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QUATERNARY GEOLOGY AND LANDFORMS OF THE EASTERN PEACE RIVER REGION, BRITISH COLUMBIA NTS 94A/1, 2, 7, 8

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INTRODUCTION

A multi-faceted series of investigations of the Quaternary geology of the Peace River region (Figure 1) of British Columbia were undertaken in 1990 (Bobrowsky *et al.*, 1991). As part of this program, the southeastern part of the region, which encompasses the 1:50 000 NTS map areas 94A/1 (Shearer Dale), 94A/2 (Fort St. John), 94A/7 (North Pine), and 94A/8 (Alces River), was mapped in detail (*see* Figures 2 to 5 in pocket). This work involved mapping from aerial photographs, followed by detailed stratigraphic and sedimentologic field investigations and laboratory analyses of sediment texture and mineralogical composition. The detailed surficial geology maps produced from this work are designed to be of practical use to industry, government, and the general public.

The extent of aggregate resources in the region, and the potential for recognition and exploitation of new resources, was not well known prior to detailed mapping, although deposits in the Fort St. John – Taylor area have been exploited for some years (Hora, 1988). Maynard (1988) commented upon the possibilities for utilizing peat resources for agricultural and other purposes, but comprehensive data were not available for the eastern Peace River region prior to the detailed mapping reported upon in this study.

This paper, therefore, is intended to accompany the maps (Figures 2 to 5 in pocket), and addresses three objectives:

- to discuss the composition, material properties, and genesis of the major types of

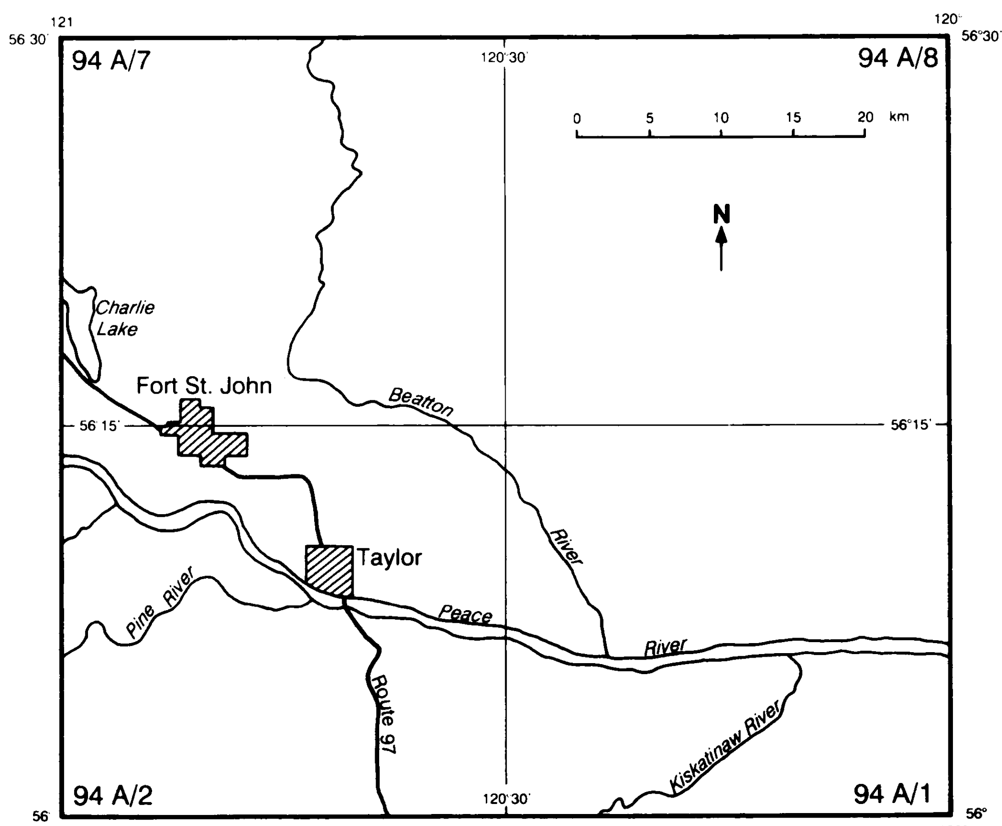


Figure 1. Location map of the Peace River area of British Columbia.

Quaternary geological units identified throughout the four map areas;

- to evaluate the aggregate and peat deposits and resources in the region; and
- to evaluate the environmental and engineering geological aspects of the region.

Study of the chronology of mass movement events and detailed stratigraphic analysis of the region formed other components of the research effort in the Peace River region, and are discussed elsewhere (Bobrowsky *et al.*, 1991).

