Geomorphology”?

“is the study of the forms of the surface of the earth, their origin, the processes involved in their development, the properties of the materials of which they are made and predictions about their future form, behavior and status”

(D Brunsden, 5th Glossop Lecture, 2002)

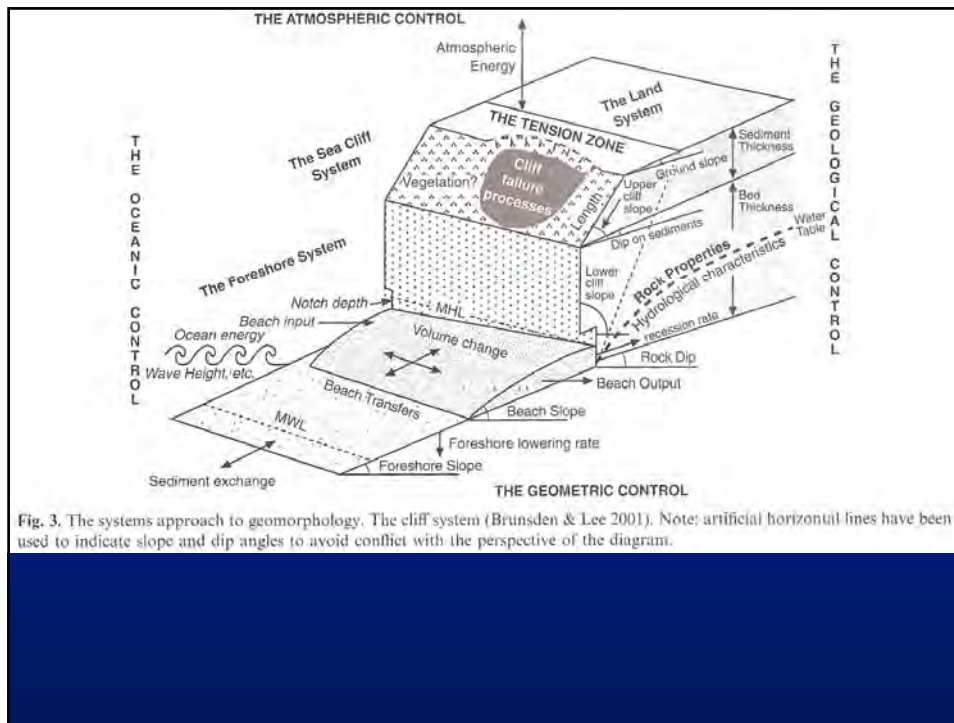
Complex interrelationship between :

### 1. Geology

- rock type
- structure
- weathering

### 2. Geomorphology

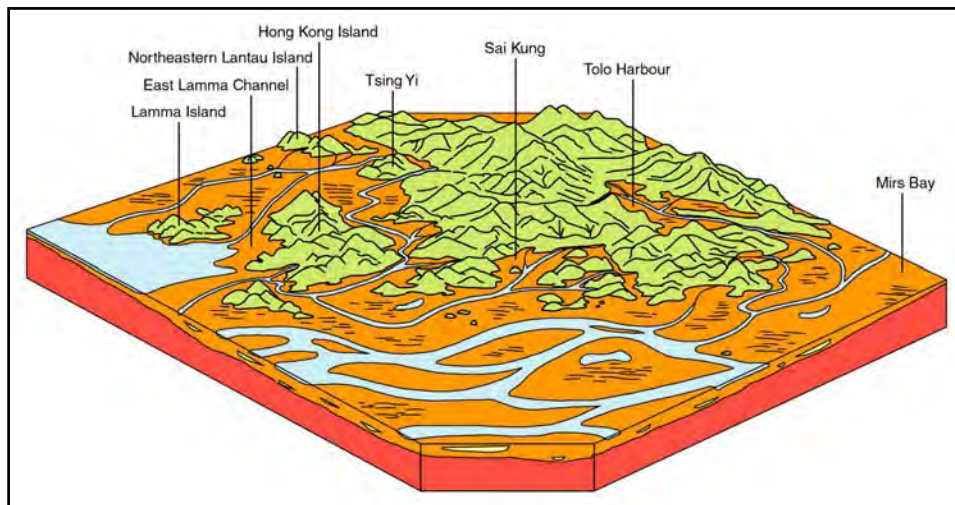
- landscape evolution
- surface processes



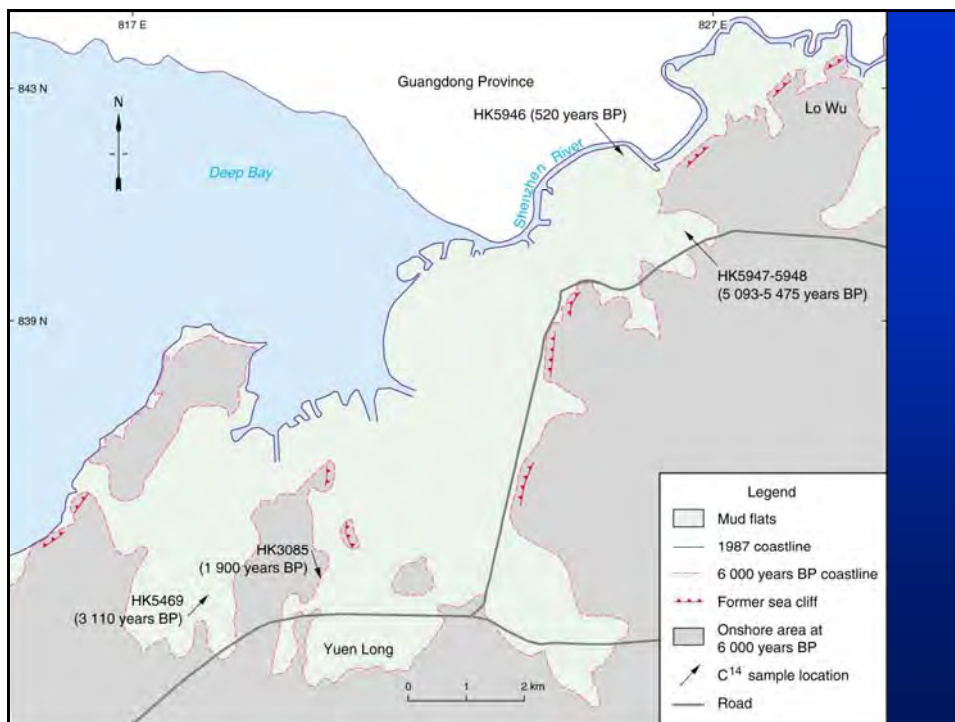
### Advantages of a geomorphological approach

