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Mark E. Walmsley, M.Sc. P.Ag.

December 31st, 1979

Mr. Peter M. Dean,
Environmental Coordinator,
Cyprus-Anvil Mining Corporation,
355 Burrard St., Suite 330,
Vancouver, B.C. V6C 2G8

Dear Peter:

RE: SOILS AND TERRAIN ANALYSIS AT YOUR TULAMEEN COAL PROJECT

I am in receipt of your December 10th letter enquiring about the nature of the soils and terrain investigations in support of your planning of engineering and environment feasibility.

In order to outline these aspects fully, Mr. D. Maynard and myself have prepared a work program as well as a hypothetical example of the kind of mapping and analysis one could expect from such a program. This work program and tentative budget is contained in the attached document.

Although I am sure you are aware of this, I feel it is important to point out that Pedology Consultants is not a geotechnical engineering firm and as such, we would not be involved in the actual site design of the mining activity. Rather, we feel our value is in determining and reporting on those characteristics of the land (soils, buildings, tailings pond location, etc.) as well as those features which will be influenced by the mining activity (drainage, soil chemistry, etc.). I anticipate you feel this information would be valuable in planning and implementing your companies mining activities.

I look forward to your response to this proposal. If you have any questions, please do not hesitate to call me.

Best regards,

M. Walmsley

Mark E. Walmsley, ~~P.Ag~~.

MW:hm

Enclosure

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* A partnership of Mentiga Pedology Consultants Ltd., Quiet Nook Pedology Consultants Ltd., Pedocan Land Evaluation Ltd., and Pacific Pedology Consultants Ltd.

PROPOSAL FOR SOIL AND TERRAIN ANALYSIS
OF
TULAMEEN COAL PROJECT AREA

Prepared for:

Mr. P. Dean
Environmental Coordinator
Cyprus-Anvil Mining Corporation

Prepared by:

PEDOLOGY CONSULTANTS
Victoria, B.C.

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APPENDICES

INTRODUCTION

This proposal has been prepared to outline exactly what information is collected by soil and terrain inventories and further, how this information can be useful in planning mining activities.

The intent is to provide a framework for a work program which is flexible so that changes can occur as needs are more fully realized while at the same time describing a plan of work which will be useful and cost-effective.

OBJECTIVES

The ultimate goal is to prepare a series of maps and reports which describe the soil and surficial geological landscape of the study area which will provide the basis for determining at a pre-planning scale, the engineering suitability and vegetative growth characteristics of the soil materials.

Immediate objectives are subdivided into three categories:

1. Data Collection and Inventory
    - a) Conduct a soils survey and a terrain survey of the study area.
    - b) Compile and assess existing climatic data, concentrating on mine-waste reclamation applications.
2. Land Capability and Evaluation
    - a) Prepare a series of interpretive maps showing engineering suitability of the surficial geologic materials, any terrain hazards or constraints to the proposed mining activity and the suitability of the soil materials for use as reclamation material.
    - b) Prepare a report on these characteristics mentioned above.
3. Liason
    - a) Work with individuals in Cyprus-Anvil to ensure the information provided under 1 and 2 above is understood and correctly applied in preparing the land-use plan for the proposed mining activity.

ACTION PLAN

The plan for meeting these objectives consists of three main phases, as outlined in detail below:

Phase 1: Initial Program

1. Acquire: aerial photographs; existing topogrphic, soil, vegetation, terrain and capability maps or reports; climatic data; and other information of importance to the project.

2. Carry-out a preliminary aerial photo interpretation of the Project Area to provide information about landforms, surficial deposits, soils, topography, drainage, vegetation, land use and access. This will aid in development of the field program and will increase the efficiency of the field mapping.

Phase 2: Field Program

1. Field mapping of soil and terrain will be conducted at a scale of 1:10,000, utilizing the orthophoto mosaic prepared for Cyprus-Anvil as the base map.

2. A minimum of twelve inspections to a depth of at least one meter will be made per square mile. Where necessary (eg. at proposed locations for the tailings pond) a back-hoe will be used to acquire information on the materials at greater depth.

