GEO Technical Guidance Note No. 22 (TGN 22) Guidelines on Geomorphological Mapping for Natural Terrain Hazard Studies

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1. SCOPE

1.1 This Technical Guidance Note (TGN) presents guidelines on geomorphological mapping for natural terrain hazard studies. This TGN is intended to supplement the guidance given in the GEO Report 138 "Guidelines on Natural Terrain Hazard Studies", with reference to some recent natural terrain hazard studies where varying types of geomorphological mapping have been used.

1.2 Any feedback on this TGN should be directed to Chief Geotechnical Engineer/Planning of the GEO.

2. TECHNICAL POLICY

2.1 The technical recommendations promulgated in this TGN were agreed by the GEO's Geotechnical Control Conference (GCC) in December 2004.

3. RELATED DOCUMENTS

3.1 Anon (1982). Land surface evaluation for engineering practice. *Quarterly Journal of Engineering Geology*, vol. 15, pp 265-316.

3.2 Brunsden, D., Doornkamp, J.C. & Jones, D.K.C. (1978). Applied Geomorphology: a British View. In: Embleton, C., Brunsden, D. & Jones D.K.C. (Eds.), *Geomorphology: Present Problems and Future Prospects*. Oxford University Press, Oxford, pp 251-262.

3.3 Halcrow China Ltd. (2003). *Detailed Study of Selected Natural Terrain Landslides at Cloudy Hill*. Landslide Study Report LSR 6/2003, Geotechnical Engineering Office, Civil Engineering Department, Hong Kong.

3.4 Hansen, A. (1984). Engineering geomorphology: the application of an evolutionary model to Hong Kong's terrain. *Zeitschrift fur Geomorphologie*, N F Supplementband, vol. 51, pp 9-50.

3.5 Hearn, G.J. (2002). Engineering geomorphology for road design in unstable mountainous areas: lessons learnt after 25 years in Nepal. *Quarterly Journal of Engineering Geology and Hydrogeology*, vol. 35, Part 2, pp 143-154.

3.6 Ng, K.C., Parry, S., King, J.P., Franks, C.A.M.F. and Shaw, R. (2003). *Guidelines for Natural Terrain Hazard Studies*. GEO Report No. 138, Geotechnical Engineering Office, Civil Engineering Department, Hong Kong.

3.7 Maunsell Fugro Joint Venture (MFJV). (2002). *Pilot Study Regolith Guide, Rock Guide and Field Mapping Proformas*. Agreement No. CE 47/2000, Natural Terrain

Hazard Study for Tsing Shan Foothill Area. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong.

3.8 Sewell, R.J. and Campbell, S.D.G. (2004). *Report on Dating of Natural Terrain Landslides in Hong Kong*. Special Project Report SPR 1/2004, Geotechnical Engineering Office, Civil Engineering Department, Hong Kong.

3.9 Ove Arup & Partners Hong Kong Ltd. (2004). *Natural Terrain Hazard Study at North Lantau Expressway - Final Report*. Agreement No. CE 89/2002, Natural Terrain Hazard Studies at North Lantau Expressway and Luk Keng Village – Feasibility Study, Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

4. BACKGROUND

4.1 The study of natural terrain hazards involves consideration of the site in the context of its regional geological and geomorphological settings, any man-made influences that may have modified this setting, and the history of landsliding in the area (Ng et al., 2003). Geomorphological maps are therefore a fundamental part of natural terrain hazard studies. By placing the site and its surroundings in a framework that integrates form, materials and process, the geomorphological map helps the practitioner assess the influence of such factors as lithology, structure, materials and processes on past landform development, and hence facilitate the analysis of future behaviour.

4.2 Geomorphological and engineering geological maps are complementary to each other and natural terrain hazard assessments require a combination of both approaches in order to assess the nature, magnitude and frequency of the various hazard types. Some practitioners consider that while engineering geological mapping is concerned with the properties of materials and their immediate or short-term engineering implication, geomorphological mapping takes in a greater sweep of time, combining the recent geological past with the present geomorphology and its foreseeable future (Hearn, 2002). Integration of the two approaches combines the short-term static with the longer dynamism of the landscape (Hearn, 2002) allowing the development of a comprehensive geological model with respect to natural terrain hazards.

4.3 Details with respect to engineering geological mapping for natural terrain hazard studies are contained in Ng et al. (2003). However, this document does not provide a detailed methodology on geomorphological mapping.

5. DEFINITIONS

5.1 <u>Geomorphology</u> can be defined as “the study of the forms of the surface of the earth, their origins, the processes involved in their development, the properties of the materials which they are made of and predictions about their future form, behaviour and status” (Brunsden et al., 1978).

5.2 Regolith for the purpose of this document is defined as the superficial layer of loose, unlithified material which overlies rockhead, e.g. saprolite, colluvium, alluvium, etc. Areas of rock outcrop, although not regolith as defined, should also be included in regolith maps for completeness.