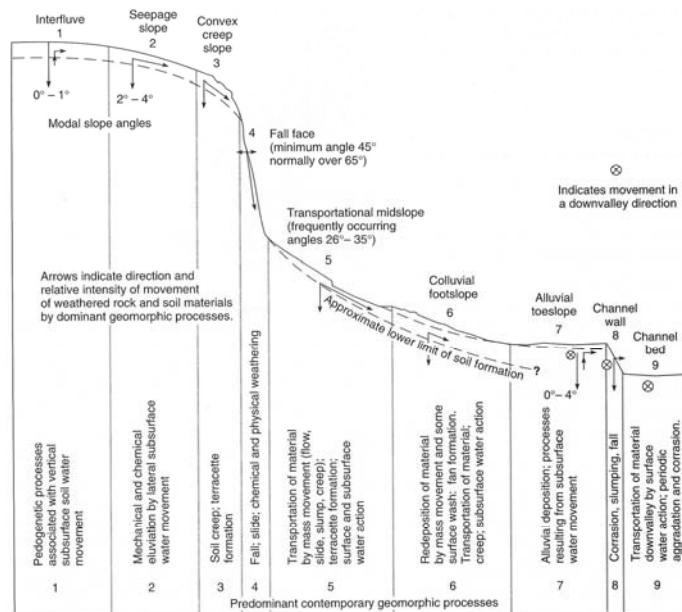
Assists in determining:

- the type of natural terrain hazards present
- the location of potential source areas
- the estimation of source volumes for hazard types
- the likely frequency of the hazard types
- the presence of entrainable material



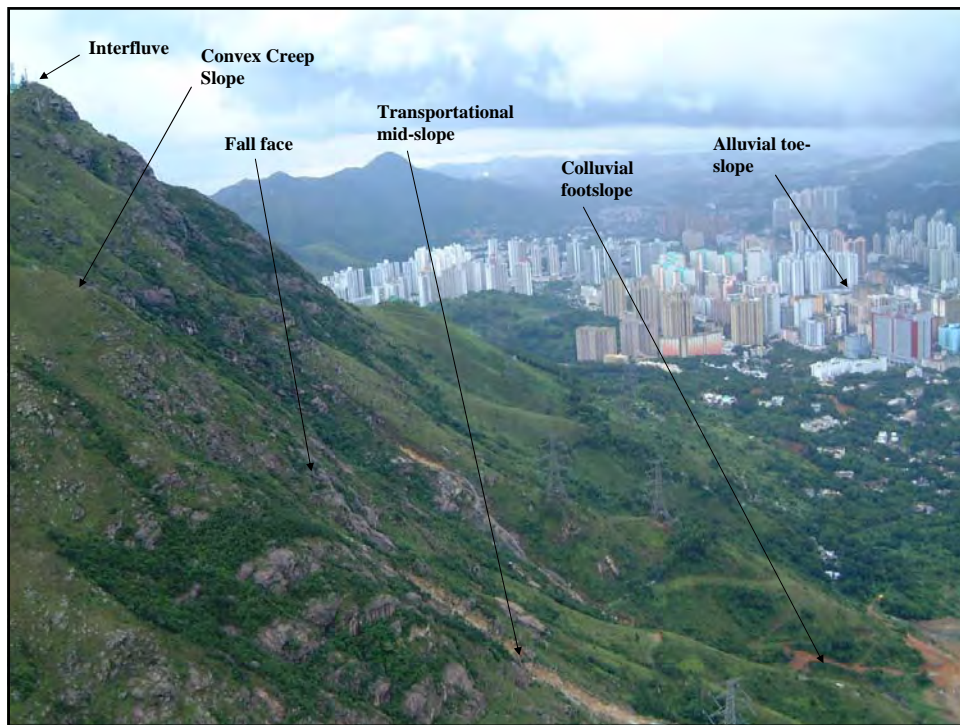
17,000BP sea-level was 120m lower than present day

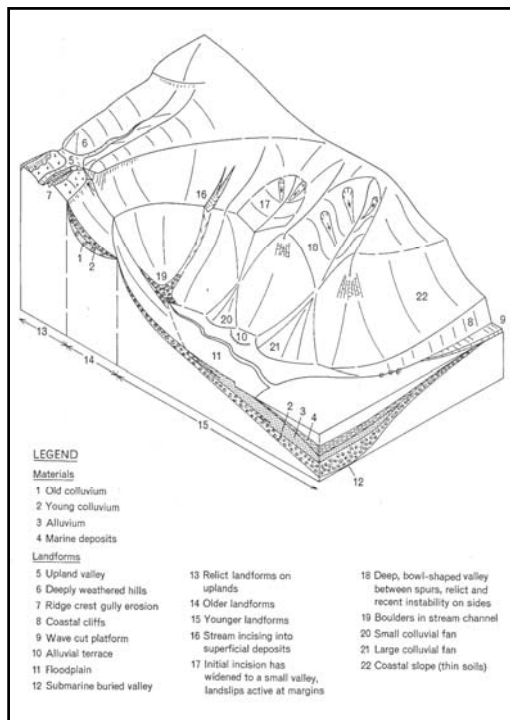




**FIGURE 4.45**  
Diagrammatic representation of the hypothetical nine-unit landsurface model.  
(Dalrymple 1968)







Hansen, 1984

Notes that up to 4 different terrain systems, associated with differing materials and processes are present in Hong Kong