3. Key geologic materials and soils will be sampled for laboratory analysis. Analysis will include: pH, particle size, exhangeable cations, calcium carbonate equivalent; nitrogen, phosphorus, potassium in topsoils; and Atterburg Limits and sieve analysis on major geologic materials to provide the AASHO and Unified Classifications. Dominant rock types will form part of the substrate to be revegetated and will also be sampled and analyzed to determine chemical make-up and hence their influence on plant growth.

4. Soil profile and landscape features will be photographed for inclusion in the final report.

Phase 3: Final Report and Map Preparation

1. Two basic maps will be prepared and presented on the 1:10,000 mosaic (see Appendix A for examples of these maps):

    a) Soil Map and Legend (the System of Soil Classification for Canada will be used and soil map units will be developed in accordance with the presently available 1:100,000 soil map).

Phase 3: Final Report and Map Preparation (cont'd)

1.b) Terrain Map and Legend (the Terrain Classification System will be used).

2. The two base data maps will be used to prepare four interpretive maps at 1:10,000 (see Appendix A for examples of these maps):

   a) Terrain Constraints and Hazards -this map will illustrate those geomorphic features such as mass wasting, flooding, poor drainage (seepage), etc., which will influence the mining activity (roads, spoil piles, tailing ponds, etc.).

   b) Potential Aggregate Sources - this map will illustrate the locations of potential sand and gravel sources which may be useful for construction purposes.

   c) Suitability of Material for Reclamation Purposes - this map will show those soil types which contain the necessary characteristics (texture, fertility, etc.) for vegetative growth.

3. A brief report will be prepared to describe the methods used for the inventory and interpretive phases of the program. Recommendations will be provided regarding the influence of terrain and soil on the proposed land-use activities.

STAFFING

Mark Walmsley will manage the Project and will be responsible to Cyprus-Anvil for meeting requirements and seeing the project through to a satisfactory conclusion. Mr. D. Maynard will provide the necessary professional input related to terrain and bedrock geology. Pedology Consultants secretarial and technical staff will do the typing and drafting.

See Appendix B for resumes.

BUDGET

1. Manpower

M. Walmsley	10 days @ $300.00/day	$3000.00
D. Maynard	18 days @ $200.00/day	$3600.00
Secretarial	12 hrs @ $ 12.00/hr.	$ 144.00
Drafting	15 hrs @ $ 17.00/hr.	$ 255.00

2. Travel

Vehicle	6 days @ $ 35.00/day	$ 210.00
Accomodation/Meals	12 days @ $ 40.00/day	$ 480.00

BUDGET (cont'd)

3.	Materials and Supplies	
	Aerial photographs, maps, Reports, etc.	$ 75.00
4.	Laboratory Analysis	$ 800.00
	TOTAL	$8,564.00

APPENDIX A

EXAMPLE OF MAPS PREPARED FOR SOIL and TERRAIN ANALYSIS

Terrain and Soil Assessment in Support of Coal Development

Introduction

The "Guidelines for Coal Development" (E.L.U.C., 1976) describe a method for planning large-scale coal developments which ensures that a rational approach to managing land-use, environmental, and community impacts is undertaken prior to final decisions on coal and related developments being made. A multi-stage assessment process, relating to both minesite (eg. pit areas, waste dump areas, drainage and road systems, etc.) and off-site (eg. community development, transportation linkages, etc.) aspects, systematically moves from a general overview of the project to more specific impact assesssments and management proposals. Preliminary and detailed assessments of major economic, environmental, and social impacts of the proposed development are carried out in Stage I and Stage II reports. The Stage II report generally parallels the Stage I report in scope but requires more in-depth analysis.

A full description of the existing biophysical environment is a major component of the Stage I assessment. Land use and land capabilities and geological hazards are factors of the biophysical environment which require terrain and soil information to help assess the influence of mine exploration and development activities. This information should assist in the analysis of land capability for the location of various developments associated with the project (eg. roads, townsite, waste dumps, tailing ponds, etc.) and in the assessment of land capability to support alternative resource uses (eg. agriculture, forestry, wildlife, urban development). Terrain data is necessary to assess the potential hazard from slope failures, avalanching, surface erosion, and flooding.

