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Terrain Evaluation Mapping for Landslide Hazard Assessment on North-eastern Hong Kong Island

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Introduction

This presentation outlines the methodology adopted for Agreement No. CE56/2006(GE), in which mappable geomorphological characteristics were used to assess landslide hazard.

Topics

Background
Study Objectives

Approach to:
Engineering Geomorphological Mapping (EGM)
Hazard Mapping (HM)

Application to NTHS

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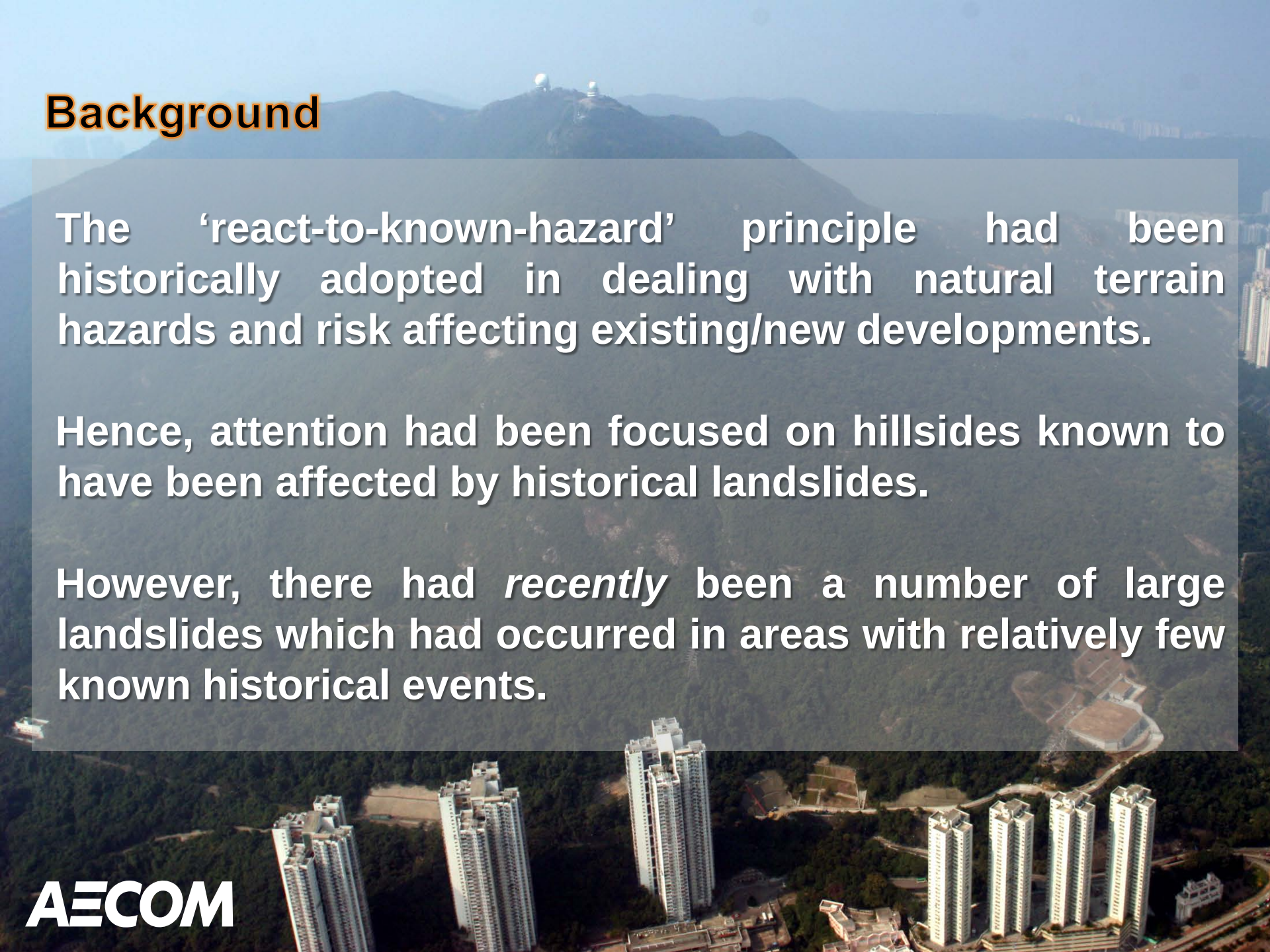
Background

The ‘react-to-known-hazard’ principle had been historically adopted in dealing with natural terrain hazards and risk affecting existing/new developments.

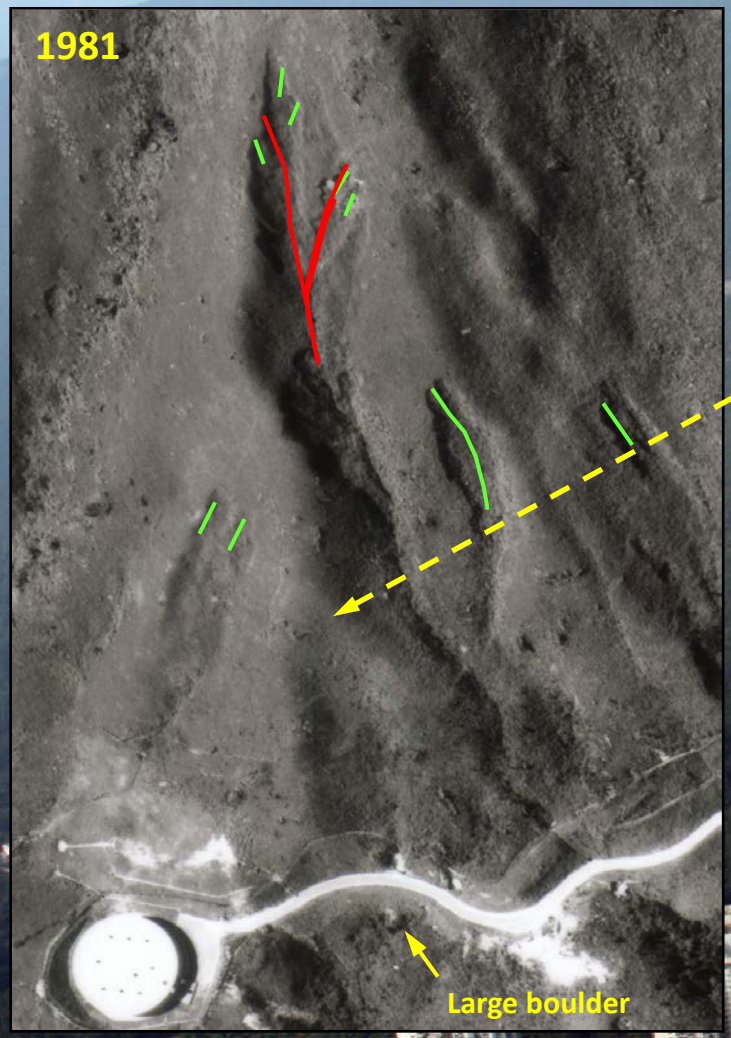
Hence, attention had been focused on hillsides known to have been affected by historical landslides.

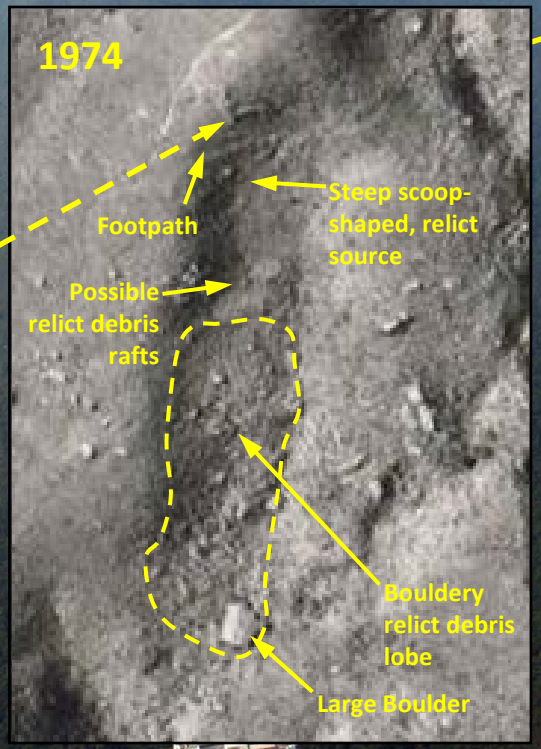
However, there had *recently* been a number of large landslides which had occurred in areas with relatively few known historical events.



Background

Fei Ngo Shan (2005)





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Study Objectives

Develop a regional natural terrain hazard review methodology to supplement the approach of identifying vulnerable hillsides based on past failure alone.

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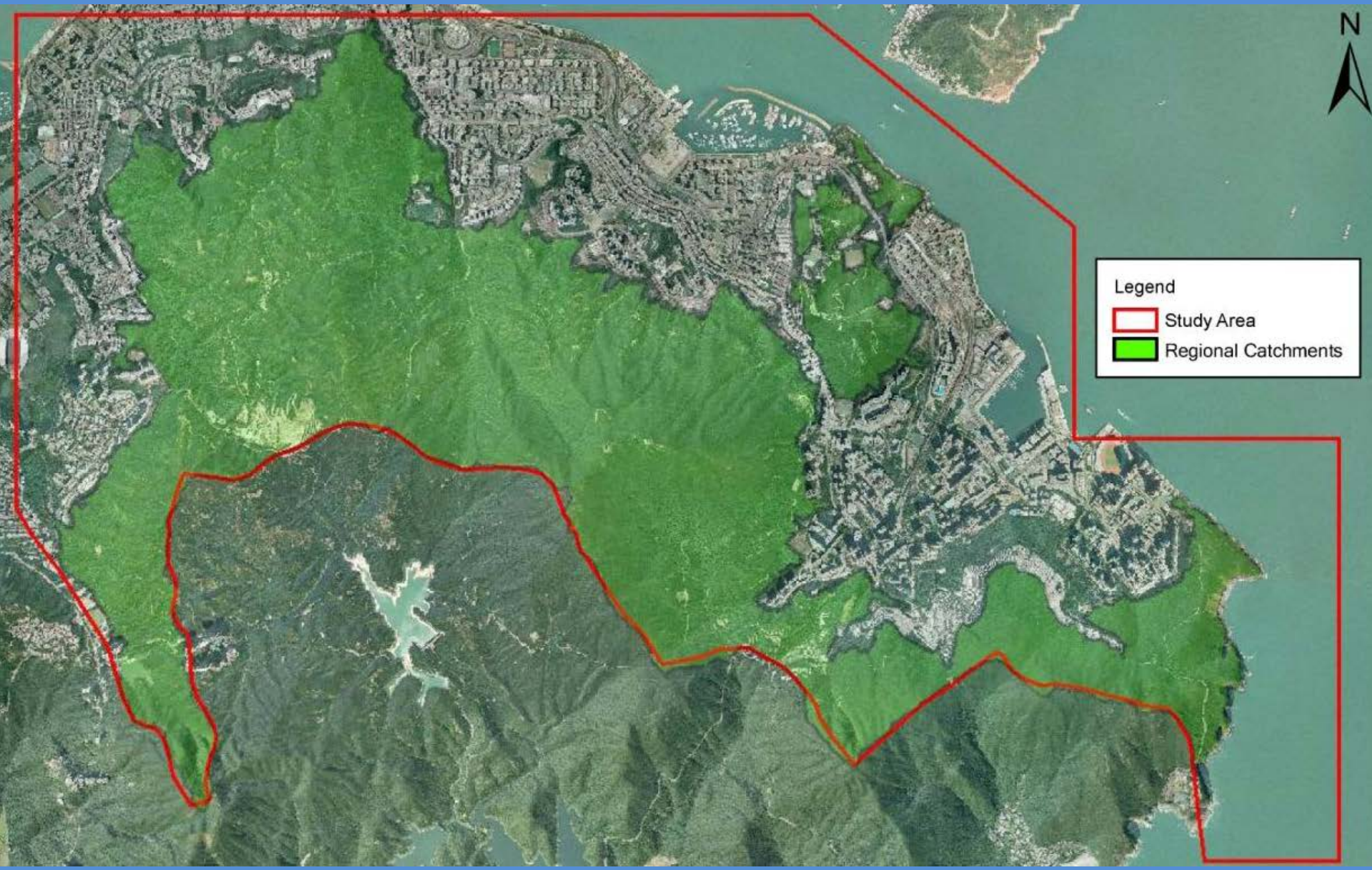

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Approach to Engineering Geomorphological Mapping

Based on two main sources of information:

1963 aerial photographs
For interpreting the 3-dimensional form (morphology) and texture (materials) of the terrain.