REGIONAL SETTING

The Peace River region (Figure 1) lies along the western edge of the Alberta Plateau within the Interior Plains (Mathews, 1986). The present climate is continental boreal, marked by cold winters (January mean temperature –18°C), warm summers (July mean 17°C), moderate annual precipitation (600 mm, 200 mm of which falls as snow), a positive net moisture budget, and prevailing westerly winds (Environment Canada, 1984). Topographic effects along the deeply incised Peace River valley have created a 'thermal oasis', where temperatures regularly exceed those of the surrounding uplands and prairies by 5°C.

Vegetation in the region is dominated by the aspen (*Populus tremuloides)* parkland assemblage, with lesser amounts of alder (*Alnus rugosa*), birch (*Betula papyrifera)*, balsam poplar (*Populus balsamifera*), white and black spruce (*Picea glauca, P. mariana*), and scattered lodgepole pine (*Pinus contorta*) (Rowe, 1972). This assemblage was actively encroaching throughout the region prior to the advent of agricultural activity. Isolated patches of midgrass prairie, dominated by wheat grass (*Agropyron*), needle grass (*Stipa*), and sedges (*Carex*), are present in the eastern section of the region. Aspect, and the thermal oasis effect along the Peace River, have a major influence on microclimate and hence on the local vegetation cover. Along south-facing escarpments, warmth-loving plants such as prickly-pear (*Opuntia polycantha*) are infrequently present. The soils in the region are dominantly dark grey luvisols (under forested terrain) and black chernozems (under grasslands and long-cultivated areas).

The topography consists of a series of rolling plateaux and northeastward-sloping plains, locally interspersed with sharp cuesta slopes. Relief is approximately 300 metres. The region is dissected by an integrated dendritic drainage system tributary to the Peace River, which declines regularly in elevation from approximately 420 metres at the western margin of the mapped area to 400 metres at the provincial boundary. Valleys of the major tributary streams (Kiskatinaw, Beatton, Pine, Moberly, and Alces Rivers) are deeply incised, with local relief exceeding 150 metres. In general, the upland terrain south of the Peace River is more dissected and shows greater relief than that north of the river. Mass movements, including rotational and translational slides and a variety of sediment gravity flows, commonly occur along all the major streams.

The bedrock consists of the Upper Cretaceous Shaftesbury Formation (dark grey shales and siltstones, and argillaceous sandstones), the Dunvegan Formation (light grey sandstone and interbedded shale, with rare thin coal seams), and the Kaskapau Formation (silty shales with thin sandstone beds) (Stott, 1975). These strata represent a broad marine transgression – regression – transgression cycle, with several fluctuations of sea level recorded in the Dunvegan rocks. These units are generally undeformed in the eastern part of the Peace River region and dip at very low angles towards the southwest. In the southwesternmost part of the area, the bedrock has been affected by northeasterly-directed thrusting from the Rocky Mountains, and eastward-dipping strata are common although the bedrock structure has little influence on the topography or geomorphic development of the region. The high concentrations of montmorillonite and bentonite in the strata, however, together with their poorly consolidated nature, greatly increase the susceptibility of these rocks to slope failure following fluvial (or anthropogenic) undercutting or overloading. The friability of the strata resulted in the erosion, transportation and incorporation of large quantities of the material into Quaternary deposits.

The Quaternary stratigraphic framework of the Peace River region has been extensively discussed by Bobrowsky (1989) and Bobrowsky *et al.* (1991). Further results with stratigraphic details, generated in part from the 1990 field and laboratory investigations, will be presented elsewhere (Bobrowsky *et al.,* in preparation), and consequently are not discussed in this contribution.

GEOLOGY

QUATERNARY GEOLOGY DESCRIPTION AND ANALYSIS

The terminology and symbols used to designate map units was developed by the British Columbia Ministries of Environment and Crown Lands (Howes and Kenk, 1988; *see* legend of Figures 2 to 5). Map units are classified in terms of texture, dominant genetic process, surface expression, geological (modifying) processes and, in some instances by specifying a qualifying descriptor. In locations where two or more sediment types are exposed within the boundaries of a single map unit, a composite unit symbol is used, with the dominant unit listed first. In areas where a unit is stratigraphically beneath a veneer or blanket of another, but influences the topographic expression or tonal qualities visible on aerial photographs, a compound symbol is used with the underlying unit symbol in the denominator.

Throughout the eastern Peace River region, many examples of complex sedimentary successions were observed, especially along the deeply incised river valleys or in areas where mass movement activity and alluvial reworking was prevalent. In these areas, the symbols are unavoidably complex, and the areas represented by each map unit relatively small. Such areas are subject to modification by further mass movement disturbances, and many such disturbances were observed during field research which post-dated the most recent aerial photographic coverage available. Users of these maps should be aware that subsequent mass movement activity in these areas may result in changes in terrain classification. In general, it is advisable to treat all slopes along the major rivers in the region as potentially unstable, and to plan accordingly.