The main emphasis in the Stage II report involves a detailed evaluation of alternative programs to avoid or manage impacts. This task requires first an explicit documentation of the major biophysical changes created by the developments and second, the evaluation of those impacts in socio-economic terms where possible. Terrain and soil data necessary to assist at this level of evaluation must be obtained in more detail and mapped more accurately at a larger scale than for the Stage I assessment.

. 2

The following discussion outlines how terrain and soil data form part of this analysis. As an aid in visulaizing what each of the maps (prepared as part of the overall program) might look like, some hypothetical examples have been drawn. These occur as figures which are presented as overlays to be used with an aerial photograph. The legends which accompany the maps are examples only and would not be the full legend which would accompany a map drawn for a specific project.

Terrain Assessment

Terrain analysis forms a fundamental part of biophysical evaluation and is the basis for assessing land capability. It is intended to serve as a guide for indicating, on a broad scale, both desirable and potentially troublesome areas. However, terrain surveys cannot be used to make an absolute capability judgement for use of the land nor can they be used to determine site-specific potential. Terrain assessment is a necessary tool for determining feasibility at the planning stage of developing an area but geotechnical evaluation (detailed subsurface examination and laboratory testing of materials) must supply the data for design and construction of specific areas or sites.

The somewhat recent advent of the "Terrain Classification System" (E.L.U.C., Secretariat, 1976) developed by personnel from the Resource Analysis Branch, B.C. Ministry of Environment, provides a concise, standardized system for supplying information about the types of geologic materials and their physical characteristics. This system has gained wide acceptance in British Columbia by a variety of land managers such as geotechnical engineers, foresters, and biologists (fish and wildlife).

This particular system is of most importance since it provides a framework for utilizing vertical aerial photographs to map the distribution of terrain characteristics in a cost-efficient manner, covering large and often inaccessible areas. By providing this framework, the Terrain Classification System reduces the problems of misunderstanding caused by differences in terminology and approach and makes the task of communicating the information to land managers much easier. Interpretations for various types of land management then become easier to understand and easier to apply by those

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personnel who are not intimately familiar with the science of surficial geology.

By combining the stereoscopic analysis of aerial photographs with field investigation, the terrain scientist is able to draw a map which cartographically illustrates the distribution of the different terrain characteristics. The terrain map may be displayed on either a topographic base or on an aerial photographic base.

Preliminary terrain assessment for use in regional and sub-regional land-use planning (eg. Stage I report) is usually carried out at scales ranging from 1:20,000 to 1:50,000 depending on the total land area and the specific uses to be studied. Detailed terrain evaluation necessary to satisfy the requirements of Stage II reports should be carried out in sufficient detail to be reliably presented at scales of about 1:10,000 or larger. This level of analysis is far more dependent on thorough field investigation than on aerial photographic interpretation and therefore is a more costly and time consuming project.

In order to understand the symbology used for terrain mapping, it is necessary to become familiar with the symbols explained in the legend which accompanies the terrain map. Figure 2 shows an example of a terrain legend produced by Pedology Consultants (originally designed by the Resource Analysis Branch). Although the terminology might appear formidable, an examination of the example symbol appearing at the top of the legend quickly shows the manner by which the symbol divides into component parts. The particular example given is used to describe an active fluvial deposit (floodplain) that is made up predominantly of gravel sized material; also, there is active erosion of the material by running water.

While terrain maps are essential to provide the data base on which landscape characteristics can be assessed, their complexity often overwhelms non-earth scientists who must use the information. To overcome this deficiency, it has proved successful to draw interpretive maps from the terrain analysis map in order to highlight certain terrain characteristics which may be important to development of the land.

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An example of terrain mapping in the area of the Tulameen coal deposit is shown on Figure 3. This map (approximate scale of 1:20,000) was compiled from aerial photographic interpretaion only, thus its accuracy is questionable. However with adequate field checking and some modifications it could be used to provide reliable information for assessing land capability and geological hazards at a Stage I level. For the purpose of this example two interpretive maps (Figures 4 and 5) have been derived which highlight terrain information which may be useful in planning a coal development project.

For a Stage II program a similar exercise can be carried out using larger scale photographs which, when combined with a detailed field program, allows a more accurate documentation of terrain conditions, therefore providing the user with more reliable and detailed data to help in selecting alternative programs to avoid or mitigate biophysical impacts.