LiDAR topographic data
To enhance the definition of geomorphological features.

1.5m contour-spacing was determined to provide optimum resolution for 1:2,500 mapping scale.

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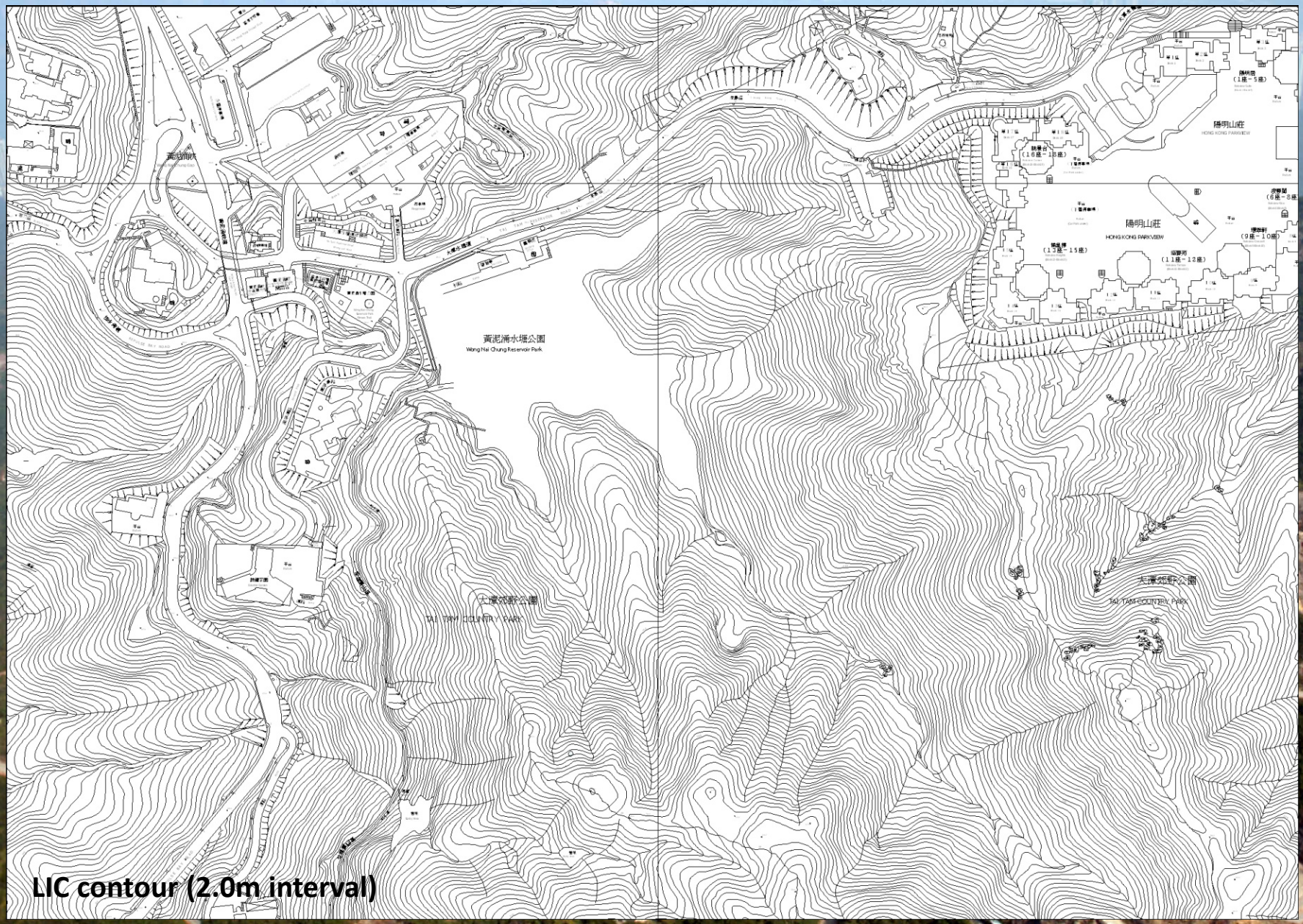

LIC contour (2.0m interval)

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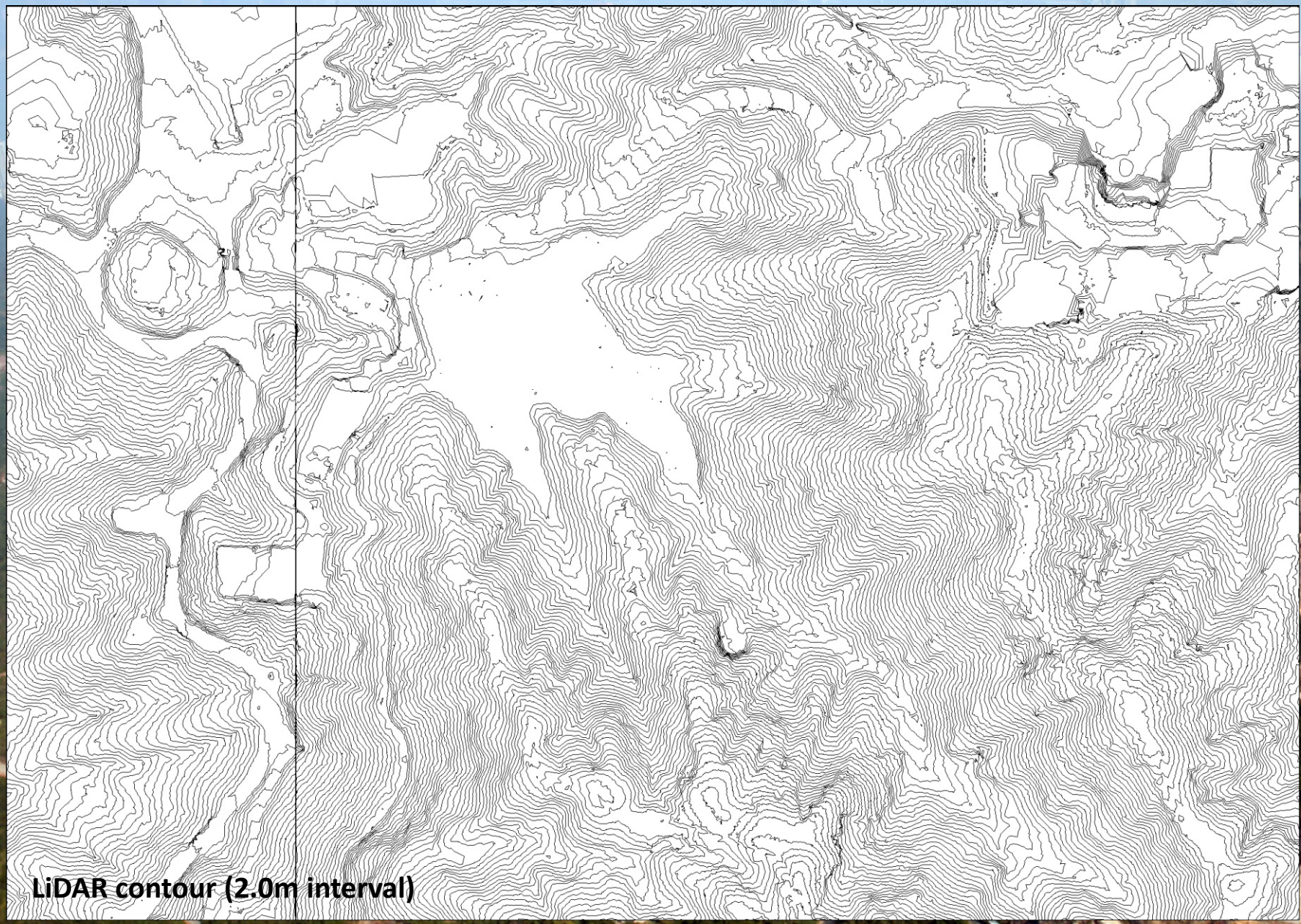

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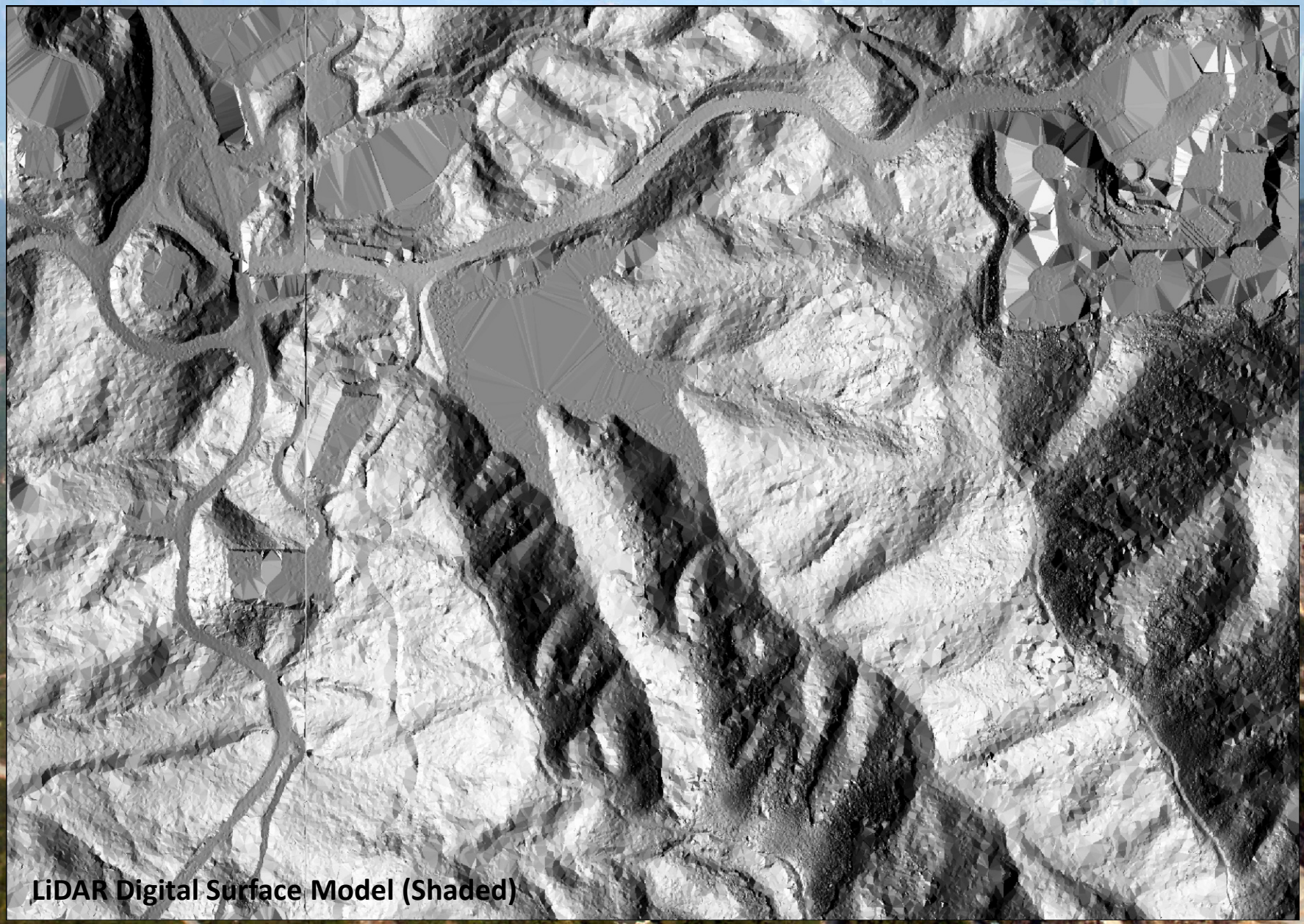