The number of map units represented by distinct terrain classification symbols precludes discussion of each individual unit. The discussion which follows is therefore based upon the dominant genetic processes which each unit type represents. The unit types are discussed in order of diminishing prominence and areal extent.

GLACIOLACUSTRINE UNITS (L^G)

Sediments associated with map units interpreted as glaciolacustrine were deposited in one or more glacial lakes which were impounded to the east by the retreating Laurentide glaciers (Mathews, 1980; Bobrowsky *et al.*, 1991). The ice front prevented drainage via the present route to the east and northeast. These deposits are confined to elevations below 820 metres in the southern part of the region (Shearer Dale and southern Fort St. John map areas). In the map areas north of the Peace River (North Pine and Alces River), glaciolacustrine deposits are generally not found above 740 metres elevation.

The most common type of glaciolacustrine unit is composed dominantly of silty clay or clayey silt, commonly containing 5 to 15 per cent sand and scattered pebbles and larger clasts. The clays are generally plastic, susceptible to sediment gravity flow if disturbed, and contain a high proportion of material derived from the local Cretaceous bedrock. The sand fraction is composed dominantly of quartz, feldspar, chert, and carbonate minerals, and also contains trace quantities of garnet, hornblende, pyroxene, fluorite, tourmaline, titanite, and other heavy minerals derived in part from the Canadian Shield of northeastern Alberta and the Mackenzie District of the N.W.T. Orthoquartzite, sandstone, shale, granitic, and gneissic pebbles, along with clasts of other lithologies, were observed.

A variety of sedimentary structures are present in the finely textured glaciolacustrine sediments. Most exposures are stratified, with either fine stratification defined by alternating clay-rich and clay-poor layers, millimetres or tens of millimetres thick, with poorly-defined contacts; or with well-defined laminations and centimetre-thick beds of clay, silt, and sand. Rarely, glaciolacustrine silt and sandy-silt beds are cross-stratified, with the orientations of the strata indicating eastward flow. The sediments in many exposures have been disturbed by either syndepositional or post depositional mass movements, as indicated by contorted stratification. Other exposures have been altered by pedogenesis, and by frost action generated under the modern climate. Such disturbances are very common in the thinner stratigraphic sequences.

The fine glaciolacustrine sediments generally form a veneer (map symbol v; < 1 metre thick) or a blanket (b; > 1 metre thick) overlying other sediments. These units have no geomorphic form independent of the underlying unit. In most instances, the underlying material is undulating, rolling, or hummocky morainic diamicton. Contacts between these materials are commonly gradational and, thin, discontinuous beds and lenses of diamicton are frequently present in the basal 1 metre of the thicker glaciolacustrine assemblages.

Glaciolacustrine deposits more than 3 metres thick tend to form hummocky (h), rolling (m), or gently undulating (u) expanses with low relief, often dotted with small hollows where uncultivated. The composition and internal structure of these units is similar to that of the glaciolacustrine blankets and veneers. Much of this sediment type is under cultivation in the Peace River region, as it forms the most fertile and potentially productive material for pedogenesis and plant growth.

The glaciolacustrine silts and clays were deposited by sediment gravity underflows and suspension settling. Minor amounts of material (including most of the coarse clasts) were deposited by melting icebergs from the adjacent Laurentide glaciers. The genesis of these deposits is discussed extensively by Bobrowsky *et al.* (1991) and by Liverman (1989 and in preparation).

Minor amounts of glaciolacustrine sands and sandy silts are also present in the region. The units generally form thin blankets over morainic silty and clayey diamictons, often on eastward-facing slopes, and are laterally and vertically gradational into both diamictons and finer-textured glaciolacustrine sediments. The units generally are poorly or moderately sorted, and are not suitable for aggregate exploitation except for very local and small-scale use.

The deposits were formed by washing and reworking of previously deposited sediments during drainage of the glacial lake, as the ice front receded to the northeast. Drainage was relatively rapid, and hence the deposits are not areally extensive or well-developed. In addition, the dominantly east-west orientation of the basin, parallel to the prevailing winds, limited wave activity on the surfaces of the glacial lakes and hence precluded the formation of well-defined strandlines.

Other minor washed zones, too thin and laterally discontinuous to be mapped as separate units, are present on the surfaces of the fine-grained glaciolacustrine units. In many instances, washing of the surface of the deposits has continued to the present. Pedogenesis and cultivation have probably resulted in the destruction of other thin examples of these features.

MORAINIC UNITS (M)

In this study, sediments mapped and interpreted as morainic are diamictons, containing significant quantities of clay, silt, sand, and larger clasts. All of these units were either:

- deposited directly from glacial ice (true morainic units or tills), or
- were initially deposited from glacial ice but were subsequently substantially modified by sediment gravity flow or other mass movement processes prior to the deposition of any overlying glaciolacustrine or

glaciofluvial sediment, (for example, in subglacial cavities), or

- were initially deposited from glacial ice but were subsequently substantially modified by sediment gravity flow or other mass movement processes in a glaciolacustrine environment prior to the deposition of finer-textured glaciolacustrine sediments.