Figure 4 is a map that depicts terrain conditions, including the presence of natural hazards, which will affect land capability. Slope instability and surface erosion are the main terrain hazards likely to be encountered in this area. A number of terrain conditions can be described but their effects will vary depending on which aspect of development activity is being considered. For example, an area of low slope gradient underlain by impermeable surficial material or massive bedrock near the surface may be ideal for location of a waste dump but its poor drainage and difficulty in excavating the rock may restrict road construction or building location. Terrain conditions which are considered important when assessing land capability associated with coal development include: high water table; near-surface seepage; restricted subsurface drainage; adverse topography; shallow depth to bedrock; and deep organic deposits.

Terrain units from Figure 3 are grouped into interpretive units which are of similar terrain conditions and which have similar physical characteristics (Figure 4). These conditions plus any hazards which may be present can then be summarized and identified for each interpretive map-unit. For example, interpretive unit 1 consists of steeply sloping land underlain mainly by bedrock at or very near the surface. The shallow depth to bedrock restricts

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subsurface drainage causing surface and near-surface runoff down the steep slopes. Concentrated runoff may create an erosion hazard in shallow surficial material and steep rock faces may be susceptible to instability.

The nature of terrain classification necessitates somewhat generalized interpretations, therefore the conditions described are averages for the map-unit and will not necessarily be encountered everywhere in that unit. However, the interpretations can be reliably used to describe those terrain features and conditions which most commonly occur and which most likely will be encountered during development activities.

Terrain analysis can also be used for preliminary assessment of potential aggregate sources (Figure 5). Delineating terrain units in which the dominant surficial geologic materials are sand and gravel or rubbly colluvium will provide users with an estimate of the areal extent of the deposits and an estimate of material texture based on the genesis of the landform. These potential aggregate sources may be subdivided into interpretive units on the basis of texture, genesis, landforms, and/or modifying processes. This grouping, although often reflecting either characteristics favourable for aggregate use (eg. thick, well-drained, gravelly fluvial terrace) or characteristics unfavourable for aggregate use (eg. flood-prone areas) in no way is meant as a recommendation for use. On-site inspection by the user will be required to determine the grade and volume of the deposit and to determine potential resource conflicts (eg. agricultural land).

Soil Assessment

Mapping of the distribution of soil types is based on the Canadian System of Soil Classification (C.S.S.C., 1978). This system provides a basis for indicating chemical and physical properties of soils which are necessary for determining use of the soil for vegetative growth as well as engineering purposes. This type of mapping is necessary for Stage I and Stage II assessments in the same way as was explained for Terrain mapping in the preceeding section.

While there are a number of properties which are examined and used in determining homogenous map units some of the most common are: drainage,

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slope, texture, organic matter content, soil depth (thickness) and fertility.

As an example, a hypothetical soil map has been drawn for the project area (Figure 1). The attached legend explains the taxanomic soil type which occurs in each of the map units (a proper soil map legend would contain much more detail). One of the interpretations which can be made from this data is the potential for use of the material as topsoil for reclamation purposes. This type of interpretation is shown in Figure 6 and constitutes only one of several interpretations which can be made from the data base.

APPENDIX B

RESUMES OF PERSONNEL

MARK E. WALMSLEY

M. Sc., P. Ag., F.G.A.C.
PEDOLOGIST

PERSONAL DATA

Date of Birth : May 1, 1947
Citizenship : Canadian
Marital Status : Married

EDUCATION

Bachelor of Science in Chemistry
Faculty of Science
University of British Columbia, 1970

Master of Science in Pedology
Department of Soil Science
University of British Columbia, 1973

PROFESSIONAL AFFILIATIONS

British Columbia Institute of Agrologists
Agricultural Institute of Canada
Geological Association of Canada

FIELDS OF SPECIALTY

Soil and Terrain (landform) surveys at all scales as the basis for interpretations such as capability for forestry, capability for agriculture, suitability for human settlement as well as specific interpretations for land use planning.

EXPERIENCE

1974 - Date - Resource Analysis Branch, Ministry of the Environment, Government of British Columbia.