LiDAR Digital Surface Model (Shaded)

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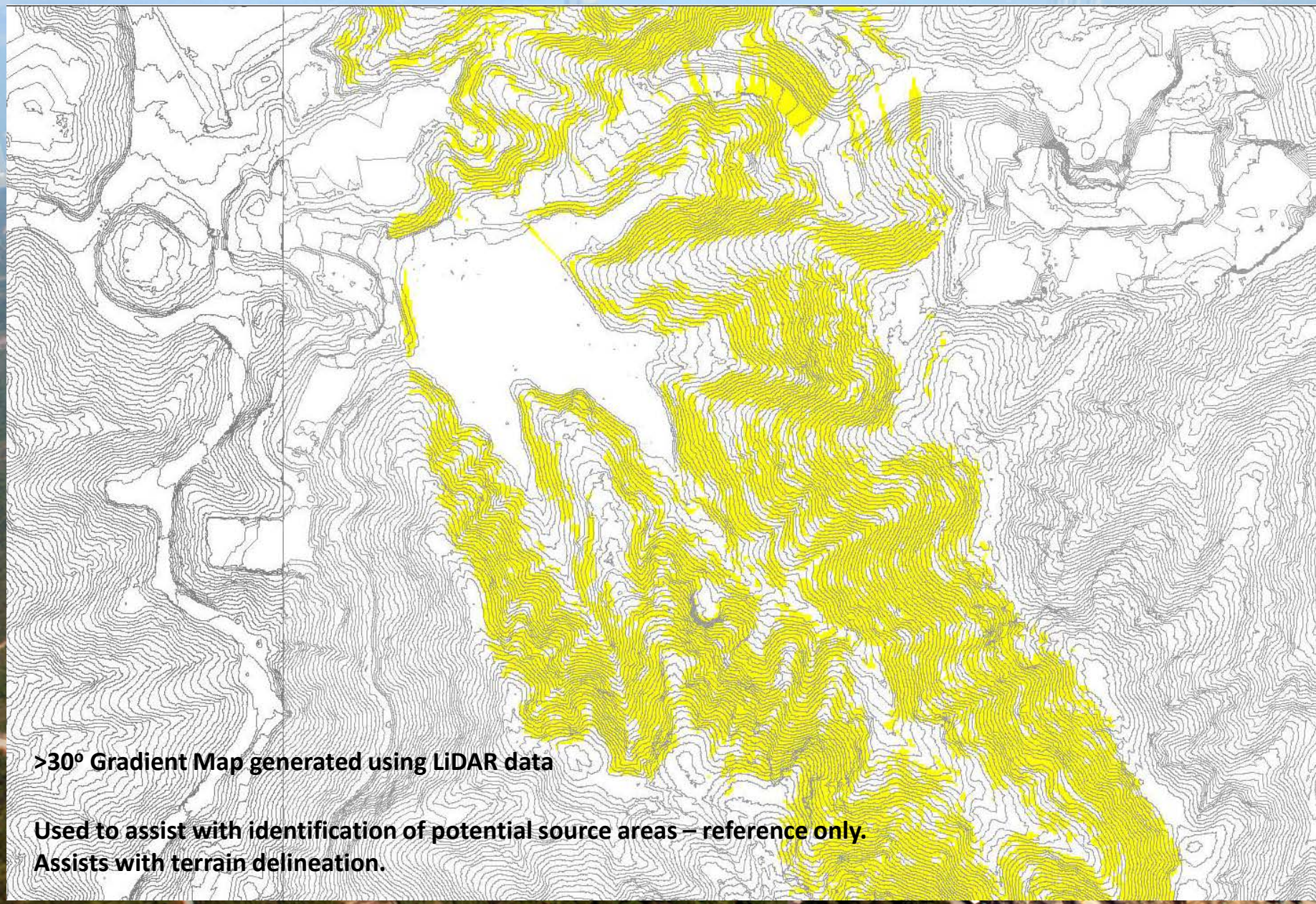

>30º Gradient Map generated using LiDAR data

Used to assist with identification of potential source areas – reference only.
Assists with terrain delineation.

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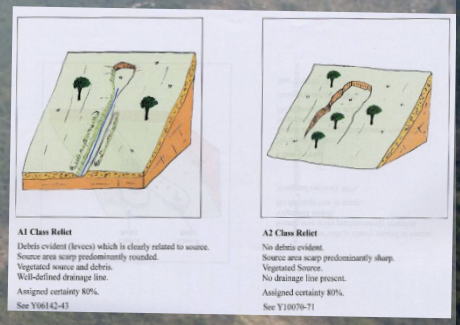
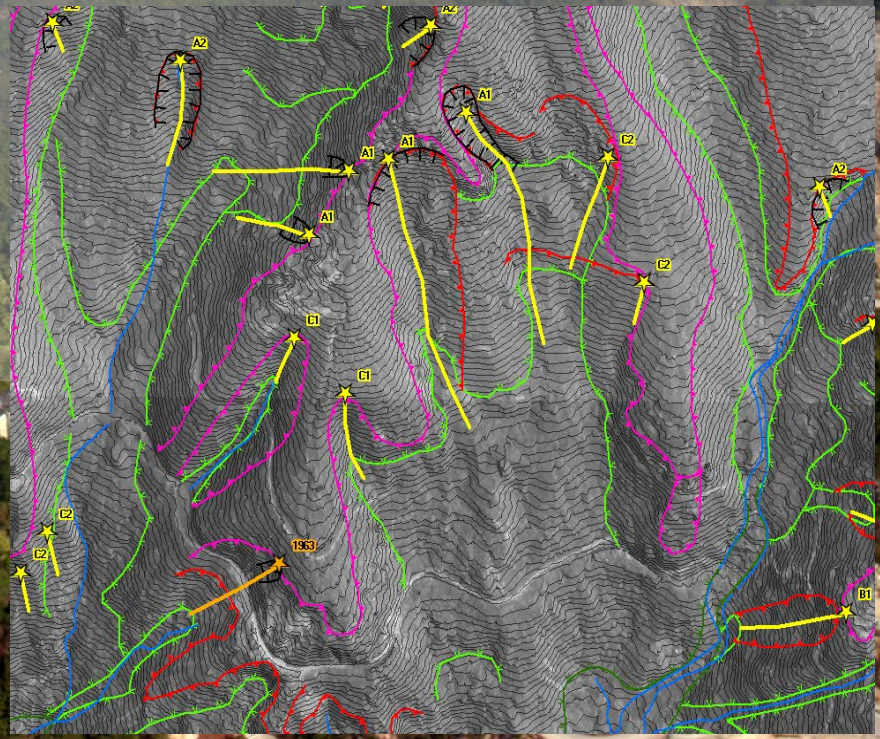
Approach to Engineering Geomorphological Mapping

Site-specific landslide inventory compiled for Study Area.
Inventory classified as per ENTLI.

Positioning of ENTLI records amended.
Nature of ENTLI records reconsidered.
New landslides identified.

Used to classify process into:
'active' and 'dormant'.





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Approach to Engineering Geomorphological Mapping

EGM comprises the following geomorphological information:

- Morphological (shape/form)
- Morphographical (regolith/surface materials)
- Morphogenetic (processes)
- Morphochronological (age relationships)

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Morphological Mapping

Base layer from which geomorphological characteristics are developed or derived.

Defines the shape and form of the terrain (convex/concave breaks or changes in gradient) defining different geomorphological features.

Used to interpret:

- Changes in process or regolith (e.g. landslide source and debris boundaries).
- Changes representative of boundaries between landforms of differing ages.

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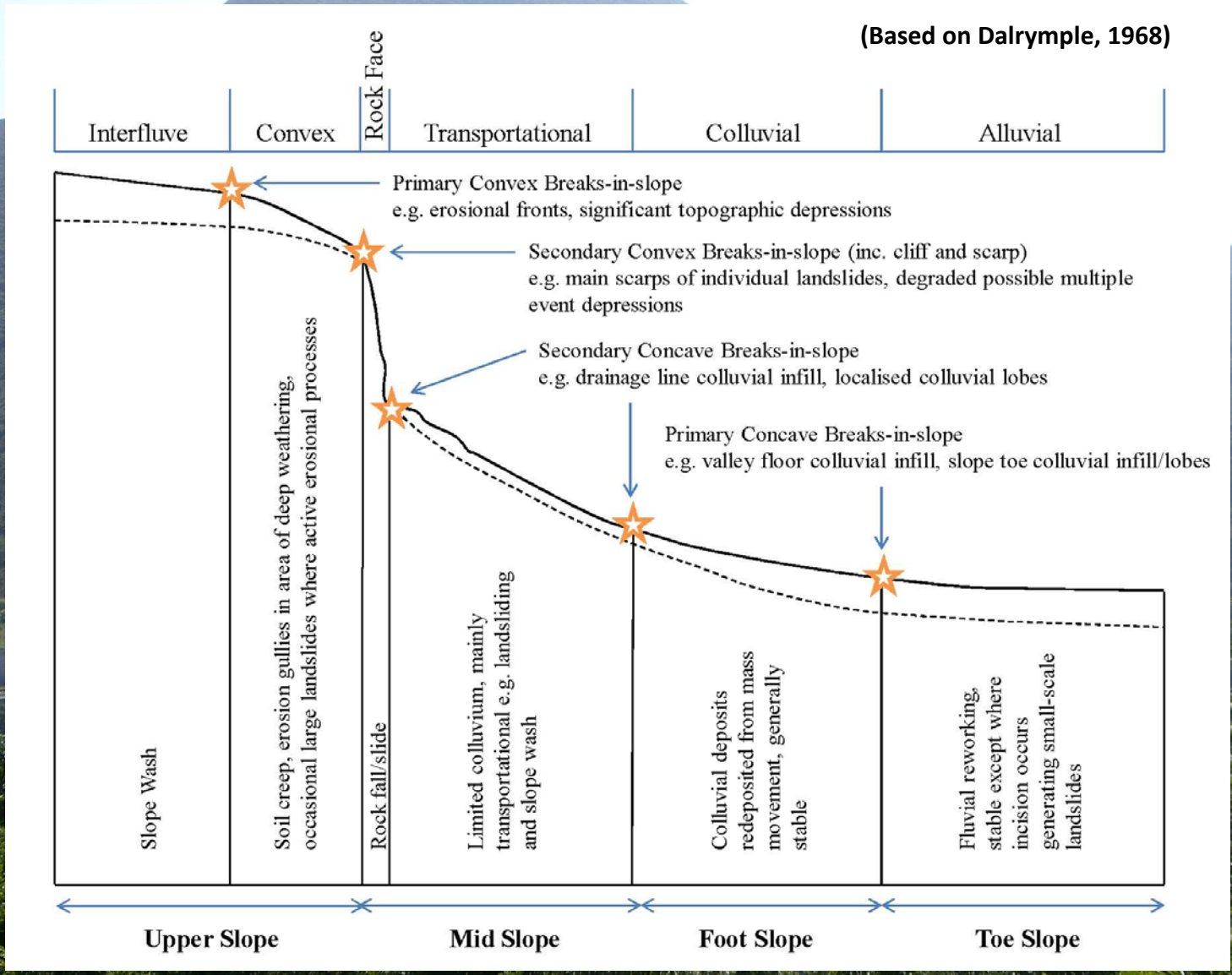
Morphological Mapping

(Based on Dalrymple, 1968)