Provides a valuable framework for hazard assessment, however the evolution of each site can be considerably different

- i.e. Land surface evaluation

## Land Surface Evaluation – an approach to the problem

*Definition: initially geomorphological mapping and aerial photograph interpretation, extended to data compilation, interpretation and conceptual ground modeling prior to a ground investigation*

## Two Approaches

### (a) Land Classification

- identification of landscape patterns, mainly from API
- typically to land facets scale
- regional surveys in developing countries
- Hong Kong (GASP, Brand et al. 1982)

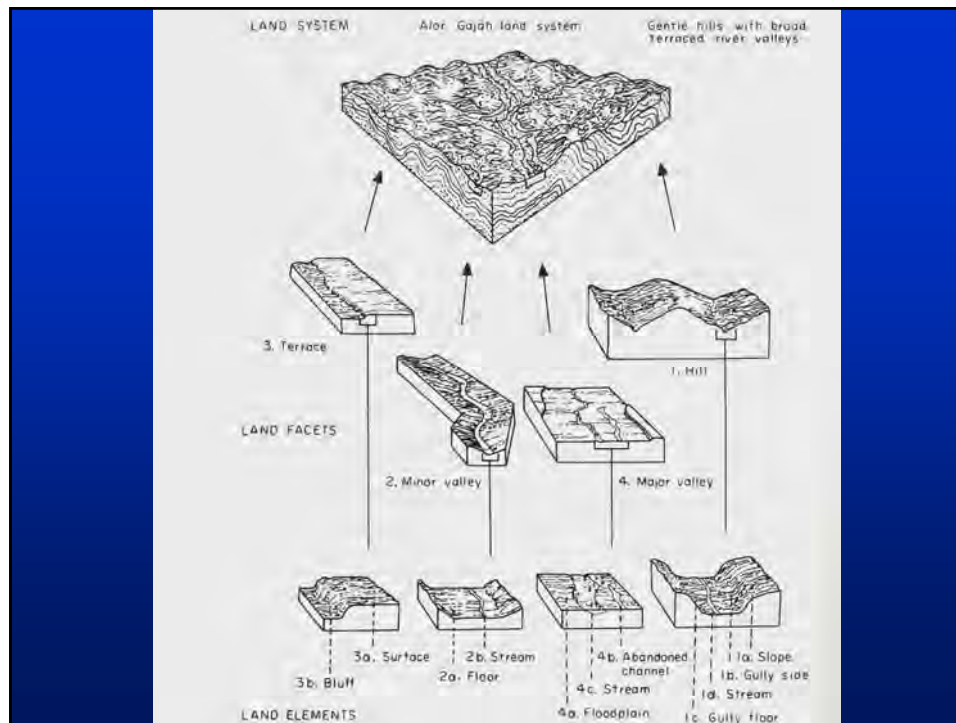
### (b) Land Surface Mapping

Geomorphological maps showing:

- typically to land elements scale,
- nature and properties of their materials
- characteristics of the processes which formed them

NTHS require an understanding of both

## Land Classification

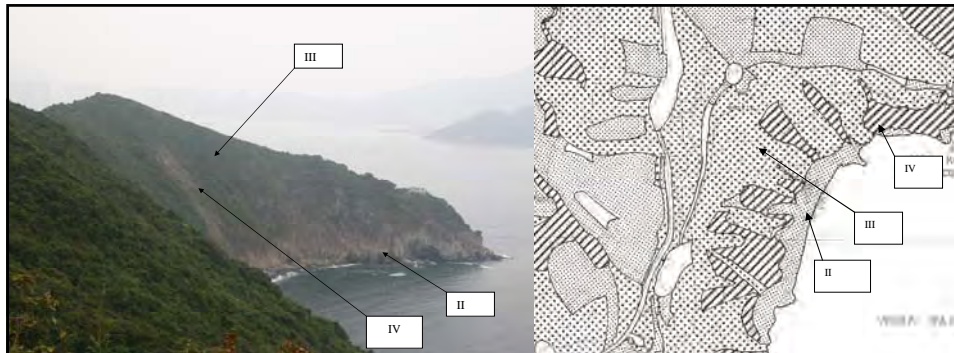


## Geotechnical Area Studies Programme (Brand et al. 1982)

- Land management and development planning purposes
- 1:20,000 scale, a few areas at 1:2,500
- Area selection based on extensive bodies of colluvium
- API used to generate GLUM
- 6 slope gradients, 13 major terrain component classes (e.g. hillcrest, sideslope, footslope, flood plain), and 5 erosion classes
- GLUM = Land Element Maps