These qualifications allow the morainic units to be treated in terms of their geomorphic expression, texture, and mineralogical composition, without requiring differentiation of the precise mode of genesis. Depositional analysis of the diamicton sediments in the Peace River region, in common with most areas of British Columbia and western Canada, is a complex process requiring intensive examination of individual outcrops (often with inconclusive results). Such intensive sedimentological analyses are discussed elsewhere (Bobrowsky *et al.*, 1991; Bobrowsky *et al.*, in preparation; Liverman, 1989).

Diamicton units which have undergone any substantial modification after deposition from glacial ice cannot be classified as tills, and are technically not morainic deposits. The diamicton units in the eastern Peace River region have broadly similar physical properties, however, regardless of the exact mode of deposition of each unit. For practicality and ease of general discussion, therefore, all of the diamicton units were mapped as morainic units, and will be treated collectively in this paper. A more precise analysis of the diamictons present at any particular site should be undertaken prior to construction.

Texturally, the diamictons vary in matrix composition from silty clay to silty sand. Clay content ranges from 5 to 35 per cent, and sand content varies between 15 to 55 per cent. The proportion of large clasts is also variable, reaching a maximum of 25 per cent. Units with coarse clast contents of less than 5 per cent were mapped as glaciolacustrine sediments, with the rare coarse clasts interpreted as ice-rafted pebbles and cobbles. Generally, the diamictons are dominated by fine-grained matrices.

The diamictons contain a varied suite of minerals, including quartz, chert, feldspar, calcite, dolomite, biotite, vermiculite, magnetite, hornblende, garnet, pyroxene, tourmaline, corundum, apatite, titanite, and kyanite. The pebbles and cobbles are dominantly locally derived shale (from the Shaftesbury and Kaskapau Formations) and sandstone (from the Dunvegan Formation), with associated orthoquartzite, chert, limestone (rarely containing fragments of Devonian corals), granites (derived from both the Canadian Shield and the Omineca Range), gneiss, gabbro, and diabase. These mineralogical and petrological assemblages indicate that Cordilleran, Montane, and Laurentide source areas all contributed to the diamicton sediments. The presence of Laurentide granites and gneisses, and of fossilferous limestone clasts derived from the Devonian strata of northeastern Alberta, indicate that the diamicton units were deposited at some time after the initial Laurentide advance. These clasts in themselves, however, are not sufficient evidence to establish that the diamictons were deposited by Laurentide glaciers, as they could have been transported by ice-rafting in proglacial lakes and redeposited in nonglacigenic diamictons, such as subaqueous debris flows. Such units are commonly found associated with proglacial lacustrine sequences.

The internal structures within the morainic units show a wide range of styles. Most of the units are texturally homogeneous, without distinctive lenses or stratification. Some diamicton exposures, however, contain small sand lenses, generally aligned horizontally or subhorizontally. Although some of these lenses contain cross-stratification, lag and shadow structures, and graded bedding, the majority are internally structureless. Thin (1 to 2 cm) planar silt lenses, dipping easterly or northeasterly at low angles, are rarely present.

At several exposures, the alignment of the large pebbles and cobbles was measured, in order to ascertain the direction of sediment transport and to assist in interpretation of the genesis of the diamictons. Results from these clast fabric analyses were extremely variable for the region's diamictons, with vector orientation strengths varying from almost perfectly random (principal eigenvalue = 0.36) to well-oriented (principal eigenvalue = 0.88). These variations indicate that the sediments mapped here as 'morainic' represent many styles and processes of deposition (Bobrowsky *et al.*, 1991).

The morainic units generally have rolling (m) or undulating (u) surfaces. Aprons are present surrounding bedrock-cored highs, and some bedrock highs are blanketed with morainic diamictons. Slopes vary from gentle (j) to moderately steep (k). Rare examples of oriented ridges (r) indicating ice flow are present in the eastern part of the region, and suggest Laurentide ice flow from the east-northeast and northeast.

The morainic deposits interpreted as true tills found in the Alces River, Shearer Dale, North Pine, and the eastern part of the St. John map areas were deposited by Laurentide ice, moving from the east-northeast and northeast. These units which can be confidently identified as undisturbed tills, however, form a small proportion of the total 'morainic' assemblage. Most of the diamictons have undergone some modification, most commonly by sediment gravity flow. The diamicton units in the southwestern part of the Fort St. John map area contain very few granitic and gneissic clasts derived from the Canadian Shield, and some are completely devoid of these clasts. These units are interpreted as the products of Montane and Cordilleran glaciation, generally reworked after initial sedimentation, with some Laurentide clasts added through ice-rafting in proglacial lacustrine environments. The sedimentology of these deposits, and the stratigraphic implications, are discussed further in Bobrowsky *et al.* (1991), Liverman (1989), and Bobrowsky *et al.* (in preparation).