Head of Terrain Systems Section; responsible for supervision of staff undertaking interdisciplinary studies to evaluate environment impacts and provide data for integrated land use planning.

Example projects include a series of maps and report on 'Resource Inventory and Interpretations for Urban Development and Transportation Requirements in the Southeast Kootenay Area'; soil and terrain survey of the Northeast Coal Study area; a series of maps and report on 'Resource Analysis for Urban Suitability : Vancouver's Northshore Area'; a resource analysis (terrain, climate, recreation, aquatic, visual) of the Ryder Lake and Chilliwack Mountain areas to determine their suitability for human settlement.

Other responsibilities included the management of the B. C. Soil Data File and design of field forms for soil and vegetation data collection.

1973 - 1974 - Lands Directorate, Ministry of Environment, Government of Canada

Environmental Impact Assessment Officer responsible for reviewing all Federally funded development projects in the Pacific Region which required geological and soils expertise.

Carried out shorezone inventory of the Greater Vancouver region; designed method for illustrating shorezone types.

1970 - 1973 - Department of Soil Science, University of British Columbia

Carried out reconnaissance soil and terrain surveys in the southeastern Yukon and Mackenzie Valley. The surveys were part of the Artic Land Use Research (ALUR) program and supplied data for land use planning. The information in the Mackenzie Valley was used to provide pedological data and permafrost information as part of the Geological Survey of Canada's terrain evaluation program for the proposed pipeline and highway system.

PUBLICATIONS

Walmsley, M. E., 1977. Resource Analysis for Urban Suitability: Vancouver's Northshore Area. Compilation of reports by E. Karanka; D. Howes; D. McCartney; R. Bennett; and C. Hawksworth. Resource Analysis Branch, Ministry of Environment.

Walmsley, M. E., 1977. Biophysical Land Classification in British Columbia; The philosophy, techniques and application. in Proc. of the first meeting Can. Comm. on Ecological Land Classification. Lands Directorate, Ottawa.

Walmsley, M. E., 1977. Physical and Chemical Properties of Peat. in Muskeg and the Northern Environment in Canada. ed. N. W. Radforth and C. O. Brawner. U. of T. Press.

Walmsley, M. E., and A. N. Boydell, 1975. Reconnaissance Biophysical Investigations for an Environmental Impact Assessment Report of the Proposed Fort Nelson to Fort Simpson Highway. Resource Analysis Branch, Ministry of Environment.

Walmsley, M. E., and L. M. Lavkulich, 1975. Landform - Soil - Vegetation-Water Chemistry Relationships, Wrigley Area, N.W.T.: I Morphology, Classification and Site Description. II Physical, Chemical and Mineralogical Determinations and Relationships.
Soil Sci. Soc. Amer. Proceedings, Vol. 39. No. 1

Walmsley, M. E., and L. M. Lavkulich, 1975. Chemical, Physical and Land-Use Investigations of Organic Terrain. Can. J. Soil Sci. 55:331 - 342.

Walmsley, M. E., and L. M. Lavkulich, 1975. Effects of Active Layer Removal from Organic Landforms in the Discontinuous Permafrost Zone. Can. J. Soil Sci. 55:235 - 238.

Lavkulich, L. M., and M. E. Walmsley, 1970 - 1973. Arctic Land Use Research Studies, Watson Lake Area, Yukon Territory. Yearly reports on research activities and findings for the study area. Indian and Northern Affairs, Ottawa.

Lavkulich, L. M., and M. E. Walmsley, 1971 - 1973. Arctic Land Use Research Studies, Mackenzie Valley, Northwest Territories. Input to Mackenzie Valley studies as part of baseline study for environmental impact assessment.

Walmsley, M. E., and J. van Barneveld, 1977. Biophysical Land Classification Techniques: the application to ecological classification of Forest Land in British Columbia: in: Ecological Classification of Forest Land in Canada and Northwestern U. S. A. Canadian Institute of Forestry.

Walmsley, M. E., 1977. Terrain Analysis for Urban Suitability: a case example in comparing alternate townsite locations using earth science information: in: Metropolitan Ecology Workshop, Toronto, 1976. Canada Comm. on Ecological Land Class.