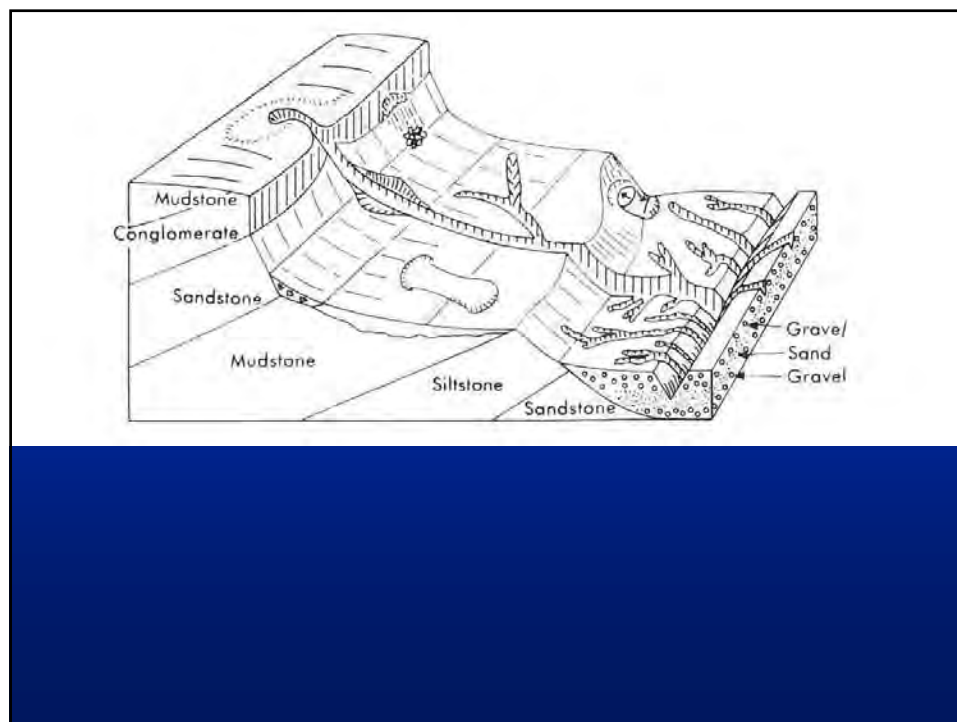
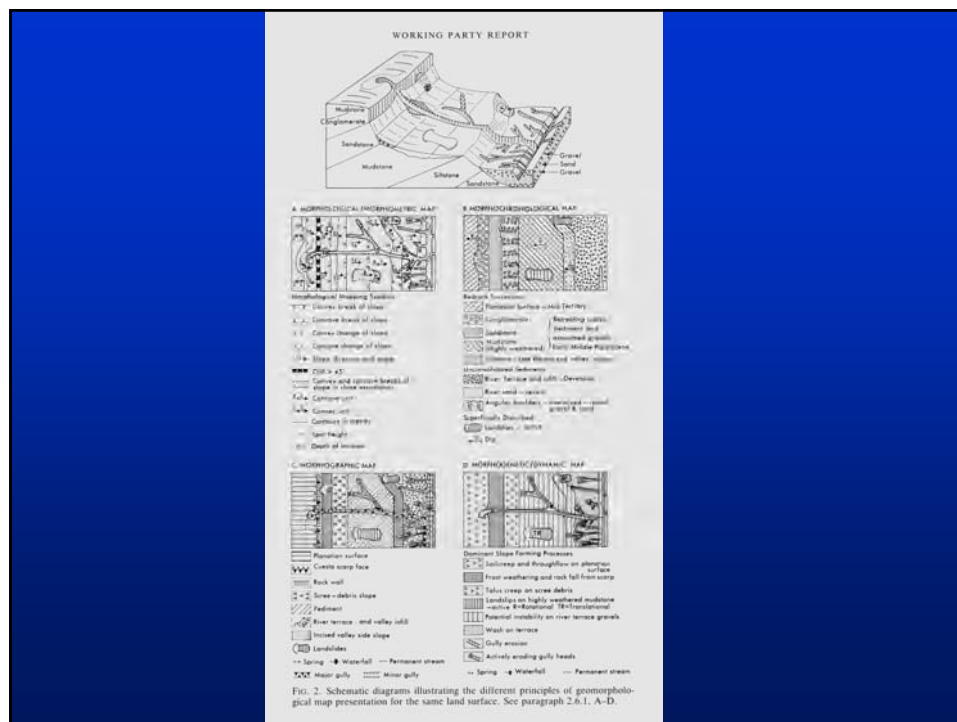
The slopes above the sea cliffs where landslides have occurred, are classified as Class IV i.e. extreme geotechnical limitations

The intervening land between landslides Class III i.e. high geotechnical limitations

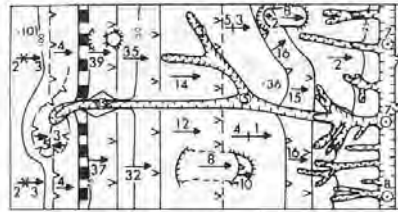
The cliffs are Class II i.e. moderate geotechnical limitation.

From a geomorphological perspective this location is a classic process-response system. The cliffs are subject to considerable oceanic wave action and on-going marine erosion. The response of the foreshore system to this is undercutting of the cliffs and structurally controlled rock falls within the fine-ash tuff. These in turn result in destabilisation of the overlying regolith, which result in debris slides. These same processes are operating along the entire section of coast and therefore this terrain is likely to have a similar probability, magnitude and frequency of landsliding.

## Land Surface Mapping



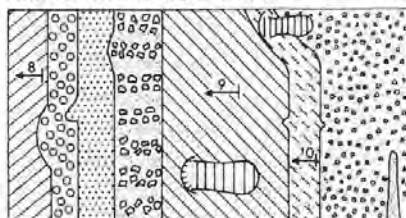
### A. MORPHOLOGICAL/MORPHOMETRIC MAP



#### Morphological Mapping Symbols

- ∇ ∇ Convex break of slope
- △ △ Concave break of slope
- ∇ ∇ Convex change of slope
- △ △ Concave change of slope
- 10 Slope direction and angle
- ■ ■ Cliff > 45°
- + — Convex and concave breaks of slope in close association
- 4 2 Concave unit
- 2 3 Convex unit
- 10 Contours in metres
- 121 Spot height
- 15 Depth of incision

### B. MORPHOCHRONOLOGICAL MAP



#### Bedrock Succession

- Planation Surface — Mid-Tertiary
- Conglomerate } Retreating scarps
- Sandstone } pediment and
- Mudstone (Highly weathered) } associated gravels
- Siltstone — Late Pleistocene valley incision

#### Unconsolidated Sediments

- River Terrace and infill — Devensian
- River sand — recent
- Angular boulders — intermixed — recent gravel & sand