5.3 Geomorphological mapping can be broadly divided into morphological (shape), morphographical (type), morphogenetic (origin) and morphochronological (age) components (Anon, 1982).

(a) Morphological mapping: The detailed shape of the land surface, e.g. convex, concave slope form, is recorded without attempting to interpret the individual features. For natural terrain hazard studies, the level of detail should be sufficient in demarcating individual land surface features.

(b) Morphographical mapping: Land surface features are identified with a specific name, e.g. valley floor and foot slope, and are depicted at the correct shape and scale. Morphographical maps identify the landform type and therefore indirectly depositional/erosional processes (e.g. valley colluvium and talus) taking place.

(c) Morphogenetic mapping: Land surface features are depicted in terms of their origin and development, i.e. process related, e.g. debris fan. Morphogenetic maps normally include information on the processes currently fashioning the landscape, e.g. actively eroding drainage lines, river undercutting, etc.

(d) Morphochronological mapping: Land surface features are mapped according to their relative age of occurrence.

6. TECHNICAL RECOMMENDATIONS

6.1 The main technique for the production of geomorphological maps in Hong Kong is a detailed aerial photograph interpretation, with an appropriate level of field verification. Different approaches to geomorphological mapping in respect of different terrain settings have been successfully used in some recent natural terrain hazard studies.

6.2 Morphological mapping is the most applicable form of geomorphological mapping to natural terrain hazard studies in Hong Kong. It has been applied to various natural terrain sites in Hong Kong regardless of lithology, elevation and geomorphological history. It can help identify landslide susceptible areas, types of landslide hazard and possible extent of debris run-out. To maximise its benefit it is best used together with morphographical or morphogenetic mapping. Particular attention should be made to identify breaks in slope associated with active or potential erosion. An example of this is shown in Figure 1 where a major break in slope was associated with ongoing erosion, including landsliding (Halcrow, 2003).

6.3 Morphographical mapping has mainly been used in Hong Kong in terms of regolith mapping. Regolith mapping has been most successful where there are lithological variations and significant elevation differences within the study area, resulting in a range of processes and hence regolith types. This approach for regolith mapping was used at the Tsing Shan foothills natural terrain hazard study using stereo coverage aerial photographs validated with an appropriate level of field checking. A regolith guide (available on <http://hkss.cedd.gov.hk>) was produced for the Tsing Shan foothills (MFJV, 2002), where the regolith units were based on a combination of topographical position, morphology, material type, vegetation cover and relative age. Figure 2 shows an example from the guide for the regolith unit “Rock Fall Debris” (Talus) and Figure 3 shows regolith units overlain on an oblique aerial photograph. Morphographical mapping should be used in conjunction with morphological mapping for maximum benefit.

6.4 Morphogenetic mapping is of most use where the landscape has been affected by different erosion and deposition processes, e.g. active regression of a drainage line, river undercutting, etc. This approach was used in the North Lantau and Luk Keng natural terrain hazard studies. The advantage of this approach is that it can be applied early on in an assessment as a reconnaissance tool to help focus the investigation. Figure 4 shows the reconnaissance morphogenetic map for North Lantau (Ove Arup, 2004). As with morphographical mapping, this approach is best used in combination with morphological mapping.

6.5 Morphochronological mapping is useful if a relative age relationship of landforms is discernible through aerial photograph interpretation. This approach is currently limited in its application given difficulties in determining absolute ages of various surface features. Improvements in dating techniques (Sewell and Campbell, 2004) may facilitate further development of this approach. However, the use of relative ages of land surface features such as Hansen’s (1984) broad two-component landscape representing relative ages has been useful for some studies (e.g. Halcrow, 2003).

6.6 While a single approach could be used, a combination of approaches to geomorphological mapping is usually more beneficial when assessing natural terrain hazards and these combinations will vary depending upon the lithology, elevation variation, size of study area and geomorphological history.