DENNY E. MAYNARD

M.Sc.
GEOLOGIST

PERSONAL DATA

Date of Birth : February 15, 1949
Citizenship : Canadian
Marital Status : Married

EDUCATION

Bachelor of Science in Geology
Faculty of Science
University of British Columbia, 1972

Master of Science in Environmental Geomorphology
Department of Geological Sciences
University of British Columbia, 1978

FIELDS OF SPECIALTY

Terrain and surficial geologic surveys which are used for various land-use assessments, including capability for human settlement and use and capability for resource development.

EXPERIENCE

July - September, 1979 Pedology Consultants, Victoria, B.C.

Consulting geologist involved in projects of assessing terrain capability for settlement planning (Lower Arrow Lake and Castlegar areas for the Central Kootenay Regional District) and for forestry operations (Herrick Valley, Prince George, B.C. for Northwood Pulp & Timber Co.)

Responsibilities include aerial photographic interpretation, field mapping of surficial geology, interpretations of terrain constraints to particular land uses, and map and report preparations.

January - June, 1979. Resource Analysis Branch, Ministry of Environment, Government of British Columbia

Consulting geologist responsible for researching (literature review in interviews) and writing a technical manual to provide guidelines for both scientists and planners to assess terrain hazards and constraints to developing urban-rural settlements.

May - September, 1978. Resource Analysis Branch, Ministry of Environment, Government of British Columbia

Surficial geologist responsible for terrain mapping and assessing terrain hazards and constraints to construction of a resource road in northern B.C. Additional responsibilities included coordinating the logistics of a multi-disciplinary field crew, meetings with technical management agencies and map and report preparation.

May - September, 1977. Resource Analysis Branch, Ministry of Environment, Government of British Columbia

Surficial geologist responsible for terrain mapping and assessing terrain constraints to settlement development on Bowen Island. A report and maps were prepared and the information presented at a public meeting.

January 1975 - April 1977. Departments of Geological Sciences and Geography, University of British Columbia

Graduate student responsible for instructing laboratories in introductory physical geography and geomorphology.

Graduate student research involved in surficial geologic and hydrologic mapping in North Vancouver, B.C. and assessing the geomorphic capability for residential development in the area.

Research assistant responsible for preparing a guidebook for geologic field trips.

May, 1972 - September, 1973. Rio Tinto Canex, Vancouver, B.C.

Exploration geologist involved in mineral exploration in southwestern and south central B.C. Computer-based research was used to highlight areas of mineral potential and these areas were field checked by geological and geochemical prospecting and detailed property examination. Additional duties included supervising field assistants, preparing progress reports, and preparing internal project reports.

May - September, 1969, 1970, 1971. Rio Tinto Canex Ltd., Vancouver, B.C.

Geological student involved in summer field programs in north central B.C. Initially employed as an assistant for geological and geochemical surveys. In 1971, employed as a party chief in charge of a large crew of students involved in geochemical prospecting. Responsibilities included organizing and running field camps, coordinating helicopter support, regional geologic mapping and a geochemical research project, preparing company progress reports and preparing an internal project report.

PUBLICATIONS

Maynard, D.E., 1979. Guidelines for Assessing Terrain Capability for Developing Residential Settlements. Volumes 1 and 2. Resource Analysis Branch, Ministry of Environment, Victoria, B.C. (In progress).

Maynard, D.E., 1979. Terrain Analysis and Interpretations for Road Construction. in M.E. Walmsley (Ed.), Sturdee Road: resource analysis for impact assessment. Resource Analysis Branch, Ministry of Environment, Victoria, B.C.

Maynard, D.E., 1978. Terrain Inventory and Interpretations for Settlement Suitability. in J. Block (Ed.), Bowen Island: a resource analysis for land-use planning. Resource Analysis Branch, Ministry of Environment, Victoria, B.C.

Maynard, D.E., 1978. Geomorphic Constraints to Urban Residential Development in the Seymour Area, District of North Vancouver, B.C. M.Sc. Thesis, Department of Geological Sciences, University of British Columbia.

Maynard, D.E., 1977. Guidebook for geologic field trips in the Lynn Canyon - Seymour Area of North Vancouver, B.C. Adventures in Earth Science Series No. 22. Department of Geological Sciences, University of British Columbia.

