Part II
User's Guide to the Atlas and Glossary

II-1
Classification Basis of the Photogeologic Geounits

The logic underlying the classification of the geounits is essentially the same as that which supports other forms of geologic mapping. Varnes (1974) has stated

> "Four fundamental categories of attributes apply to (geologic) maps; these pertain to time, space, the inherent qualities or properties of real matter, and the relations of objects. Geologic units commonly are defined by combinations of these four kinds of attributes."

The typological individuals of the classification conform to these attributes and their nomenclature conforms to accepted geoscience usage.

II-2
Selection Criteria of the Geounits

The following criteria were used in selecting the specific geohazard related geounits from the general classification.

- That the typological individuals be detectable and recognizable in current operational civil satellite images and airphotos with a spatial resolution range of submetric to 1 km, subject to other factors conditioning observability (Sect. II-3.2).
- That the classification includes all the major terrestrial environments.
- That the units possess a compositional homogeneity with respect to a number of observable and inferred attributes.
- That the units be significant in broader engineering and environmental terms.

The approach chosen to document the type units has been to examine airphoto coverage and satellite images of *known lithologies and structures* located in the various terrestrial environments. Reproductions of representative photos and images studied were thus progressively incorporated in the data sets of the geounit files as the group of illustrations in support of their textual characterizations.

II-3
Characterization of the Classification

II-3.1
Purpose

Geological and geomorphological interpretation and mapping requires the use of a set of descriptor codes to designate geounits. The codes best consist of combinations

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of alpha-numeric symbols (Fulton 1993). The complete set of descriptors constitutes a terrain classification system. When the units are compiled as a photogeologic map these codes can also become the map legend.

II-3.2
Mappability of Photogeologic Geounits

The expression of a geounit within a photo or image, and hence its mappability, is conditioned by a number of factors:

- sufficient distinction in lithologic composition or structure occurring in a terrain
- nature of the denudational processes that act or have acted on it
- environment in which it presently occurs
- spectral characteristics of geologic materials in outcrop
- spectral characteristics of associated vegetation or land-use
- spatial, spectral and temporal resolutions of the sensor system that acquired the imagery or airphoto
- data processing techniques employed to generate the image
- available background information
- aptitude of the person performing the interpretation

Subject to the above factors, a given photogeologic interpretation or map will result in geologic information of differing specificity and accuracy.

II-3.3
Relationship to Other Image-Based Geo-Science Terrain Classifications

Beginning in the 1950s a number of systematic treatments of genetic terrain units were formulated for the interpretation of stereoscopic vertical air photographs in what has become recognized as the field of Photogeology. A notable example of this is the manual by Howes and Kenk (1988).

Since the advent of multispectral scanners aboard Earth-Observation satellites in the 1970s, a number of texts dealing with remote sensing in geology and geomorphology have appeared. A comprehensive lexicon of lithologic geology was not central to the purposes of these works. Only Meijerink (1988) and Short and Blair (1986) contain classifications approximating the systematization introduced here. The listings of Terrain Mapping Units in Meijerink (1988) is incidental to the presentation of a GIS-compatible methodology, while Short and Blair (1986) focus on structural (rather than lithologic) patterns associated with tectonic terranes and selected denudational landform categories as they appear on the early Landsat images. Mesoscale units best resolved on airphotos are not considered in that book.

II-3.4
Present Professional Context of the Classification

In his advanced text on the use of remote sensing in the geological sciences Scanvic (1993) stated:

> (the geoscience community) "… can anticipate methodological developments whose aims are to optimize the application of remote sensing techniques to the traditional activities of the (field) geologist. This applies particularly to the photo-image analyst who is attempting to gain an understanding of the geological environment of a given area. It proceeds from the normal synthesizing of multi bits of photo-image and extra-image evidence (integrated as distinct terrain units), currently the most operational photo-image interpretation method directed to the goal of an objective characterization of the terrain." (author's translation).

II-4
Organization of the Classification

The classification is ordered in 4 lithologic and structural Divisions and 19 Genetic Groups.

II-4.1
Division 1: Magmatic Rocks and Structures

The Units of this Division are primary igneous rock bodies lithified or welded.

Genetic Groups of this Division include:

- extrusive microlithic magmas
- pyro- and volcaniclastic deposits
- modern volcanic structures
- modern epiclastic deposits

II-4.2
Division 2: Sedimentary Rocks and Duricrusts

This Division consists of 5 Genetic Groups:

- carbonates
- saline and phosphatic rocks
- detrital rocks
- interbedded sequences
- duricrusts

Note: No metamorphic rocks appear in the present classification. As stated by Ehlen (1983) none of the three common classifications for predicting metamorphic rocks, textural, facies and formational, were found adequate for use on airphotos. Subsequent remote sensing research indicates a potential possibility for identification of these rock types spectrally.

- Pre-Phanerozoic cratonic metamorphic rocks, like intrusive magmatic rocks, do not have geohazard relations as defined in this glossary.
- Non-cratonic metamorphic rocks that have geohazard relations are low-grade slate and schist. Due to their cleavages and foliations these rocks are susceptible to mechanical weathering and erosion in the same manner as siltstones and lutites among detrital and interbedded rocks.

II-4.3
Division 3: Geostructures

The Structural Units are areas of deformation and displacement of rocks of Divisions 2, 3 and 4. Three structural Groups include:

- gravity structures
- fault line traces
- general lineaments

II-4.4
Division 4: Surficial Deposits

With the exception of the basinal sediments and paraglacial groups, Geounits of this Division result from the transport and deposition in an unconsolidated state of materials eroded from the rocks and structures of the other Divisions by subaerial and marine denudation processes.