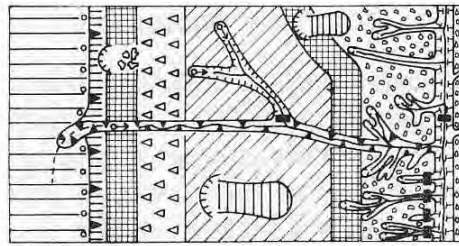
#### Superficially Disturbed

- Landslips — active
- Dip

Age of Terrain



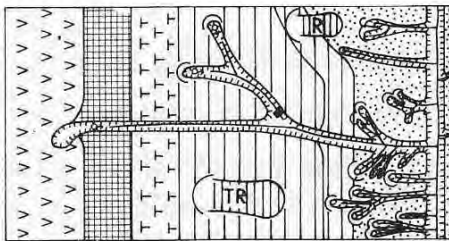
### C. MORPHOGRAPHIC MAP



- Planation surface
- Cuesta scarp face
- Rock wall
- Scree-debris slope
- Pediment
- River terrace - and valley infill
- Incised valley side slope
- Landslides
- Spring   Waterfall   Permanent stream
- Major gully   Minor gully

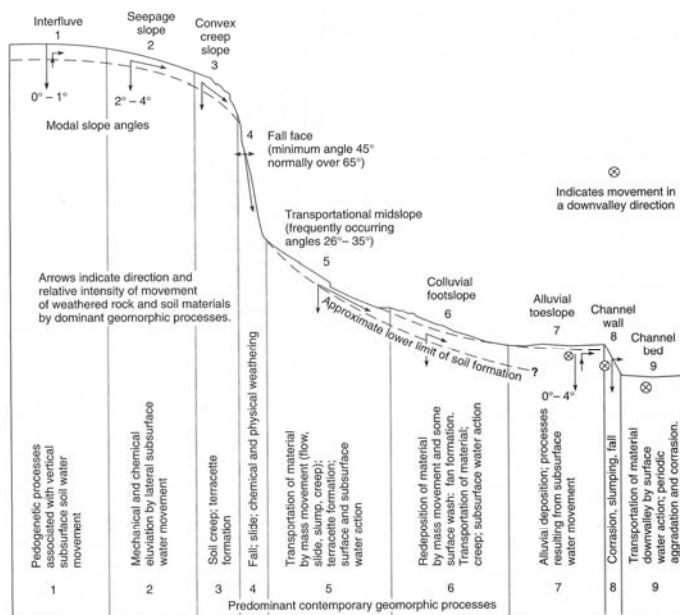
Landscape  
components

### D. MORPHOGENETIC/DYNAMIC MAP



- Dominant Slope Forming Processes
- Soilcreep and throughflow on planation surface
  - Frost weathering and rock fall from scarp
  - Talus creep on scree debris
  - Landslips on highly weathered mudstone  
—active R=Rotational TR=Translational
  - Potential instability on river terrace gravels
  - Wash on terrace
  - Gully erosion
  - Actively eroding gully heads
  - Spring   Waterfall   Permanent stream

Landscape  
processes



**FIGURE 4.45**  
Diagrammatic representation of the hypothetical nine-unit landsurface model.  
(Dalrymple 1968)

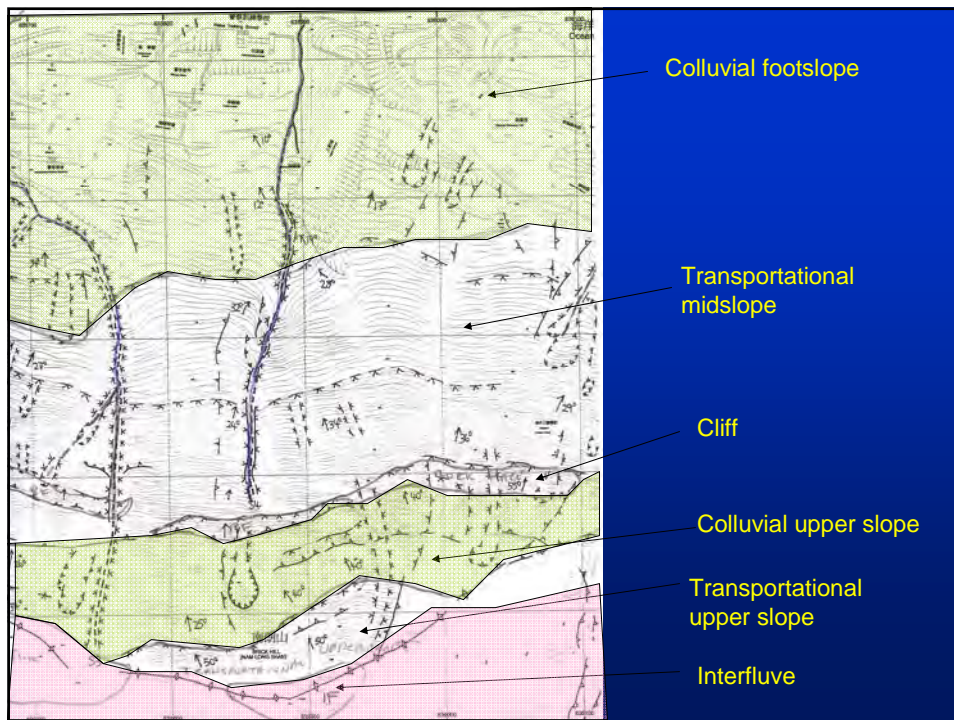
There is limited experience of geomorphological mapping in Hong Kong and even less experience with respect to developing models of landscape evolution