Maynard, D.E. and W.K. Fletcher, 1973. A comparison of total and partial extractable copper in anomalous and background peat samples. Journal of Geochemical Exploration Vol. 2, No. 1, pp. 19-24.

Figure 2
TERRAIN

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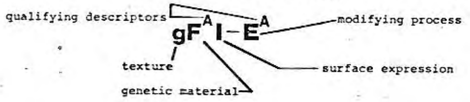
EXPLANATION OF LETTER NOTATION

A combination of letters is used to designate each map unit. The relative position of letters within the symbol indicates the characteristic that they represent.



Units consisting of two or more types of terrain are designated by two or more groups of letters separated by dots and slashes:-

e.g. gFt/aCf (See Composite Units below)

Material underlying the surface unit is shown by a symbol that is written beneath the surface unit symbol and separated from it by a horizontal line:-

e.g. $\frac{\text{sEv}}{\text{gFt}}$

TEXTURE

letter symbol	name	particle size (mm)	
b	bouldery	256	rounded or subrounded particles
k	cobbly	64-256	rounded or subrounded particles
p	pebbly	2-64	rounded or subrounded particles
s	sandy	.062-2	rounded or angular particles
s̸	silty	.0039-.062	rounded or angular particles
c	clayey	.0039	rounded or angular particles
Common Clastic Terms			
a	blocky	256	angular and subangular particles
r	rubbly	.062-256	angular and subangular particles, may include interstitial sand
g	gravelly	2	rounded and subrounded particles
f	fines	.062	a mixture of silt and clay size particles, may contain a minor fraction of fine sand

Notes:- (1) The absence of a textural term from a unit symbol indicates that texture of the material was not observed in the field and cannot be reliably interpreted from air photos. The reader is referred to the general textural descriptions under the heading Genetic Materials (below).

(2) Where two textural terms are used together, they are written in order of increasing importance, e.g., s̸s is silty sand.

GENETIC MATERIALS

letter symbol	name (process status*)	description
A	anthropogenic (A)	man-made or modified materials including those associated with mineral exploitation and waste disposal.
C	colluvial (A)	products of mass wastage; includes rubbly bedrock-derived material and material derived from unconsolidated Quaternary sediments; includes earthflow, mudflow and landslide deposits and talus material. - generally consists of massive to moderately well-stratified sediments with a great range of particle sizes.
F	fluvial (I)	material transported and deposited by streams and rivers; alluvial materials -generally consists of moderately to well-bedded and moderately to well-sorted gravels and/or silt.
F^G	fluvio-glacial (I)	fluvial materials that were deposited either in contact with or directly in front of glacier ice. - generally consists of non-bedded to poorly-bedded and non-sorted to poorly-sorted gravels with minor amounts of sand; evidence of collapse associated with melting ice (slump structures, kettles, irregular topography) is commonly present; includes kames, kame terraces, eskers and pitted outwash.
L	lacustrine (I)	sediments that have accumulated in lakes. - generally consists of stratified and sorted sand, silt and clay, and moderately to well-sorted, rounded gravels that are the products of lakeshore wave action.
L^G	glacio-lacustrine (I)	lacustrine materials that were deposited in contact with, or directly from, melting glacier ice. - typically consists of stratified silt and sand with slump and settling structures and with scattered (ice-rafted) stones; surface is irregular and/or kettled.
M	morainal (I)	material deposited directly by glaciers; till. - generally consists of compact, non-sorted and non-stratified material that contains a wide range of particle sizes and a matrix of silt or clay.
O	organic (A)	material resulting from the accumulation and decay of vegetative matter. - generally consists of peat, unstratified and locally containing minor amounts of marl and inorganic detritus.
R	bedrock (I)	outcrops and rock covered by less than 10 cm of unconsolidated material.
U	undifferentiated	a layered sequence of more than three types of genetic material outcropping on a steep, erosional slope.