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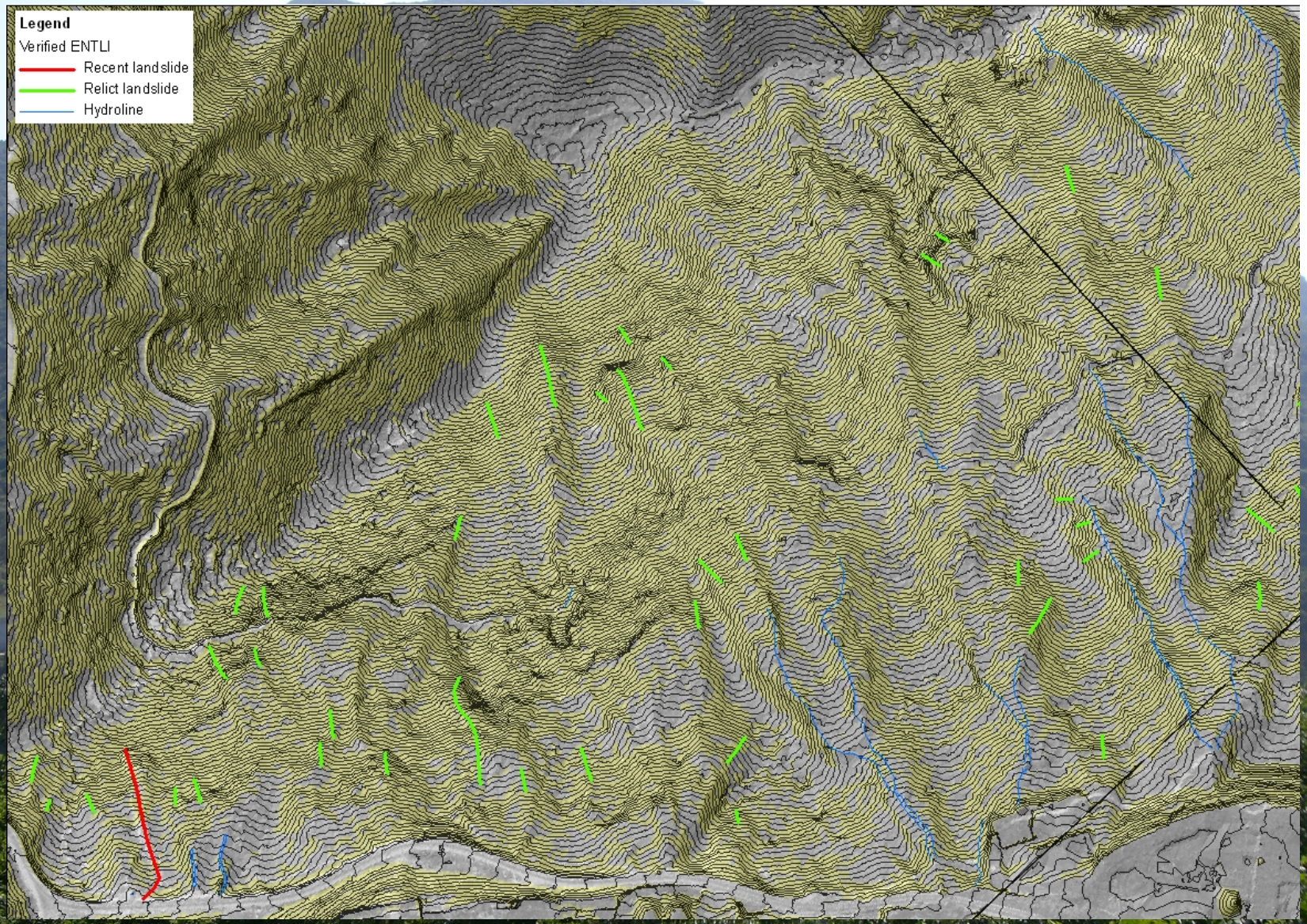
Morphological Mapping

Orthophoto mosaic superimposed by 1.5m LiDAR contours
Validated site-specific landslide inventory



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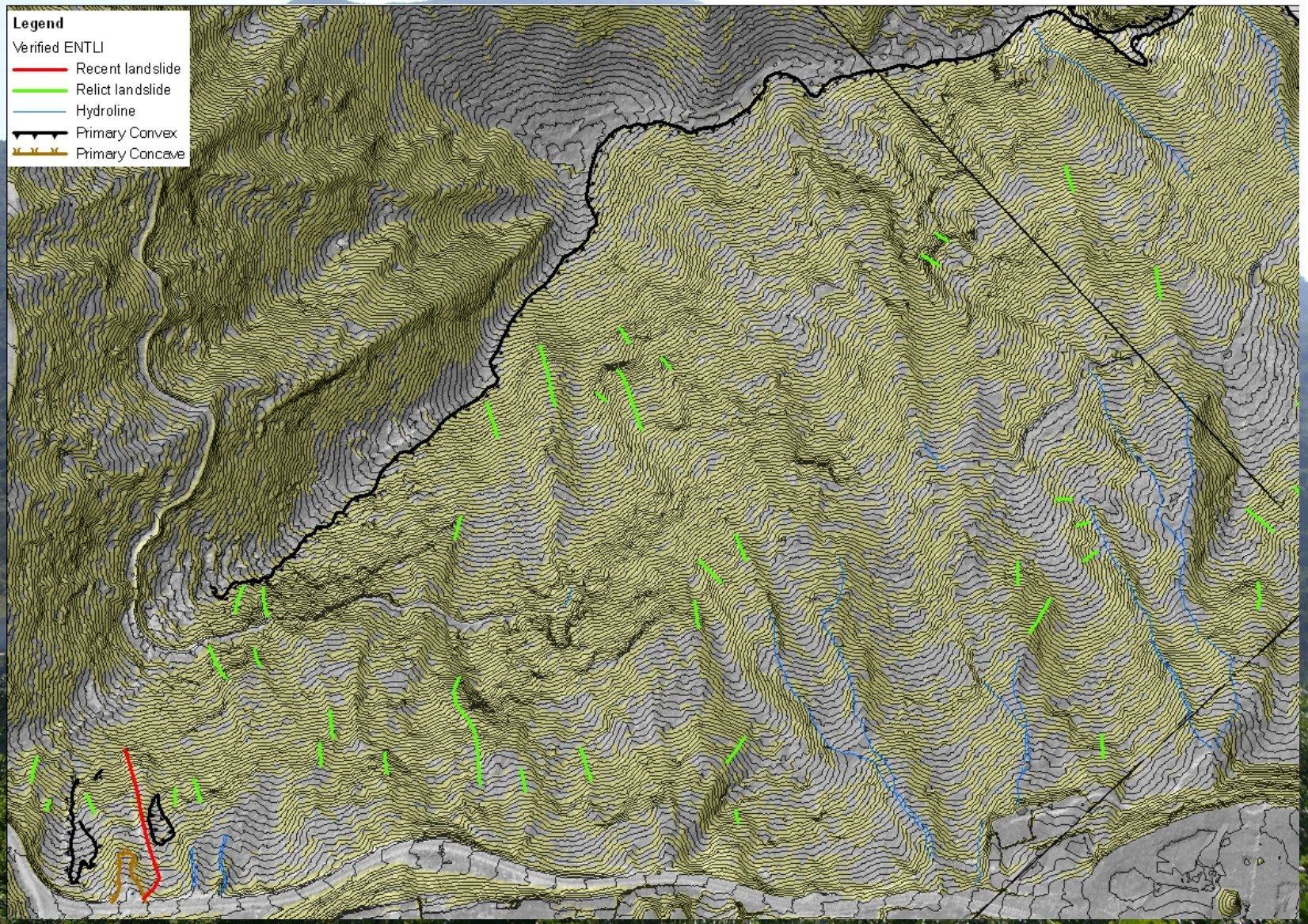
Morphological Mapping

Primary Concave and Convex Delineated



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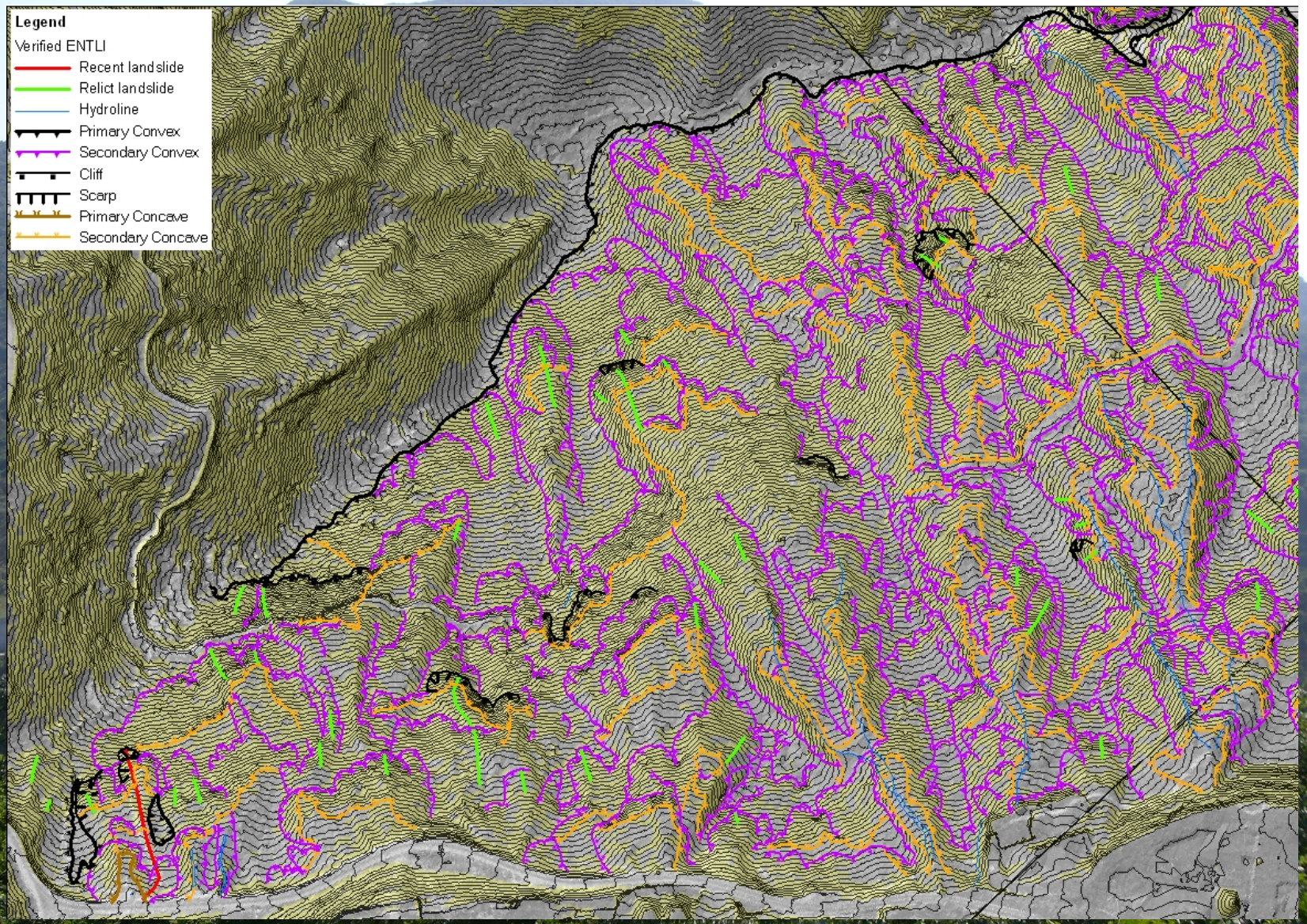
Morphological Mapping

Secondary Concave and Convex Delineated



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Morphographical Mapping

Interpretation of surface materials (i.e. regolith)
Indicative of potential landslide initiation, volumes and debris entrainment potential.