FLUVIAL UNITS (F)

Fluvial units include sand and gravel bars adjacent to the major rivers, minor alluvial fans and small aprons developed at the bases of some escarpments, and valley fill deposits along the lesser tributaries. Much alluvial modification of colluviated deposits has occurred along the deeper parts of the major rivers in the region, resulting in the development of complexly interbedded and washed fluvial/colluvial assemblages.

Texturally, the fluvial deposits vary from silt and clay to grain-supported coarse gravel. Sand and fine gravel units are the most common types present. The deposits are generally moderately to well-sorted, except where modified by or interbedded with colluviated materials. Clast types present commonly include sandstone, shale, orthoquartzite, chert, carbonates, granites, granodiorites, and gneisses, derived from Laurentide, Cordilleran, and Montane sources. The deposits are generally thick along the major streams, but thin in minor tributary areas. All of the mappable fluvial units were formed post-glacially, as indicated by their stratigraphic position and by ^{14}C dating (Bobrowsky *et al.*, 1991).

The lateral extent, composition, and internal structure of the fluvial units is directly related to the stream type. The largest streams in the region, the Peace and Pine Rivers, display both sandy braided and wandering reaches. Sedimentation along these streams is characterised by the development of large sand and gravel flats and longitudinal and lateral bars. The internal structures of these geomorphic features are marked by fining-upward sequences of well-sorted trough cross-stratified gravel and sand, with associated planar tabular and asymptotic cross-bedding. Imbricated gravel sheets are commonly developed on the upstream sides of the bars. The large bars and flats are commonly capped with medium and fine-grained sand and silt veneers, often rippled or horizontally laminated, that represent a combination of low-energy fluvial sedimentation during receding floods and aeolian reworking over the exposed surfaces.

Evidence preserved in the sedimentary record indicates that fluctuations of water levels in the Peace River were much greater in previous times than on today's regulated stream. Evidence of similar fluctuations is present in the sediments found along the Pine River.

Trunk channel (thalweg) deposits, consisting of well-sorted sands and gravels, are commonly interbedded in the bar and flat sequences, indicating irregular channel switching and avulsion. The main channel of the Peace River has migrated as much as 4 kilometres south of its present position along the reach southwest of Fort St. John (Seyers and Buchanan, 1990).

Pre-existing river channel positions are also indicated by the larger gravel and sand deposits in the Taylor area, many of which have been or are being actively exploited as aggregate sources. These sequences represent lateral and longitudinal bars formed in the earliest postglacial stage of the Peace River. A ^{14}C date obtained from a *Bison sp.* bone dates this event at 10 240±160 years B.P. (AECV - 1206C). This date has necessitated revision of the originally assigned mid-Wisconsinan age for some of the gravels in the Taylor area (Mathews, 1978). The geomorphic evidence, coupled with ongoing stratigraphic and chronologic investigations, indicates that all of the gravels in the Taylor area are post-glacial deposits (Bobrowsky *et al.*, 1991; Bobrowsky *et al.*, in preparation).

The other major streams in the region, the Kiskatinaw, Moberly, Beatton, and Alces Rivers, are all meandering systems which have become ingrown as a result of downcutting induced by falls in level of the Peace River. This downcutting has recently accelerated due to the regulation of the Peace, and will probably become more pronounced in the Beatton, Alces, and Kiskatinaw valleys if the Peace River is further dammed at Site C. Sediments are deposited along these streams as point bars, consisting of cross-strata successively fining upwards from coarse to medium sand, to fine sand and silt, and finally to silt and clay. The gently dipping cross-beds were deposited during successive falling water stages associated with seasonal flooding. The absence of coarser gravel deposits, or other sediments associated with thalweg channels, indicates that erosion has progressed predominantly by downcutting.

COLLUVIAL UNITS (C)

Units mapped as colluvial are predominantly diamictons, or poorly-sorted sandy and clayey silts. Surface washing, and to a lesser extent sorting during colluviation, has resulted in a concentration of coarser clasts on the surfaces of many colluvial units. The colluvial units are thus generally coarser than the morainic diamictons. The colluvial sediment is derived from a number of sources, but most deposits incorporate morainic, glaciolacustrine, and bedrock material. Many are interbedded with alluvial deposits, and have undergone surface washing. The geomorphic expression of these units is somewhat variable, but most are roughly undulating or hummocky, with steep or moderately steep slopes. Isolated depressions, ridges, and upthrown blocks of sediment are common.