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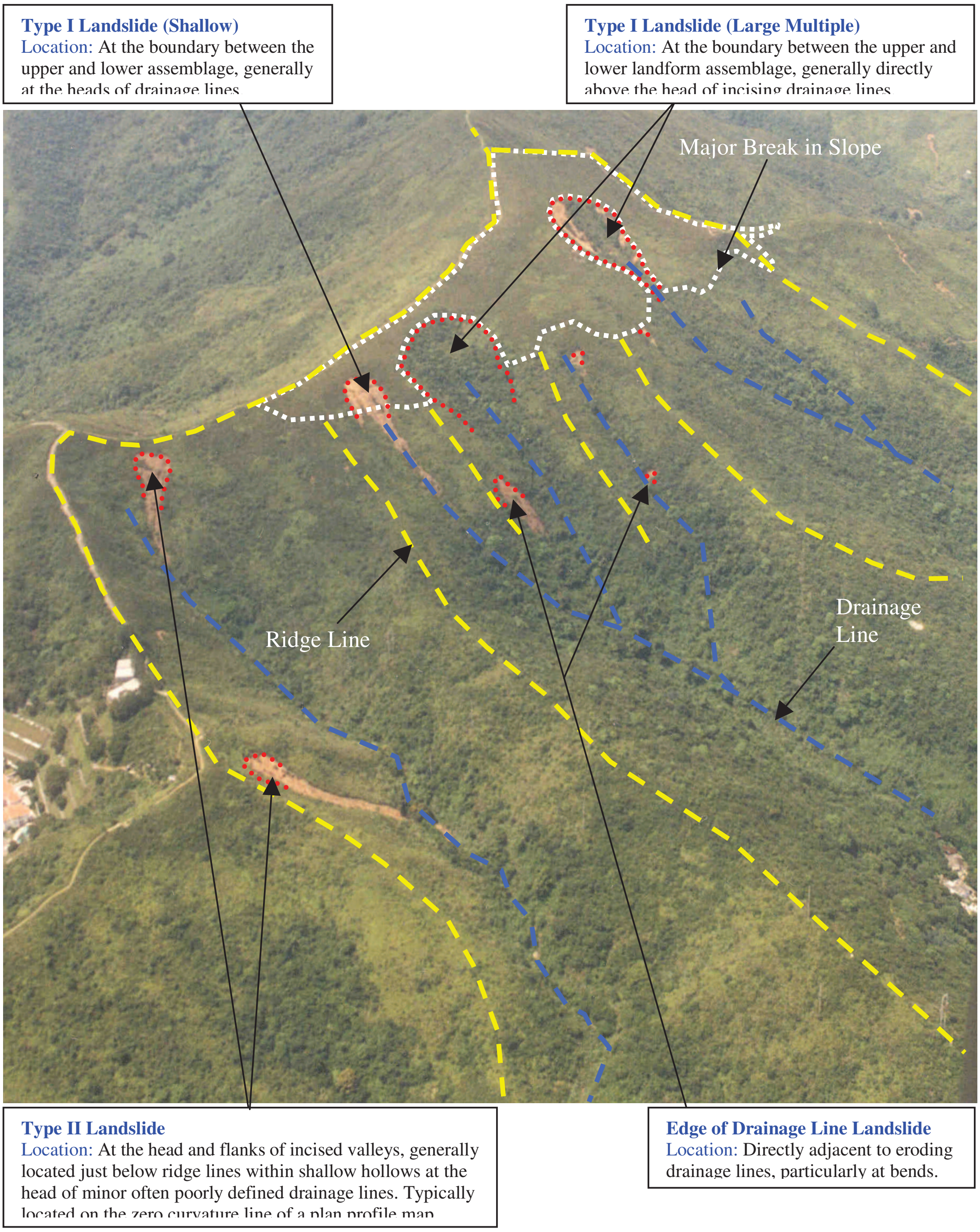
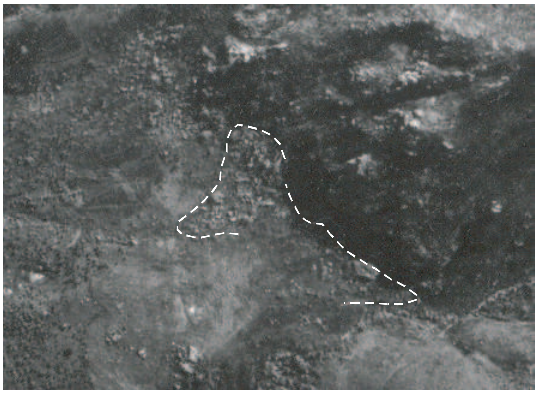


Figure 1 - Major Break in Slope Associated with Landsliding (Halcrow, 2003)



1963 Aerial Photograph

2000 Aerial Photograph

Oblique Aerial Photograph

Regolith Type	Crf (Rock Fall Debris - Talus)
General description	Forms below rock slopes/escarpments either as a result of individual rock block failures or rock avalanches. The size of the rock blocks generally depends upon joint characteristics (e.g. spacing and orientation).
Topographical position	**Must occur down-slope of rock outcrops.** Commonly can form on planar (unconfined) slopes. Rock fall deposits can commonly be confined by topographic depressions e.g. gullies/ ephemeral drainage lines.
Morphology	Concave break in slope usually occurs at the toe of the deposit. Can commonly be fan-shaped, becoming more linear on steeper slope angles. Can form a planar surface, which locally appears hummocky/irregular. Individual boulders commonly apparent. Occasionally incised/truncated by recent landslides or drainage lines.
Material Properties	**Must be clastic debris comprising angular boulders and cobbles with fine material either not present or present in minor amounts**. The size of the blocks is dependent upon both joint spacing and the degree of comminution the blocks suffer in transport.
Vegetation	Can be bare on steep slopes, but commonly vegetated by both ferns and grasses if topographically confined.
Relative Age	Relatively recent (Category A).
Aerial Photograph Characteristics	
1963	Appears as a hummocky/irregular surface with boulders commonly apparent.
2000	Commonly vegetated with tall grasses; larger boulders can be apparent protruding above the vegetation.