Genetic Groups of Surficial Deposits include:

- aeolian deposits
- basinal sediments
- fluvial system sediments
- marine littoral systems
- paraglacial geosystems
- periglacial-related forms
- mass movement materials

II-5
Geounit Terminology

The Classification contains four types of typological individuals: ***Geostructures***, ***Geounits***, ***Variants*** and ***Components.*** They are defined and symbolically designated as follows.

II-5.1
Geostructure

Definition. A Geostructure is a geounit of macro or meso scale which occurs in one of two modes:

- as a portion of or all of the mass of a rock Unit which has been subjected to particular diastrophic processes
- as a macroscopic scale Unit in its own right

Designation. A Geostructure is designated by conventional geological map symbols and by numeric codes as indicated for individual units in the Division.

II-5.2
Geounit

Definition. Photogeologically a geounit is a portion of a tract of land having *recognizable boundaries* at appropriate photo or imagery scales and whose overall homogeneity is a function of its genesis, composition, geologic structure and relief type.

A geounit approximates in conception the pedologist's "polypedon" (Gerrard 1981, pp 6–7) and the engineering geologist's "lithologic type" (IAEG 1981, pp 252–253).

Designation. A geounit is identified by a pairing of a single upper case letter code and number, when it is part of a Group (e.g. **X1** for a (undisturbed) basalt flow); or by an upper and lower case letter combination and number when it is part of a Sub-group (e.g. **Ed1** for linear dunes).

The alpha character codes for Genetic Groups are given in Table II.1.

Table II.1. Alpha character codes for the Geounits of Divisions 1, 2 and 4

Code	Group	Division
A	Modern volcanic epiclastic deposits	Magmatic
B	Marine littoral systems	Surficial
D	Duricrusts	Sedimentary
E	Aeolian deposits	Surficial
F	Fluvial system sediments	Surficial
G	Paraglacial geosystems	Surficial
H	Saline and phosphatic rocks	Sedimentary
K	Carbonates	Sedimentary
L	Basinal sediments	Surficial
M	Mass movement materials	Surficial
P	Tephra deposits	Magmatic
S	Detrital rocks	Sedimentary
V	Volcanic structures	Magmatic
W	Interbedded sequences	Sedimentary
X	Extrusive magmas	Magmatic
Z	Periglacial-related forms	Surficial

II-5.3
Variant

Definition. The Variant is a photo-image distinguishable 'facies' resulting from the action of one of a number of geologic or environmental factors. It is genetically assignable to a parent geounit. A variety of geologic factors are illustrated in the following examples. (Refer to the classification tables for the geological designations.)

- genesis, e.g. **Fv1.2, Zm1.2**
- diagenesis, e.g. **Ps1.1, S1.2**
- tectonism, e.g. **X1.3**
- relative age, e.g. **Ms1.1**
- morphology, e.g. **Mv1.1, Ed1.1**
- topographic site, e.g. **X1.2**
- climatic occurrence, e.g. **Bb1.1**

Designation. A Variant is identified by a number following the Unit designation, (e.g. Variant **S2.1** – lutite dissected facies of Unit **S2** – lutites undifferentiated).

II-5.4
Component

Definition. A Component is a mesoscale deposit or landform produced by genetic, structural or erosional processes. It has the following attributes:

- functionally integrated with the parent Unit
- dimensions are smaller than the parent Unit

Designation. Components are indicated by a qualifying lower case letter descriptor following the Unit or Variant designation (e.g. **Fv2b** – a levee within a low energy alluvial deposit Unit polygon; **L3c** clay-salt temporal wet zone).

II-5.5
Relative Chronology

Existing geological maps may enable interpreters to specify the age relations of adjacent geounits or superposed sequences of units. Suggested symbols of a general temporal nomenclature that may be used in such cases are listed in Table II.2.

Table II.2. Geological timescale and age symbols

EON	ERA	PERIOD	EPOCH
PHANEROZOIC	Cn CENOZOIC	Q Quaternary	R *Holocene*
			Pl *Pleistocene*
		T Tertiary	Po *Pliocene*
			Mc *Miocene*
			Og *Oligocene*
			E *Eocene*
			Pe *Paleocene*
	M MESOZOIC	K Cretaceous	Ku *Upper*
			Kl *Lower*
		J Jurassic	
		Tr Triassic	
	Pz PALEOZOIC	Pm Permian	
		Cb Carboniferous	Cbu *Upper*
			Cbl *Lower*
		D Devonian	
		S Silurian	
		O Ordovician	
		C Cambrian	
Pc PRECAMBRIAN			
Pr PROTEROZOIC			
Ar ARCHEAN			
(HADEAN)			

II-6 Mode of Designation of Mapped Units

The degree of certainty of identification and designation of geounits that is achievable in any photo-image interpretation is conditioned by the factors listed in Sect. II-3.2:

Subject to those factors, an interpreter may combine descriptor codes of the classification to geounits that have been delineated and about which he/she can be more specific. For example, composition codes may be added to structural rock units or other deposits. Some specific examples are:

- **2-S1.1** designates not only a cuesta in layered rocks, but more specifically one in stabilised cemented sandstones
- **Br2.1-X1** designates an unstable high rock cliff of basalt
- **Mv2-S2/S1.2** designates a rock avalanche in shale beds overlying a mass of weakly-cemented sandstones
- relative thickness and superposition of certain surficial deposits (fluvial, lacustrine, glacial) when interpretable may be designated by use of a fractional code:
  - **Zi4/L2** designates ice wedge polygons developed on glaciolacustrine sediments
  - **Ef1/X1** designates sand sheets flowing over a basalt flow field

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