Colluviation in the Peace River region occurs in several dynamic styles. Rotational slides (slumps) are commonly the first stage in an actively failing area. Failure involves motion of a cohesive block of material as a unit, without internal deformation. In the Peace River region, these blocks may be several tens of metres thick and several hundreds of square metres in area. Although failure surfaces can occur in glaciolacustrine strata, the failure plane is most commonly situated within the bedrock. This is especially true where shale units are involved.

Slumping is generally followed by internal deformation of the weakened material, generation of flows from the toe of the slump block, and flow of material in the exposed headwall of the block. These debris flows are generally laterally extensive, and result in considerable modification of the original slump block topography, usually to the point of completely obscuring the original morphology. Along river valleys where material is constantly removed from the toes by fluvial erosion, flow from the toe continues essentially constantly (although the rates vary widely throughout a year and between years), and thus slope failure by debris flow results in essentially continuous modification of the terrain. This situation exists along all of the major tributaries to the Peace River (especially along the Beatton and Kiskatinaw Rivers), and debris flow colluvial deposits thus form a large proportion of the margins of these streams. Along the Peace River, removal of material from the toes is often not as rapid, because many of the deposits terminate at abandoned or seldom-occupied channels along the margins of the braided and wandering stream reaches. In these areas, preservation of the original slump morphology is more likely, although modification from debris flows induced from above the slump blocks is very extensive.

Mass movements in the region can be induced by fluvial undercutting, natural overloading of the slopes (*eg.* by debris flow from above), loss of internal cohesion due to sudden saturation (as was common during June 1990), or by human activity. Evidence of past colluviation in the region is extensive (Bobrowsky *et al.*, 1991), and extreme caution is required in any effort to exploit or utilize river valley slopes.

ORGANIC UNITS (O)

Organic units are defined as those composed largely of organic materials resulting from the accumulation of plant material, containing at least 30 per cent organic material by weight (Howes and Kenk, 1988). They are associated with fens and bogs developed above relatively impermeable glaciolacustrine, lacustrine, and morainic materials. The surfaces of the units are generally level, forming veneers (v), blankets (b), and plains (p).

The organic deposits are classified according to the system of the Canadian Soil Survey Committee (1978). Fibric (f) deposits are the most common surface forms. Many of these deposits are associated with standing or seasonal water in sedge (*Carex*) fenlands, and are composed dominantly of *Carex* fragments. Decomposition of these deposits has not progressed to a large degree (1 to 4 on the Von Post scale, as used by the Canadian Soil Survey Committee), and many of the fibric layers are essentially unaltered plant debris. Local detrital transport of plant debris and small amounts of clay and silt has affected some fenlands, especially those adjacent to standing bodies of water or streams.

Mesic (u) deposits are rarely encountered as surface features, but underlie approximately 10 per cent of the fibric units. These units display an intermediate degree of decomposition (5 to 6 on the Von Post scale). Mesic horizons which underlie fibric *Carex* horizons are composed of decomposed *Carex* fragments. In contrast, some surficial mesic units are dominated by remains of *Sphagnum* moss, such as the unit exposed in the northeastern part of the North Pine map area at UTM 508619. This exposure represents the thickest mesic deposit observed in the region, with a total depth of 120 centimetres of *Sphagnum* peat, and has a surface area of approximately 0.07 square kilometre.

Humic units (those with Von Post decomposition values of 7 or greater) are not exposed on the surface within the region. Thin humic horizons were rarely encountered at the bases of mesic *Sphagnum* successions, but many of these horizons also contained substantial quantities of silt and clay. The thickest humic horizon measured, at UTM 508619 in the North Pine map area, was 10 centimetres.

GLACIOFLUVIAL UNITS (FG)

Units mapped as glaciofluvial are associated with morainic or glaciolacustrine deposits, are isolated from the major river systems, and form undulating, elongate ridges. The major area of occurrence in the eastern Peace River region is a northwest trending belt of isolated, undulating mounds 15 to 30 metres high, located west and southwest of Fort St. John in the North Pine and Fort St. John map areas.

The glaciofluvial deposits are well-sorted sands and granule, pebble, and cobble gravels. Clast assemblages are dominated by feldspathic sandstone and orthoquartzite, with lesser amounts of limestone, granite (predominantly from Canadian Shield sources, although some clasts derived from the Omineca Range are also present), gneiss, and minor amounts of chert. The mineralogy of the units indicates that material from Laurentide, Cordilleran, and Montane sources has been incorporated in the deposits. These deposits are currently being exploited as sources of aggregate.

Sedimentary structures within the glaciofluvial units, and their relationship with the adjacent glacigenic sediments, suggest that the deposits formed predominantly as fans, fan-deltas, and aprons developed along the margins of retreating Laurentide ice, rather than as subglacial esker segments. Flow indicators, such as cross-stratification and clast imbrication, measured in active aggregate pits in the Grand Haven – Fort St. John area vary in direction but are dominantly indicative of southwestern and southeastern flow. These directions are normal and parallel to the postulated ice front in the area.