Figure 2 - An Example of Regolith Mapping Guide (MFJV, 2002)

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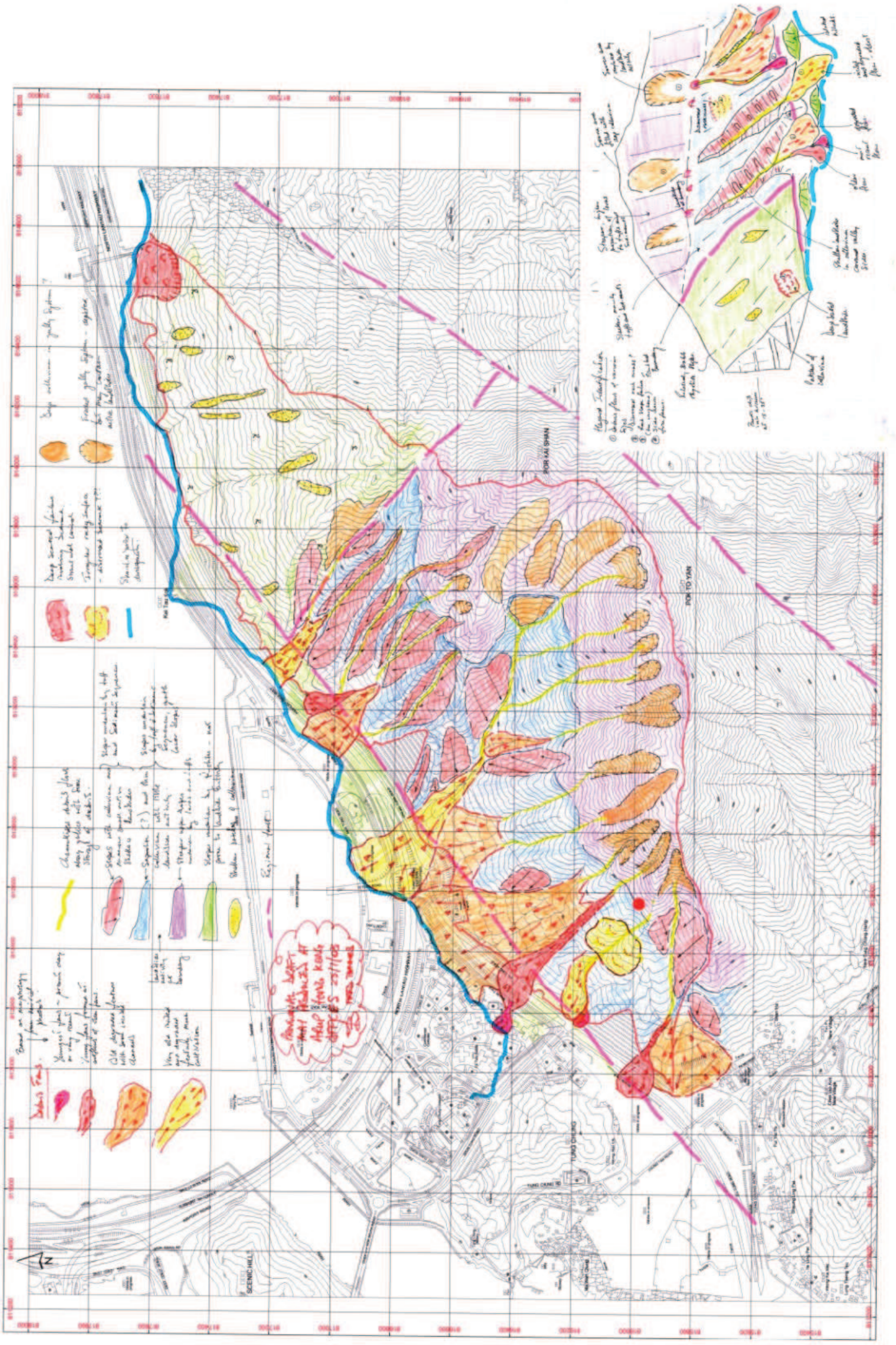
Figure 3 - Regolith Units Overlain on an Oblique Photograph (MFJV, 2002)



Prepared by Baynes Geologic

Figure 4 - Reconnaissance Morphogenetic Map for North Lantau (Ove Arup, 2004)