Classes chosen included:
Co - Unconfined colluvium (e.g. open hillslope colluvium)
Cc - Confined colluvium (e.g. drainage line infill colluvium)
Cd - Distal Colluvium (e.g. low angle valley floor infills, fans)
Ct - Talus/Talluvium
S - Saprolite (suffix denotes solid geology e.g. Sg)
R - Rock outcrop (e.g. Rg)
Ri - Intermittent outcrop (e.g. Rig)
Q - Alluvium

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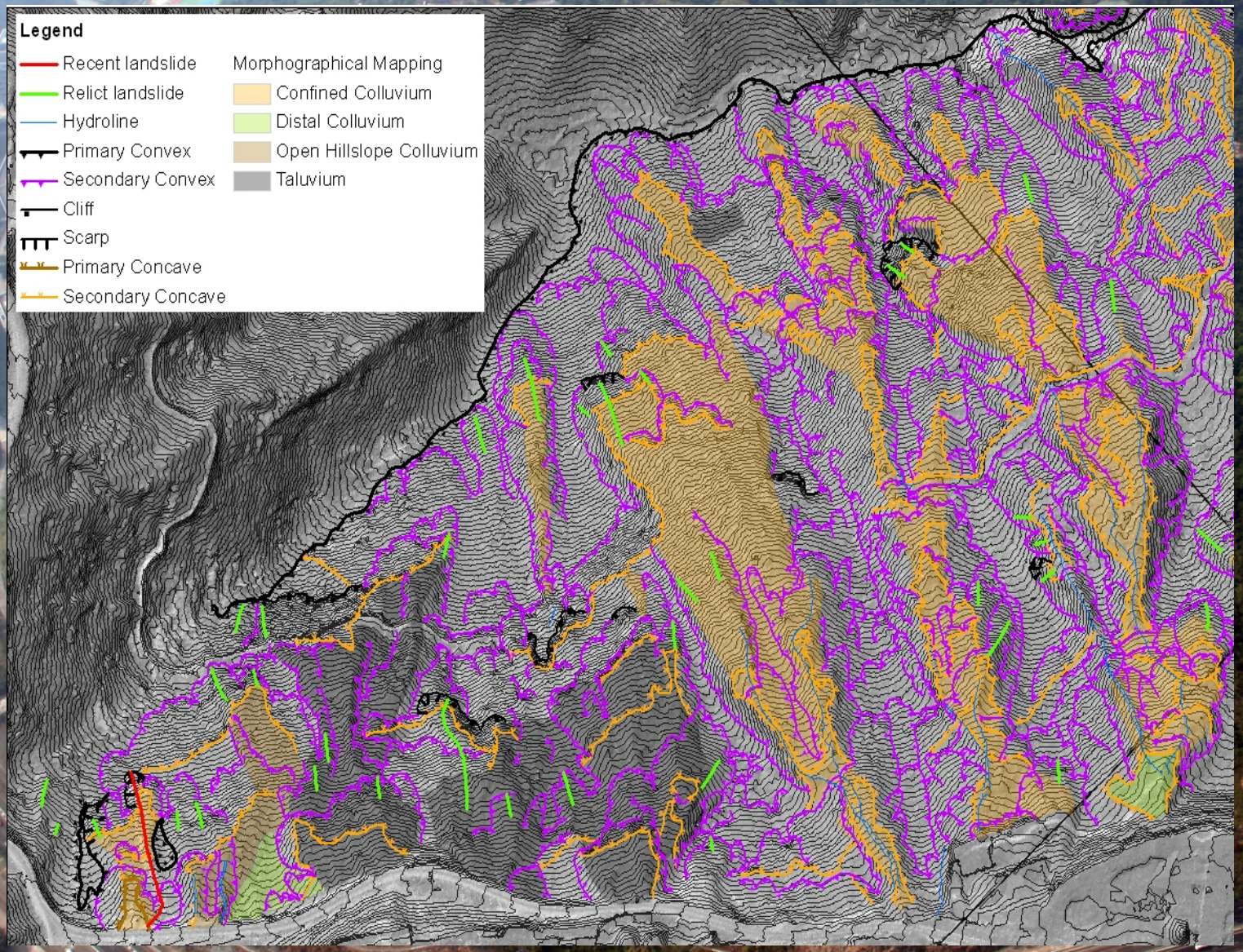
Morphographical Mapping

Confined, distal, OH Colluvium and talluvium



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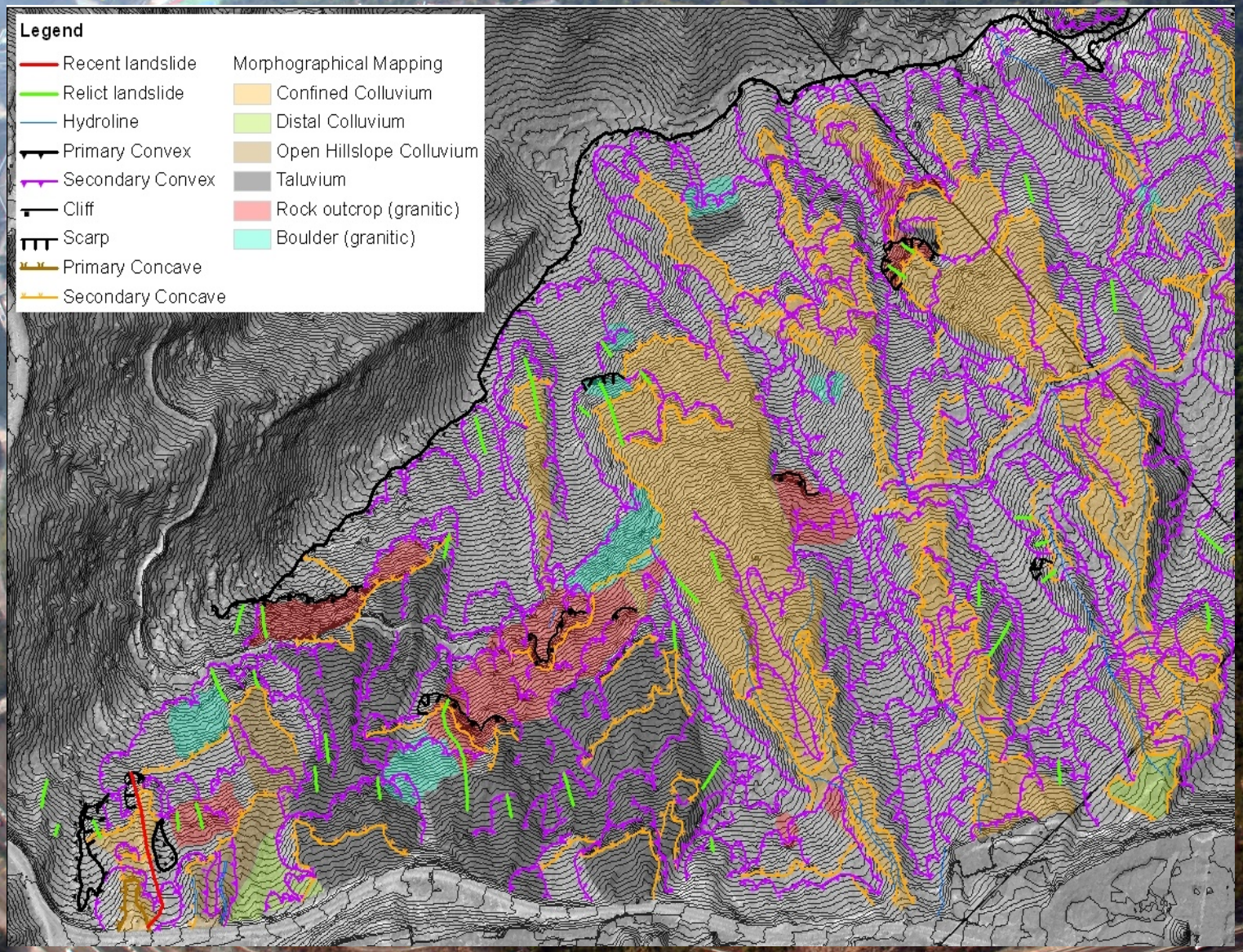
Morphographical Mapping

Rock outcrop and Boulders



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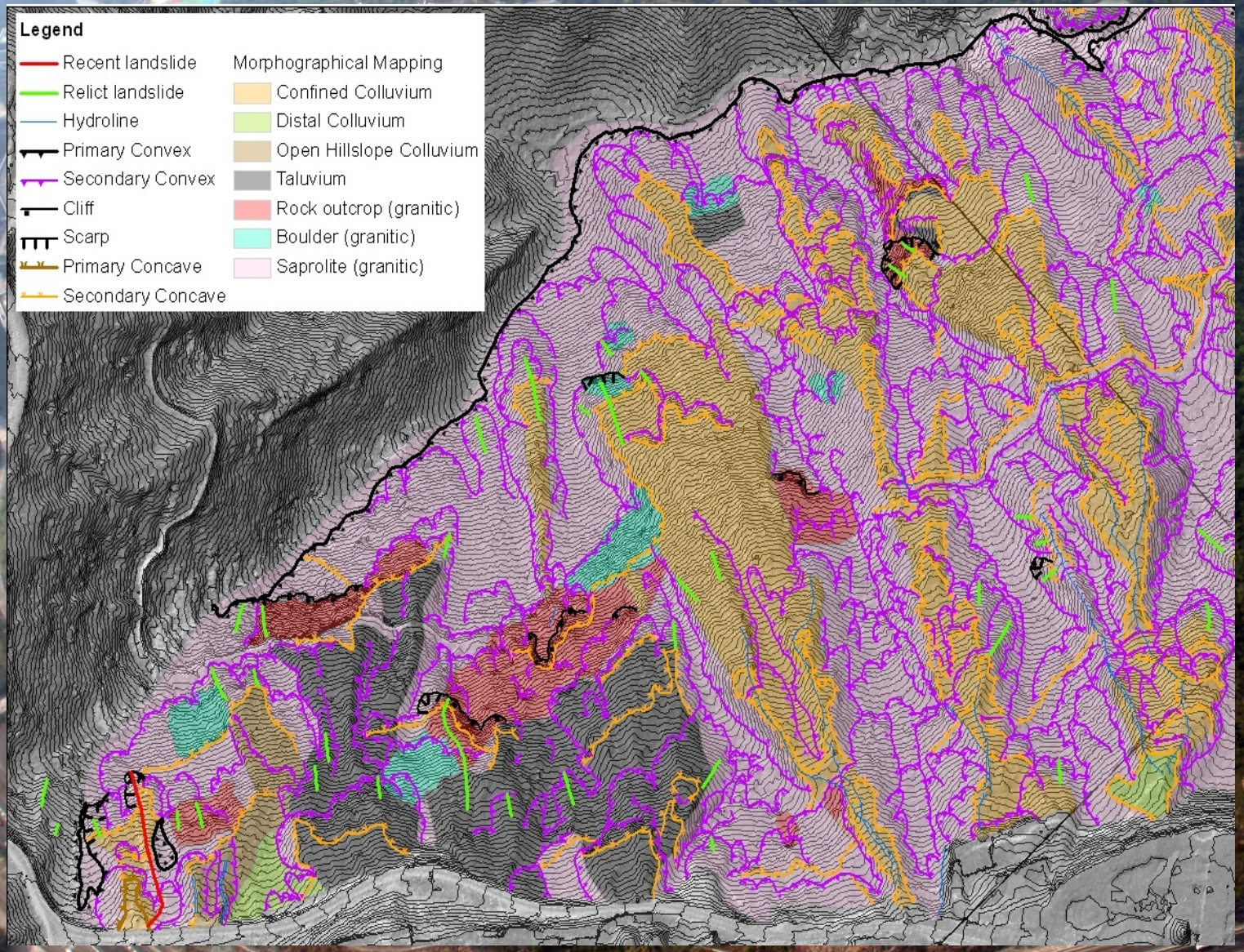
Morphographical Mapping

Saprolite



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Morphogenetic Mapping

Identification of geomorphological processes, e.g. fluvial, mass movement and erosional.