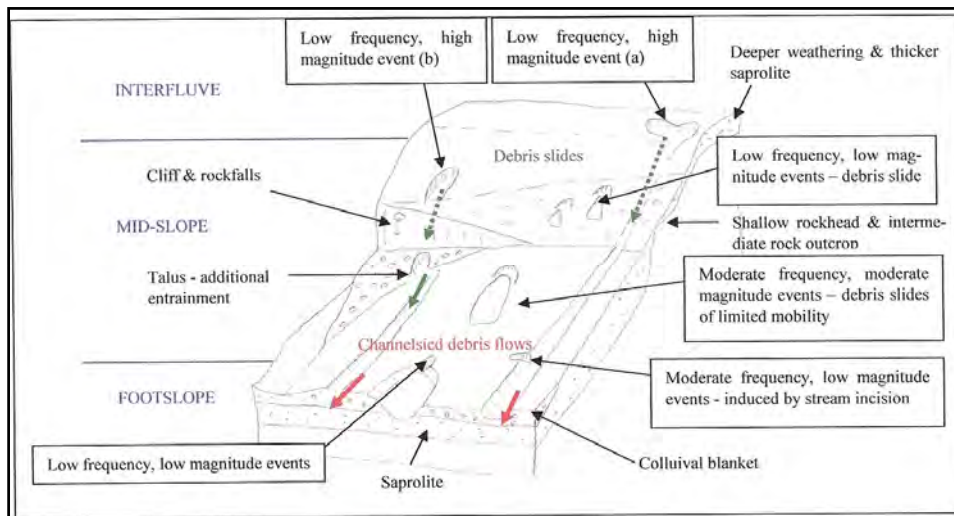
Many APIs focus on site histories and when geomorphological mapping is carried out it simply shows rudimentary morphological data

Geomorphological boundaries derived from API are not verified in the field

Assessments are often restricted to site boundaries. Landforms do not evolve in isolation and in order to develop a model a sufficient large area has to be studied

Geomorphology assessments can be very rapid





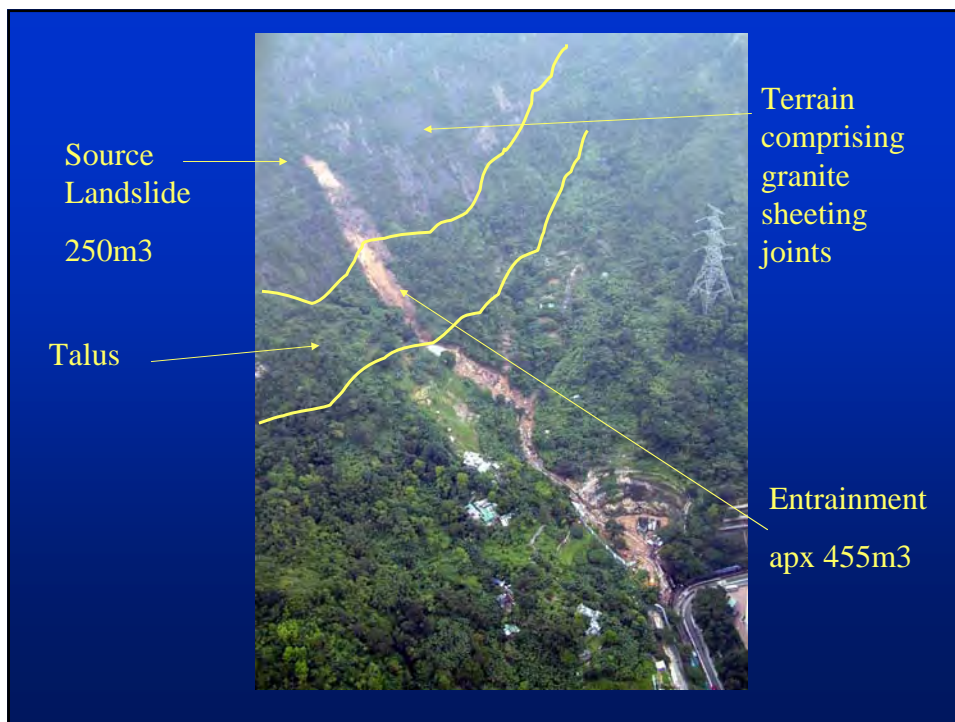
Note potential for entrainment

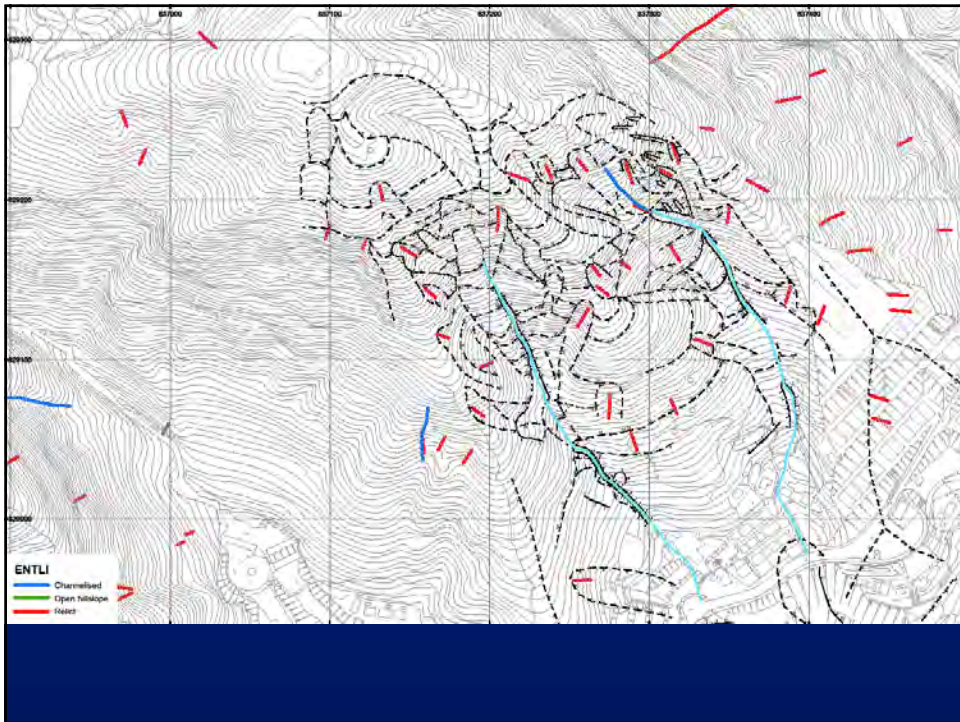
Potential entrainment is problematic

Values commonly used in HK are either from dissimilar geomorphological settings (e.g. British Columbia) or early work in HK, which has been shown to be problematic due to lack of separation of post-landslide scour from the actual landslide