LACUSTRINE UNITS (L)

Units mapped as lacustrine were deposited in shallow lakes not developed as a result of glaciation. These sediments thus represent suspension settling and minor underflow deposits that were exposed when small lakes partially or totally dissipated. The lacustrine units are of very limited areal extent.

These units are composed of silt and silty clay, either horizontally laminated or structureless, and lack large clasts and associated diamicton beds. Their surface expression generally takes the form of a veneer or blanket over underlying glaciolacustrine silts and clays, or (for thicker deposits) as small, featureless plains. The sediments commonly border existing or ephemeral ponds and sloughs.

EOLIAN UNITS (E)

Eolian units are uncommon in the eastern Peace River region. Although thin veneers of eolian silt and silty sand loess rarely occur as caps over glaciolacustrine, morainic, and fluvial sediments, these deposits are too thin and limited in areal extent to be mappable. The loess veneers do not have a distinctive geomorphic expression.

Veneers of eolian sand are present in the northeastern part of the North Pine map area. These units consist of thin, structureless, medium to fine-grained, well to moderately-sorted sand, generally overlying undulating glaciolacustrine and/or morainic deposits. Small mounds, which represent incipient, poorly-developed, or highly modified dome dunes are present in some areas, but generally are too small to be confidently recognized on aerial photographs. The few cross-strata preserved on the flanks of these dome dunes suggest westerly wind activity, but the number and degree of preservation of cross-strata is not sufficient to permit regional conclusions to be formulated. The deposits are too thin and fine grained to be suitable as sand aggregate sources.

RESOURCES

AGGREGATE RESOURCES

Units currently exploited for sand and/or gravel include those mapped as fluvial (terrace deposits along the Peace River), and glaciofluvial (in the unit sporadically exposed in the Grand Haven – Fort St. John area). The lateral extents of both of these unit types are well known locally, and extraction of material from the deposits has been conducted for several years (Hora, 1988). Additional aggregate extraction operations could be developed in currently unexploited parts of these units.

Few potential new sources of aggregate are present in the region. No mappable deposits of unexploited gravel units were observed. The rare examples of sand-dominated glaciolacustrine sediments and eolian deposits are too thin, limited in areal extent, and in many instances too poorly sorted to be satisfactory as sources of sandy aggregate. The low concentration of pebbles and larger clasts in the morainic diamicton deposits limits their utility as aggregate sources. Extensive processing would be required to isolate the 5 to 25 per cent gravel fraction from the silt and clay matrix. Some diamicton deposits observed contained chert clasts, which could prove unsuitable in some aggregate applications.

Bedrock exposures are present along the major river valleys, although they are commonly obscured by colluvium. The majority of the bedrock in the region is unsuitable for aggregate production, however, as it is dominated by shaly strata (Shaftesbury and Kaskapau Formations). Sandy beds within the Dunvegan Formation could possibly be used as aggregate sources, but contain substantial amounts of silt and clay and are poorly consolidated. In addition, these beds contain chert and bentonite, both of which are unsuitable for aggregate.

Aggregate resources in the region, therefore, are somewhat limited. At present, local demand for aggregate is met by exploitation of the glaciofluvial and elevated fluvial deposits in the vicinity of Fort St. John and Taylor.

PEAT RESOURCES

In a preliminary assessment, Maynard (1988) rated the eastern Peace River region as having a relatively low potential as a peat resource area. This assessment has been largely confirmed by field study. The majority of the organic deposits in the region are fibric units dominated by *Carex* fragments, associated with fenlands. These units are unsuitable for use in agricultural applications.

Mesic *Sphagnum* peat deposits are present at scattered localities, most notably in the eastern part of the North Pine map area, but these deposits are small and thin. The estimated total volume of the largest deposit is approximately 60 000 cubic metres, which limits its use. Preliminary investigations suggest the the map areas north and northwest of the study region may contain larger, more economic peat deposits.

ENVIRONMENTAL AND ENGINEERING GEOLOGY

Planning for construction, hydroelectric development, and waste disposal in the eastern Peace River region will require a knowledge of the engineering geological properties and potential environmental geological hazards associated with the Quaternary deposits. Although the Quaternary stratigraphy throughout most of the region is relatively simple, complex sedimentological successions are present within stratigraphic and geomorphologic units at many localities. In addition, successions found in areas subject to colluviation are commonly stratigraphically and geomorphologically complex. The major environmental and engineering geological concerns in the region centre around slope stability and waste disposal.