Used to interpret:
Landform evolutionary processes, such as:

- Active regressive erosion fronts/landslide scars
- Deep-seated/progressive landslides
- Depositional/accumulation area
- Erosional gullies/drainage lines
- Stream downcutting
- Coastal erosion

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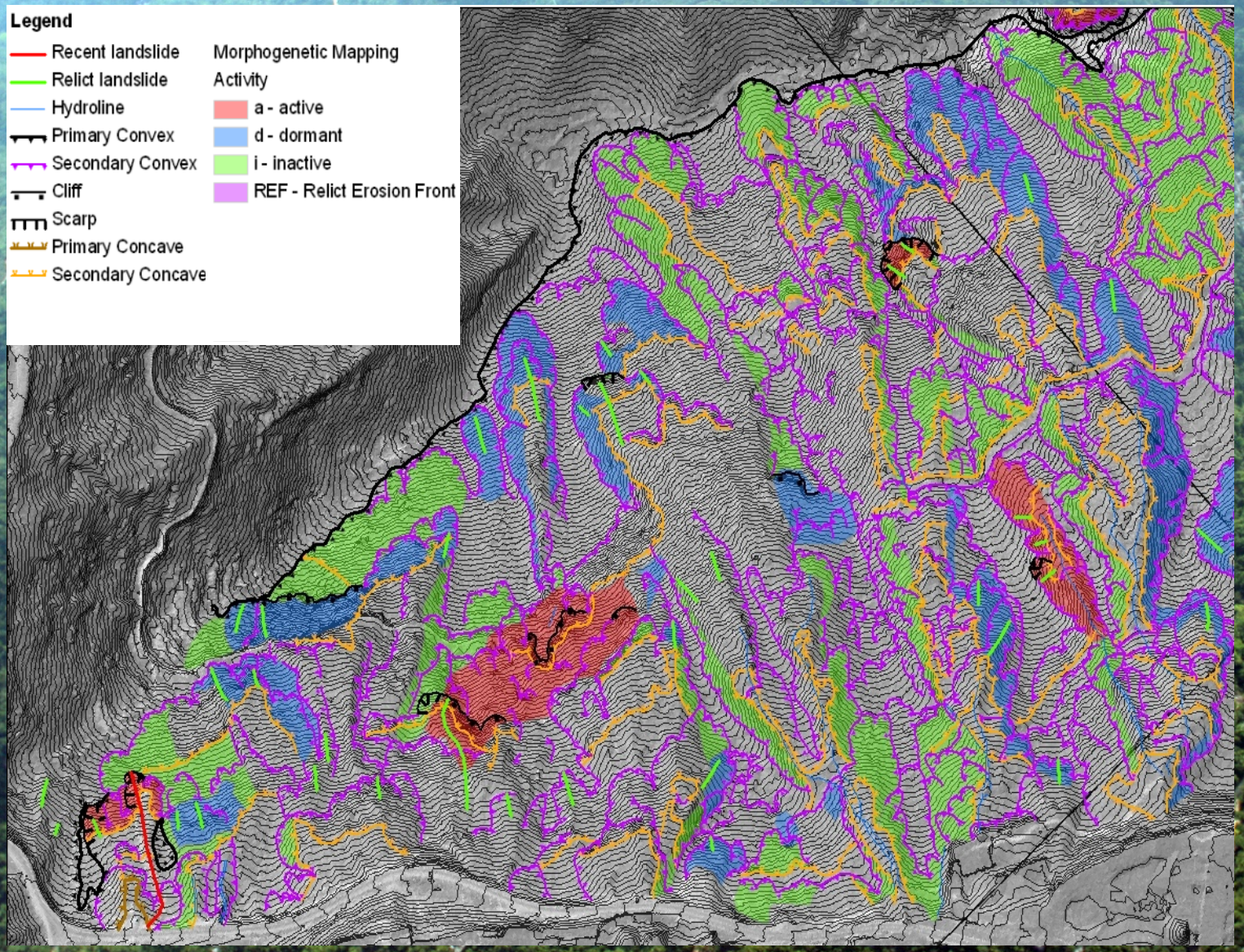
Morphogenetic Mapping

Source Area (Activity)



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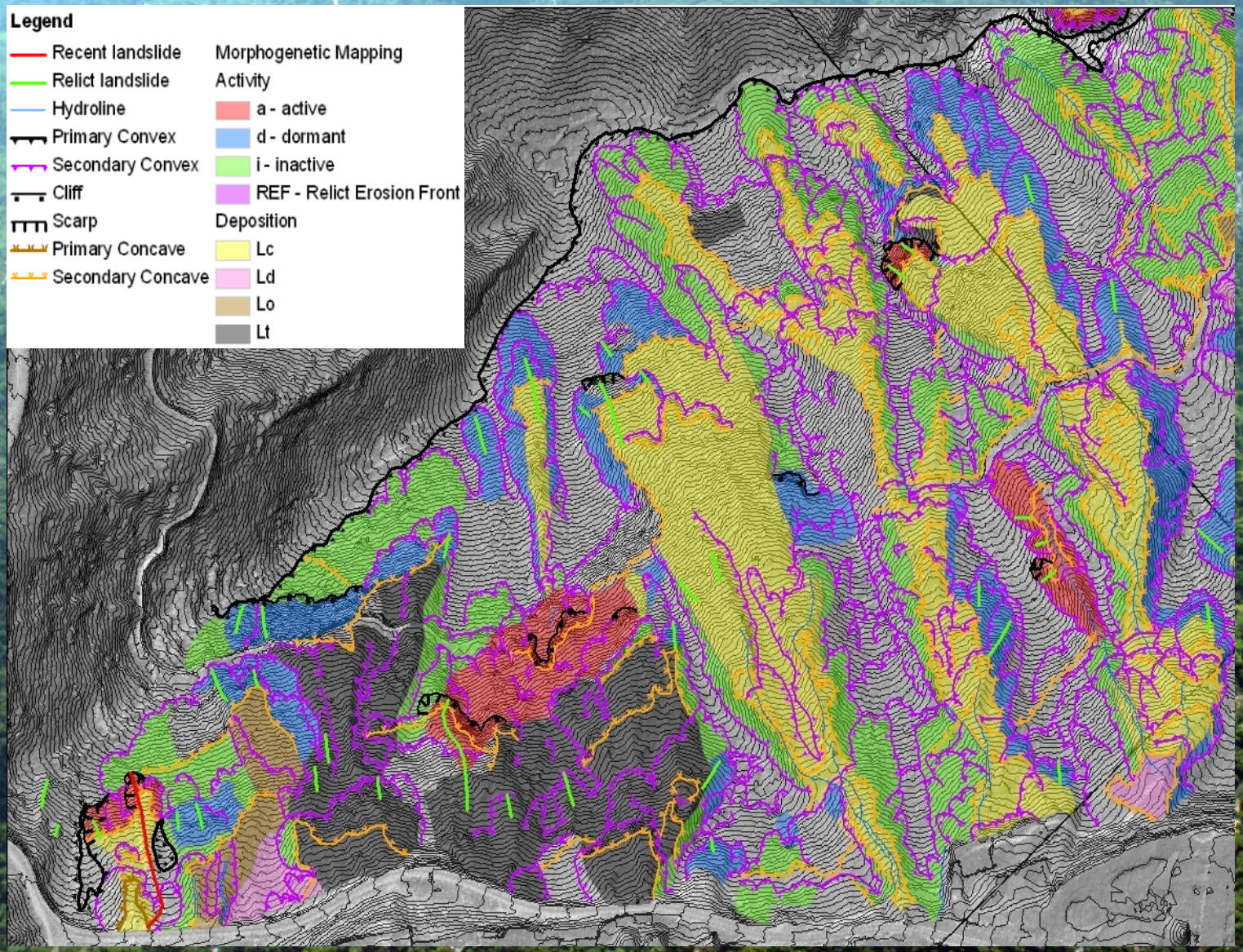
Morphogenetic Mapping

Deposition



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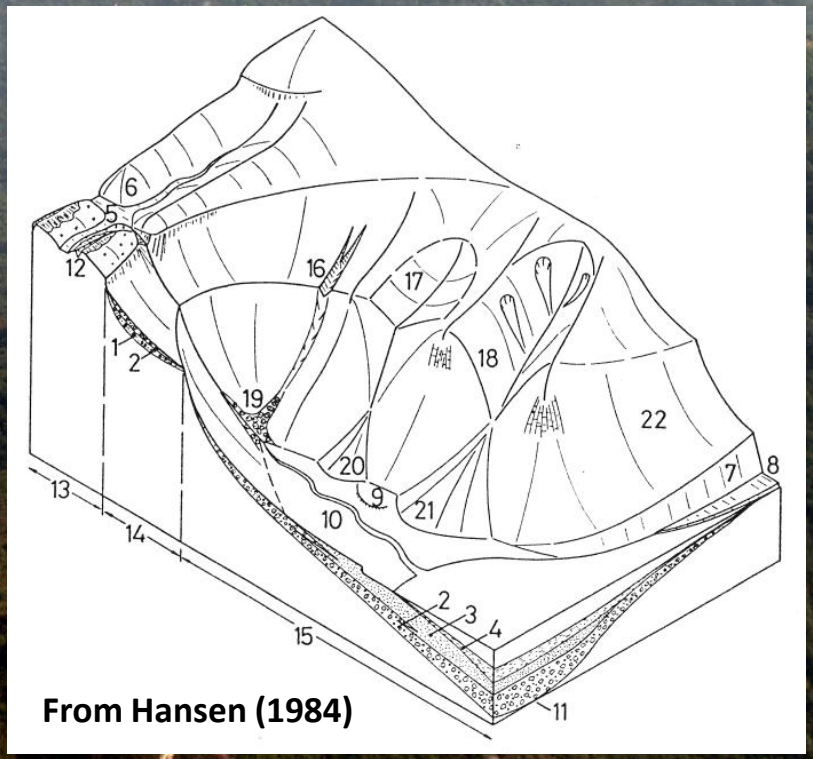
Morphochronological Mapping

Based on superposition of geomorphological feature boundaries, especially at significant breaks in slope.

Delineates morphological changes interpreted to represent boundaries between landforms of differing ages.



From Hansen (1984)

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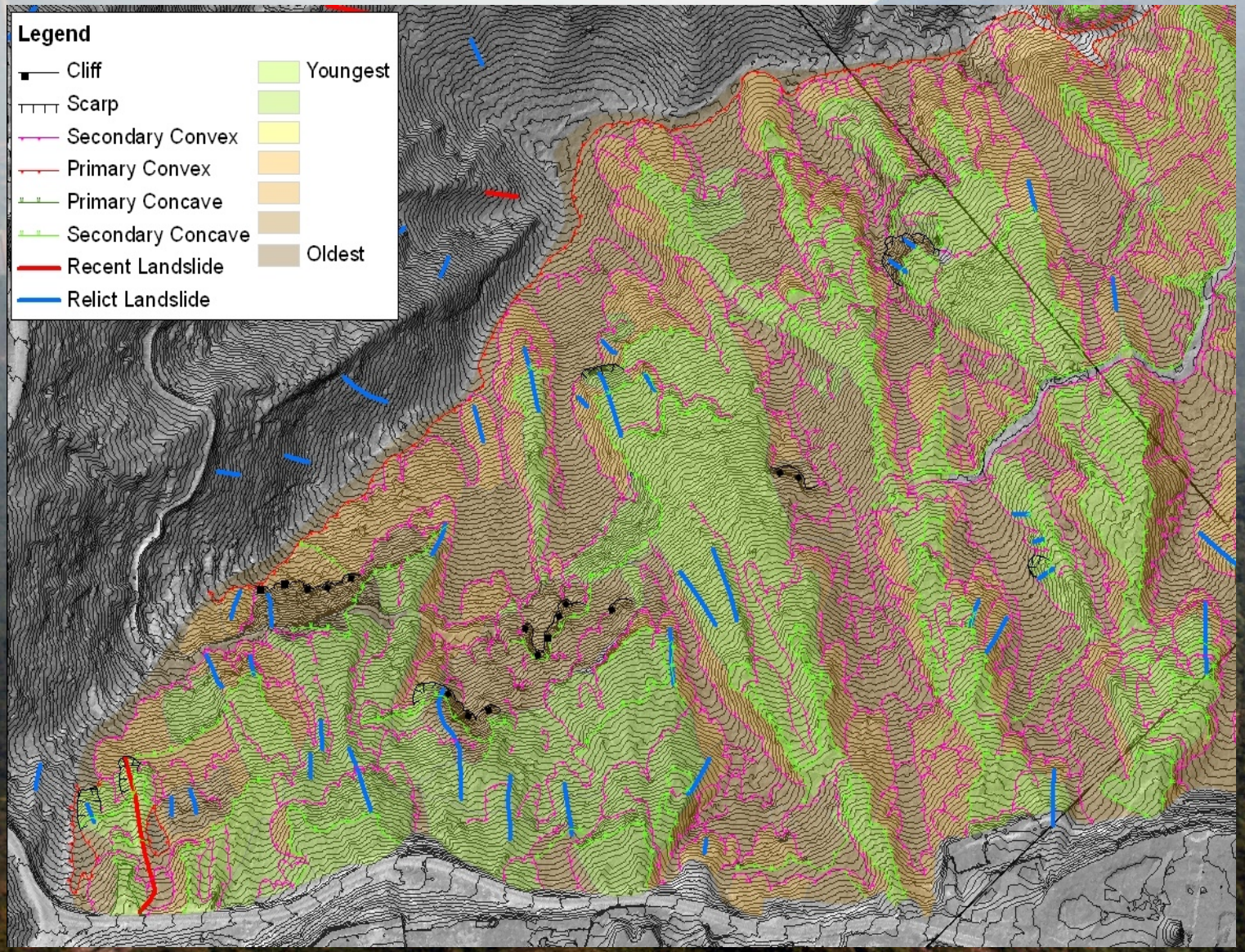
Morphochronological Mapping