More recent work in Hong Kong has shown that entrainment potential is generally low but it can occur in significant amounts with the right combination of circumstances



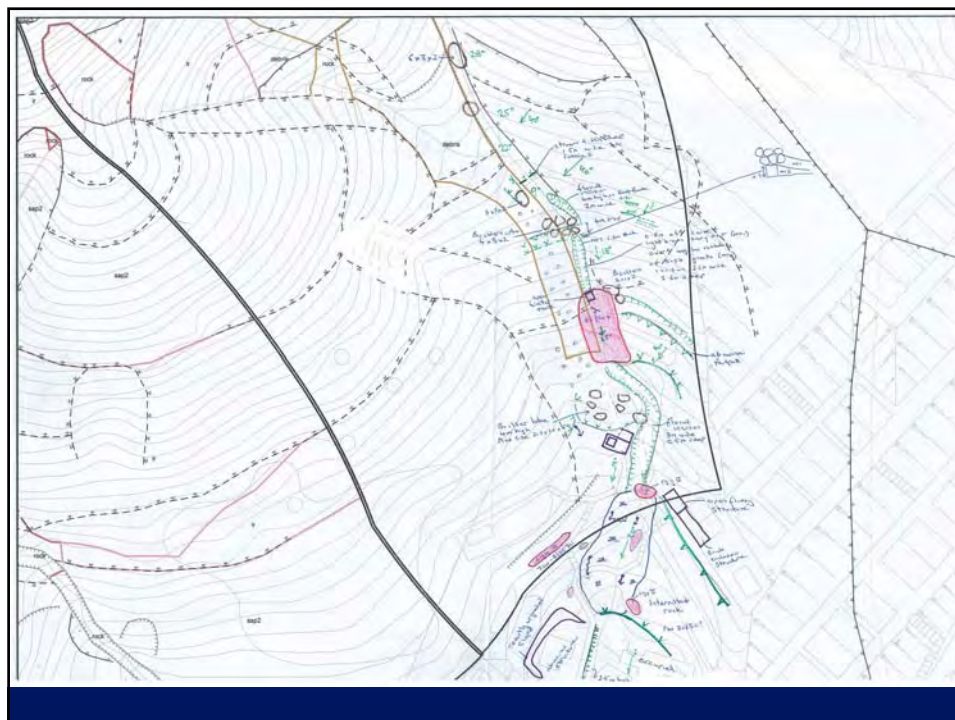
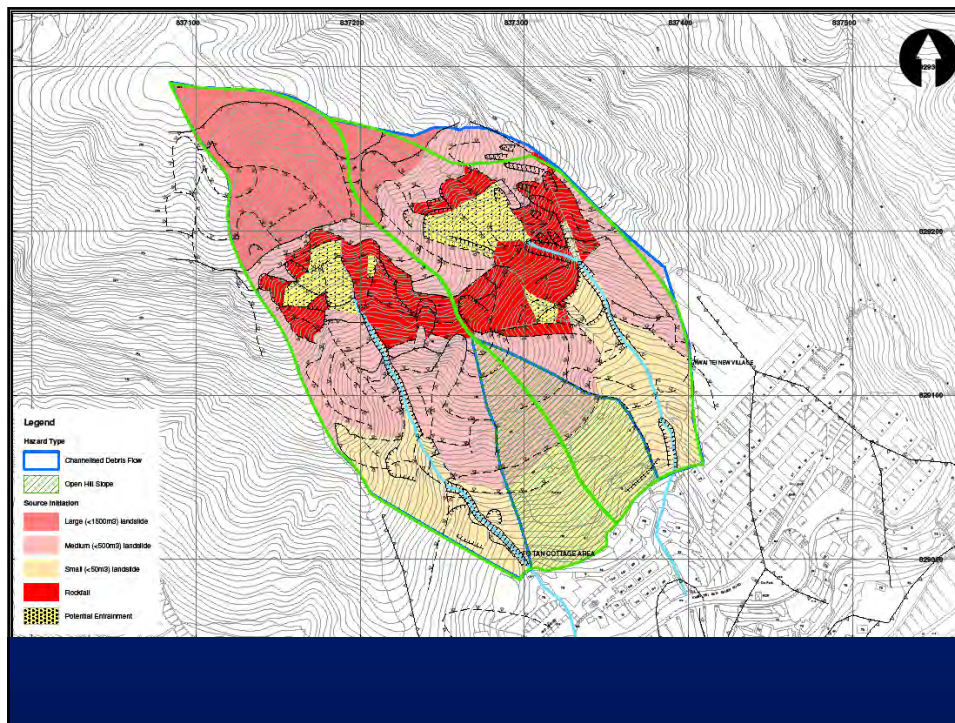