*See QUALIFYING DESCRIPTORS - for definition of PROCESS STATUS

MODIFYING PROCESSES

letter symbol	name (process status*)	description
-E	Channelled (I)	surfaces crossed by channels formed by running water
$-E^G$	Channelled by glacial meltwater (I)	surfaces crossed by glacial meltwater channels
-F	Failing (A)	slopes where slow downslope movement of masses of unconsolidated material or bedrock is occurring.
-H	Kettled (I)	surfaces marked by depressions formed due to melting of ice blocks in fluvioglacial, glaciolacustrine or morainal sediments.
-V	Gullied (A)	the modification of surfaces by fluvial erosion, resulting in the development of parallel and sub-parallel, steep sided and narrow ravines in both consolidated and unconsolidated materials.

SURFACE EXPRESSION

letter symbol	name	description
a	apron	a sloping surface that is typically at the foot of a steeper slope and underlain by material from above.
b	blanket	a mantle of unconsolidated material which has no constructional form of its own, but derives its general surface expression from the topography of the unit which it overlies; it masks minor topographic irregularities in the underlying unit and is more than 1 m thick. - if the underlying unit consists of unconsolidated material, it is shown in the unit symbol; if no underlying unit is shown, it may be assumed to be bedrock.
f	fan	a surface that is the sector of a cone.
h	hummocky	steep-sided hillocks and hollows that are rounded or irregular in plan; slopes of 15 to 35° predominate on unconsolidated materials, and slopes of 15 to 90° predominate on bedrock; local relief is greater than 1 m.
l	level	a flat or gently inclined (less than 5°) surface with uniform slope and local relief of less than 1 m.
m	subdued	linear and non-linear forms with slopes ranging up to 10° and with local relief greater than 1 m.
r	ridged	elongate or linear, parallel or subparallel hills or ridges with slopes predominantly between 15 and 35° on unconsolidated materials and between 15 and 90° on bedrock.
s	steep	steeply inclined erosional slopes (scarps) with gradients commonly greater than 35° on unconsolidated materials and greater than 35° on bedrock.
t	terraced	step-like topography; includes both scarp face and the horizontal or gently inclined surface above it.
v	veneer	a mantle of unconsolidated material which has no constructional form of its own, but derives its surface expression from the topography of the underlying unit; it reflects minor irregularities of the underlying surface, is generally between 10 cm and 1 m in thickness, and outcrops of the underlying unit are common. - if the underlying material is unconsolidated, it is included in the unit symbol; if no underlying unit is indicated, it is assumed to be bedrock.

COMPOSITE UNITS

Composite units are employed where two or three types of terrain are intermixed or occupy such small areas that they cannot be designated as separate units at the scale of mapping. Symbols (defined below) are used to indicate the relative amounts of each terrain type and the components are always written in decreasing order of importance.

= the components on either side of this symbol are approximately equal

/ the component in front of the symbol is more extensive than the one that follows

// the component in front of the symbol is considerably more extensive than the one that follows

e.g.	Mb//R	Mb is considerably more extensive than R
	Mb//R=Cv	Mb is considerably more extensive than R; R and Cv are of roughly equal extent
	Mb/R//Cv	R is less extensive than Mb; Cv is considerably less than R

ON-SITE SYMBOLS

Quaternary Fossil Locality	Ⓕ
Gravel Pit	Ⓖ
Abandoned Rock Quarry	Ⓠ
Anthropogenic Site	Ⓗ
Dunes (active)	ʃʃʃ
Kettle	Ⓚ
Esker (direction unknown)	<><><>

QUALIFYING DESCRIPTORS

letter symbol	name	description
G	glacial	- used to qualify non-glacial genetic materials or process modifiers where there is evidence that glacier ice affected the mode of deposition of materials or the mode of operation of a process. (See F^G and W^G above).
A,I	active, inactive process status descriptors	- used to qualify genetic materials and modifying processes with regard to their current state of activity. Active: there is evidence that a modifying process is either operating continuously or is of a recurrent nature at the present time; there is evidence that the process of formation of a genetic material is operative at the present time. Inactive: there is no evidence to suggest that a modifying process is continuing or recurrent; the process of formation of a genetic material has ceased. A process status descriptor is designated for each genetic material and for each modifying process on the basis of their most common state of activity at the present time. (See process status column in Genetic Materials and Modifying Processes above). Process status descriptors are shown in unit symbols on the map only where the current state of activity is contrary to the designated state.