Age Relationship



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Approach to Hazard Mapping

EGM characteristics considered when evaluating landslide hazard:

Initiation: potential source area location, magnitude (volume) and likelihood of occurrence (activity).

Mobility: geomorphological setting, drainage line characteristics, including entrainment potential.

Assumption:

Hazards are likely to occur in the future because of similar conditions and processes that produced them in the past.

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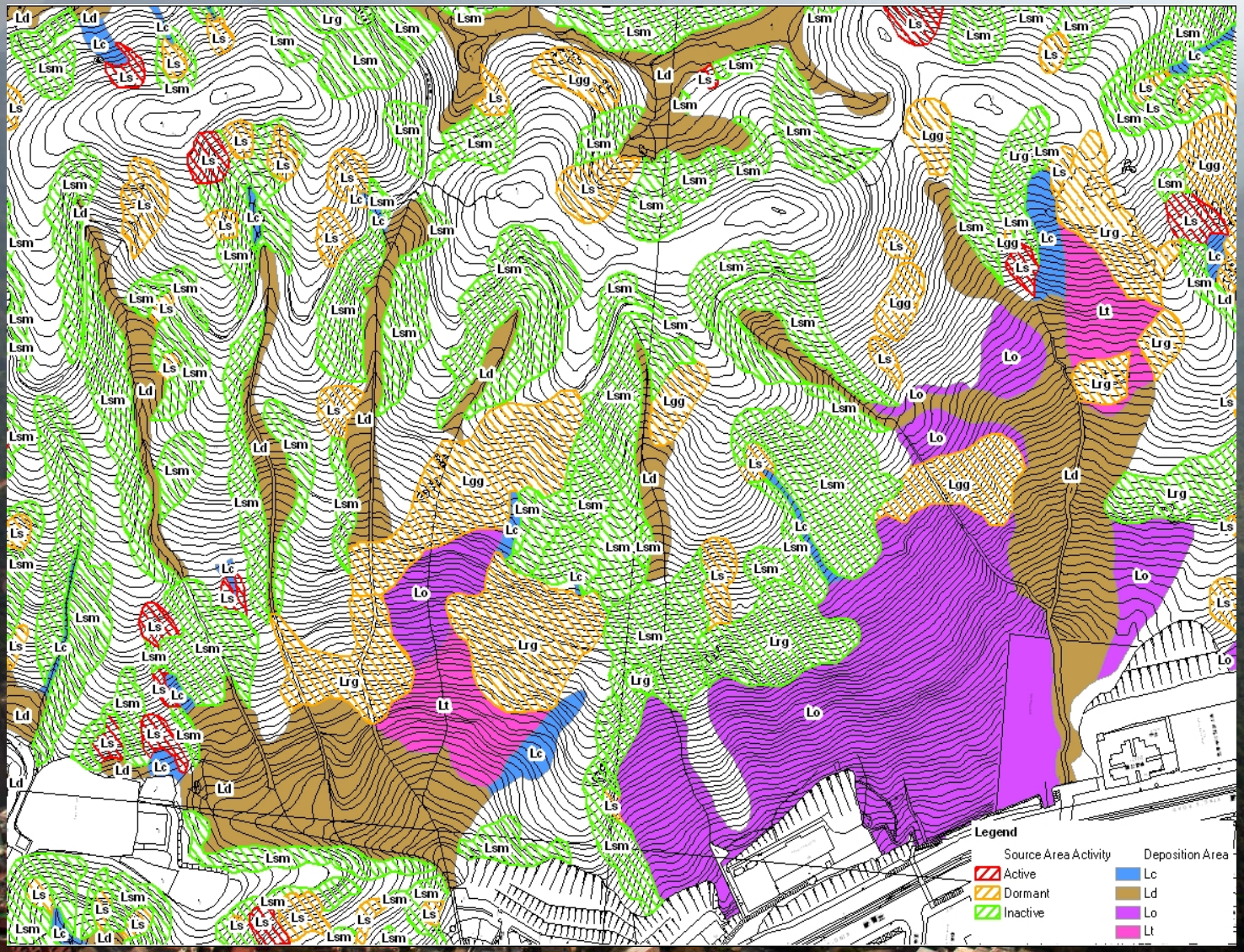
Terrain Units



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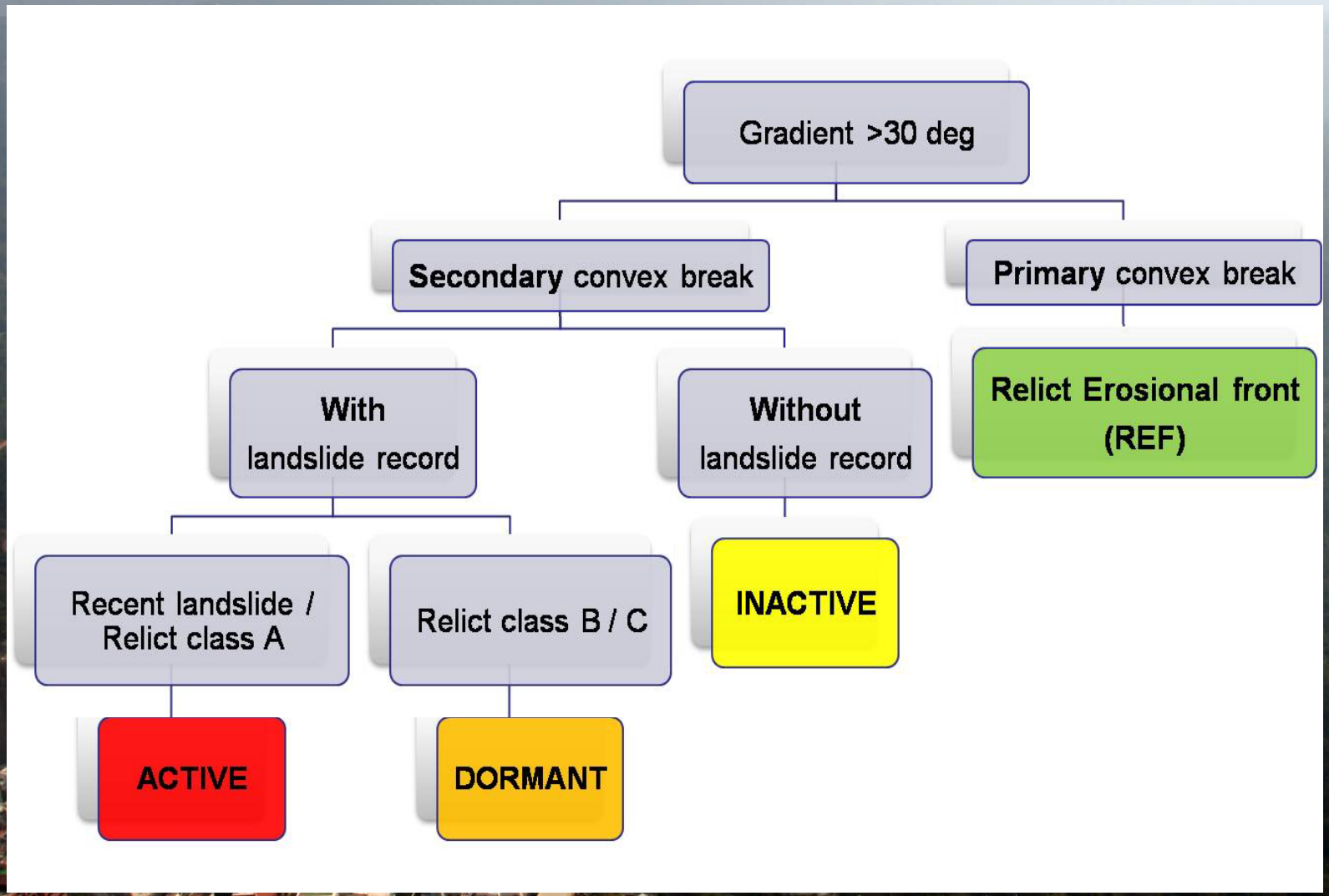
Activity



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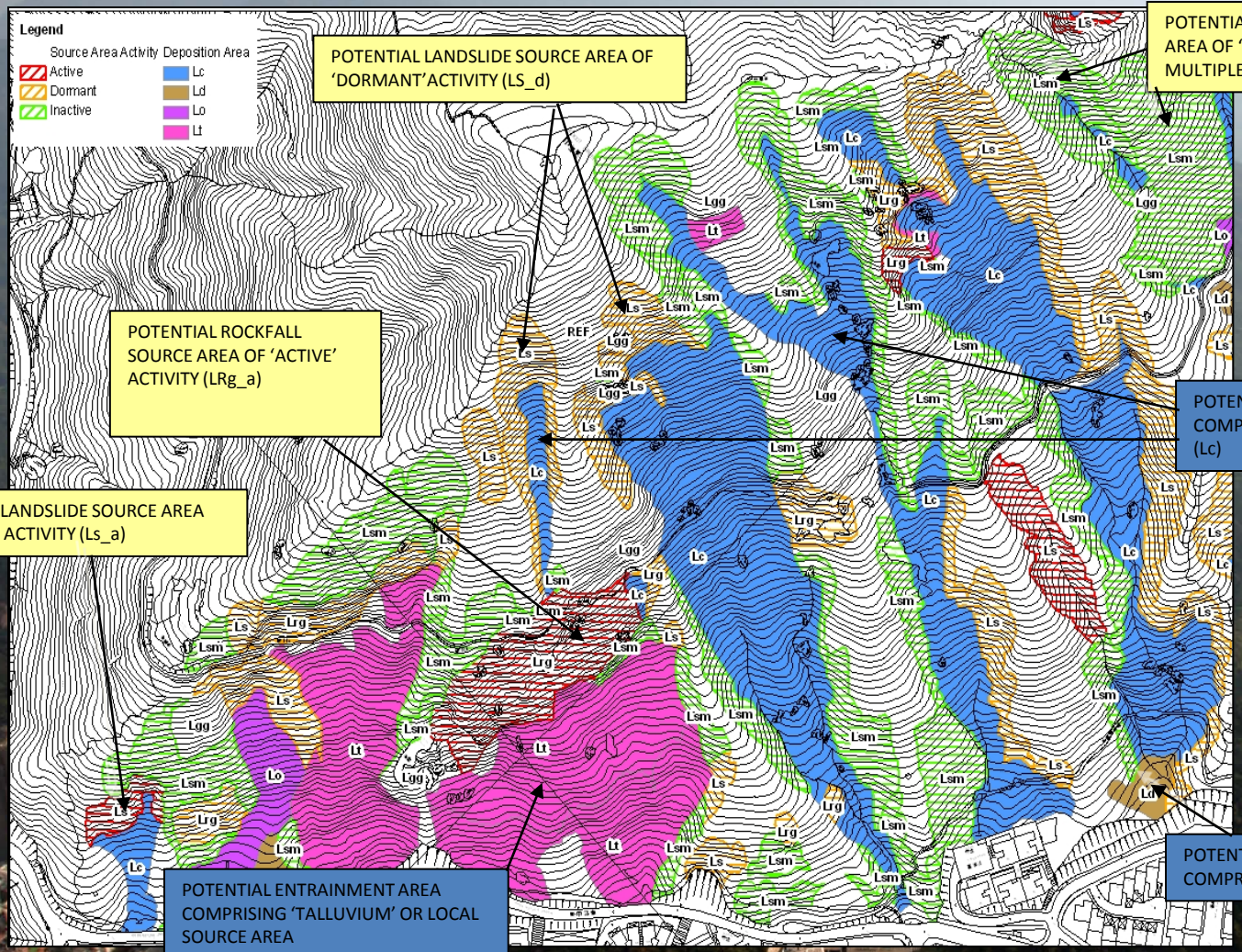
Delineation of process-based Terrain Units