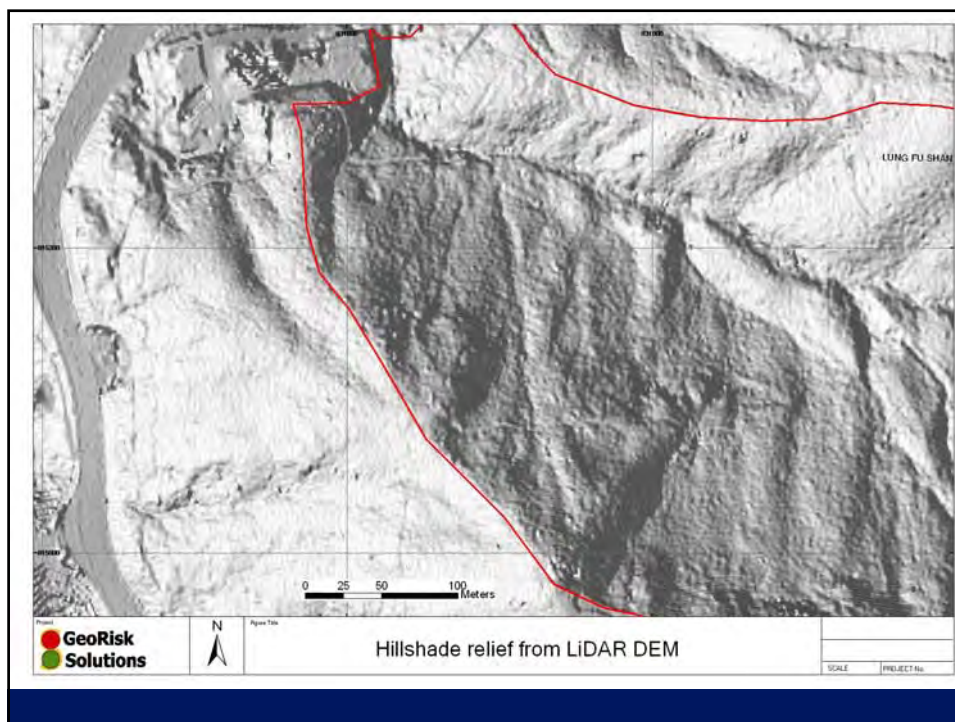
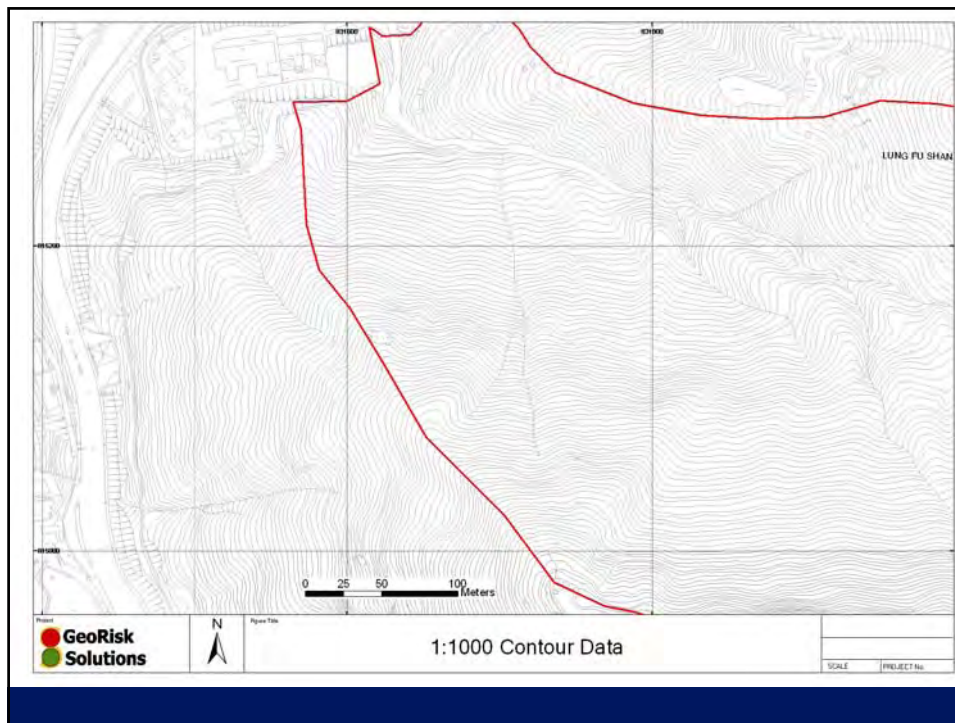




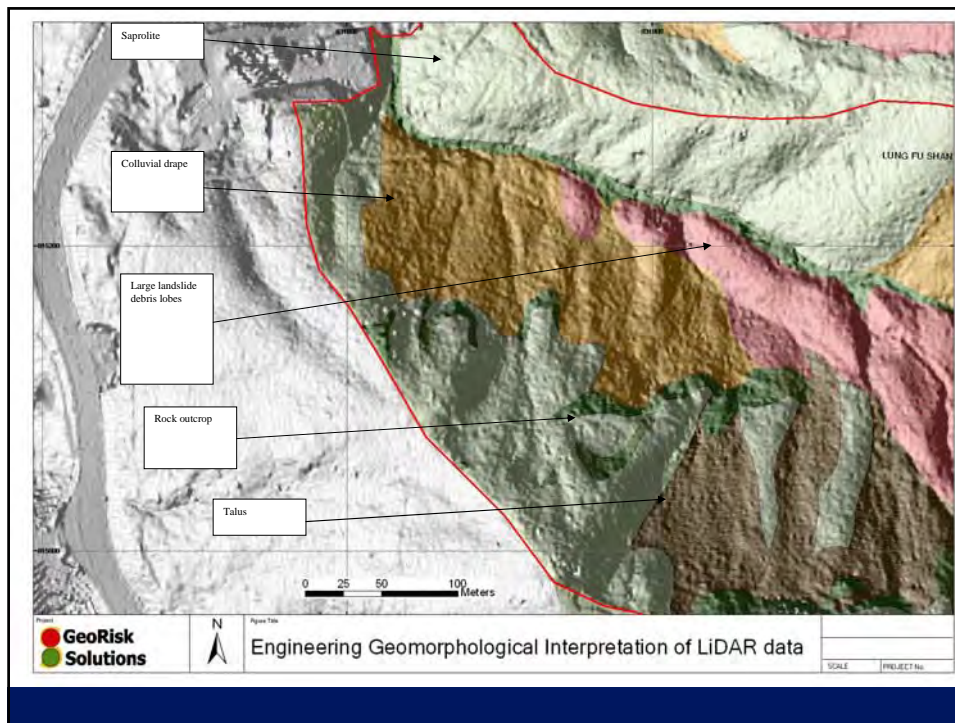












To summarize:

There is no single approach to geomorphological mapping

The method selected should reflect the nature of problem to be solved

However, all maps should sub divide the landscape into units with similar surface form, materials and process

The maps should not be limited to what has occurred but to convey what might occur