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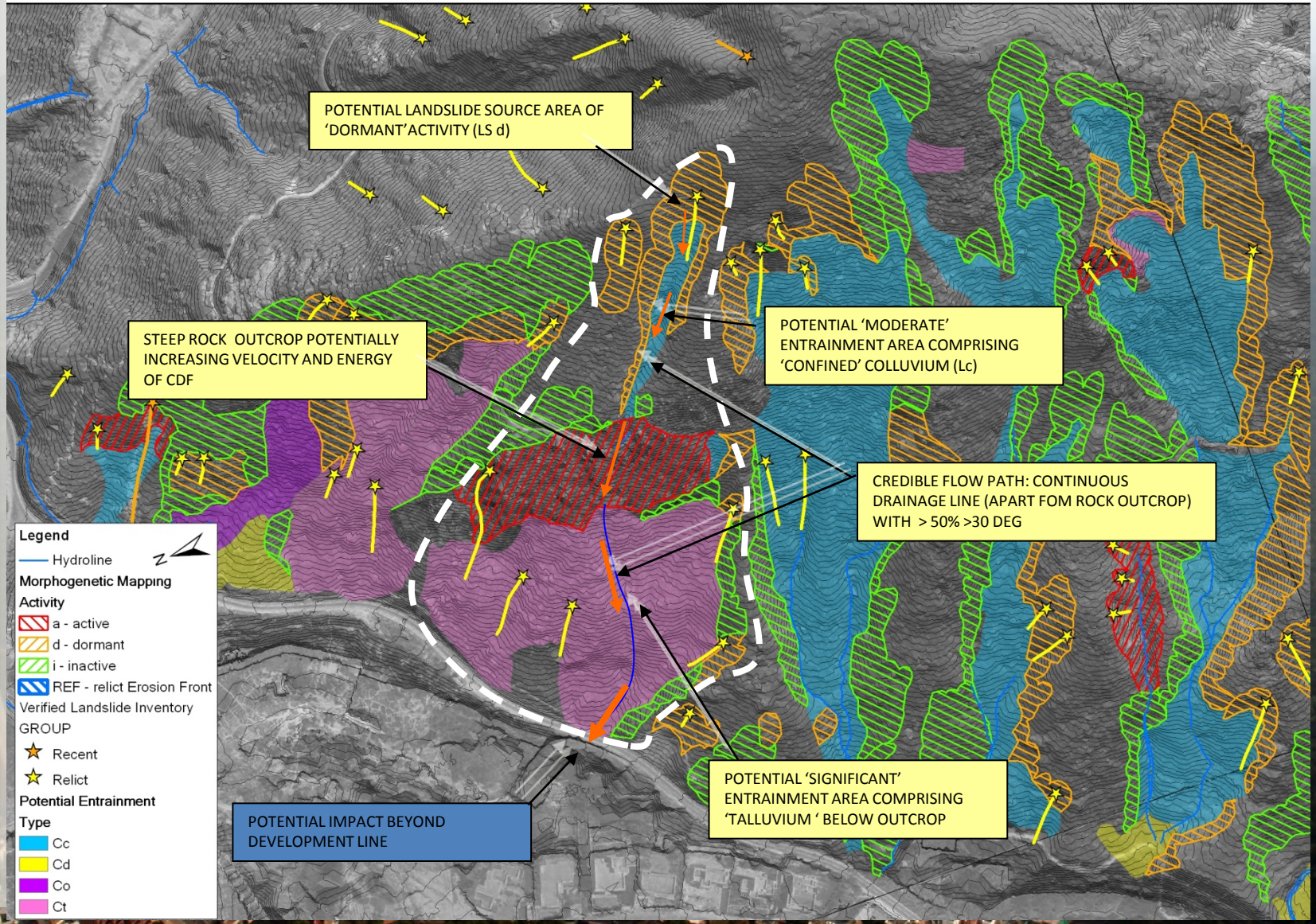
Example Hazard Model



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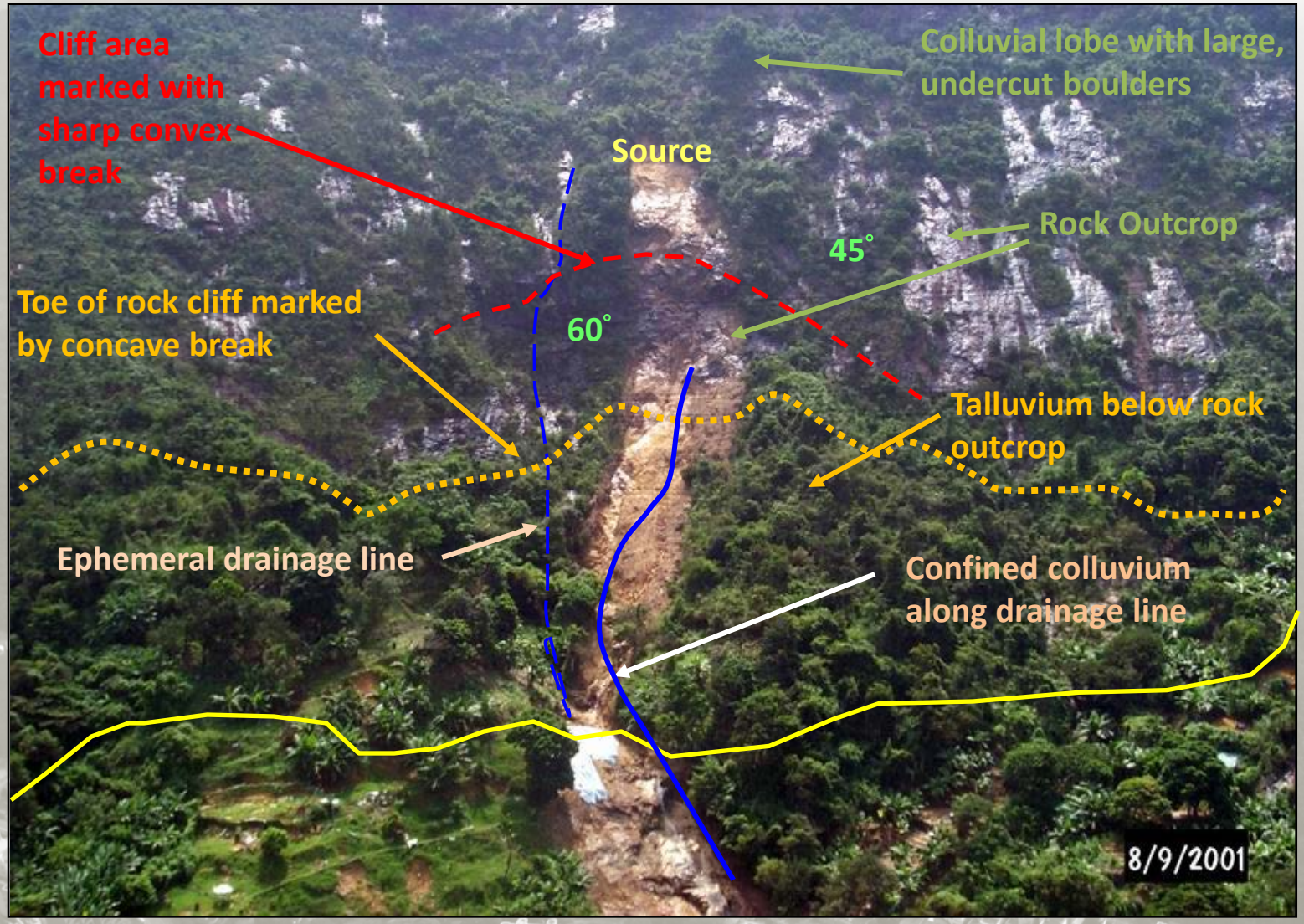
Channelised Debris Flow Hazard Model

Lei Pui Street (2001) – 200m^3 initial – 700m^3 eventual



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Conclusion

- One of the first assignments to use LiDAR and detailed API for geomorphological mapping.

- An approach to landslide hazard assessment was developed using mapped geomorphological characteristics.

- Areas with similar characteristics (terrain units) were delineated to assess landslide hazard.

- Combinations of terrain units were used to define specific hazard models (e.g. large magnitude/low-frequency).

- Approach has been applied to subsequent LIC, LPMit and other NTHS studies.

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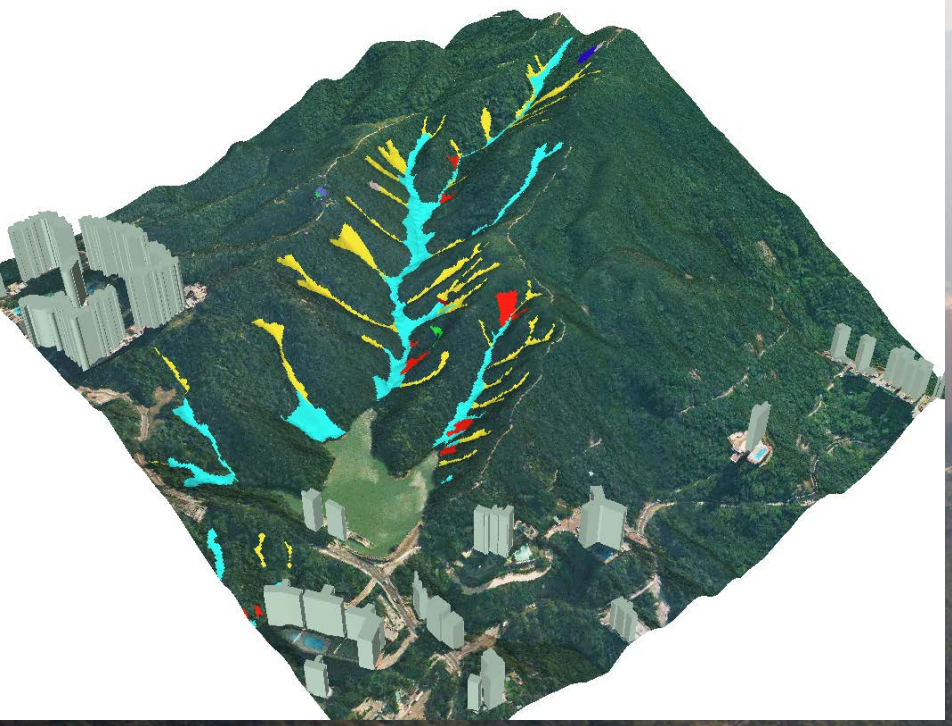

Thank You!