SLOPE STABILITY

Slope failure is ubiquitous along all of the major streams in the region. The extent of colluvial deposits formed by rotational slides (slumps) and flows indicates that all of the river banks should be regarded as potentially unstable. Sedimentological and chronological investigations have indicated that mass movements have occurred regularly since deglaciation (Bobrowsky *et al.*, 1991). During the 1990 field season, many active examples of both styles of mass movements induced by fluvial undercutting, overloading of the slopes, and loss of internal cohesion due to sudden saturation were observed. Failures along the north side of the Peace River valley have necessitated the periodic repair and relocation of several parts of Highway 29, and other damage to roadways is evident along the Kiskatinaw, Beatton, and Pine Rivers, and along other tributary streams.

The units mapped as colluvium (C) should be regarded as potentially unstable, and subject to failure if disturbed by any form of construction. The morainic units (M), characterized by silty and clayey matrices and low concentrations of coarse clasts, are subject to failure in areas where they crop out along river valleys or at the crests of slopes. These diamictons do not differ greatly in stability from the glaciolacustrine silt and clay units (LG), and failures of both sediment types are common. Large-scale failures in fluvial deposits (F) are relatively rare, due to the coarse texture of most fluvial units. Small grain flow failures are common, however, where the sediment is subject to fluvial undercutting or where colluviation of adjacent units has left fluvial sediments without lateral support. Many slope failure planes are developed in the underlying shale bedrock, and thus any overlying surficial unit can undergo failure if the bedrock loses lateral support due to fluvial downcutting.

Thus, all of the major terrain units present in the eastern Peace River region are subject to slope failure. Extreme caution should therefore be observed in any effort to exploit or utilize river valley slopes.

WASTE DISPOSAL

In order for a sedimentary unit to be suitable for the disposal of liquid waste, it must be relatively impermeable and isolated from the regional groundwater system, as well as not subject to slope failure. In areas removed from the major river valleys, both glaciolacustrine silt and clay units and morainic diamicton units with fine-textured matrices are potentially suitable for waste disposal. Many of these deposits, however, contain sand lenses which are permeable. Thus, extensive site investigation must be undertaken prior to designation of any waste disposal site. Units mapped as veneers (v) or blankets (b) are unsuitable for waste disposal sites, because their thinness precludes isolation of the excavation floor from the underlying sedimentary unit and from the groundwater system.

Coarse-textured morainic, fluvial, and glaciofluvial units are unsuitable as liquid waste repositories, because their texture allows rapid percolation of the waste into the groundwater system. These deposits may be suitable for the disposal of small quantities of non-hazardous solid waste, but the waste must be isolated from the groundwater system and from other sources of water, including precipitation. The difficulties in ensuring that no waste reaches the groundwater table from such sites are extensive. The abundance of suitable silt and clay deposits throughout the eastern Peace River region, combined with the scarcity of coarse-textured deposits and their consequent value as sources of aggregate, indicates that waste disposal sites should be located in the fine-textured units.

SUMMARY

Sediments exposed in the eastern Peace River region consist dominantly of fine-grained glaciolacustrine deposits and morainic silty and clayey diamictons. Fluvial and colluvial deposits are present along the Peace River and its major tributaries. Organic deposits consist mainly of fibric units derived from *Carex*, with lesser amounts of mesic *Sphagnum* deposits. Glaciofluvial sands and gravels, lacustrine silts, and eolian sands are present in minor amounts in isolated areas.

Aggregate exploitation in the region is confined to the glaciofluvial deposits, and to terraces of coarse fluvial sediments along the Peace River. No new, readily accessible sources of aggregate were noted. Peat resources in the region are also limited, and economic exploitation is not feasible at present.

Valley slopes throughout the region are subject to slope failure and colluviation, and development of these sites should be minimized. Liquid and solid waste disposal sites should be located in thick fine-textured glaciolacustrine and morainic units, but only after sedimentological investigation.

ACKNOWLEDGMENTS

This research was supported by a British Columbia Geoscience Research Grant. I am indebted to Dr. P.T. Bobrowsky and V.M. Levson of the Surficial Geology Unit, British Columbia Ministry of Energy, Mines, and Petroleum Resources, for extensive discussions of Peace River geology. G. Bradbury provided capable assistance in the field.

REFERENCES

Bobrowsky, P.T. (1989): Late Cenozoic Geology of the Northern Rocky Mountain Trench, British Columbia; unpublished Ph.D. thesis, *University of Alberta*, Edmonton, Alberta, 463 pages.

Bobrowsky, P.T., Catto, N.R. and Levson, V. (1991): Reconnaissance Quaternary Geological Investigations in Peace River District, British Columbia (93P, 94A); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1990, Paper 1991-1, pages 345-358.

Bobrowsky, P.T., Catto, N.R., Liverman, D.G.E. and Rutter, N.W. (in preparation): Laurentide, Cordilleran, and Montane Glaciers in the Peace River – Grande Prairie Region, Alberta and British Columbia.

Canada Soil Survey Committee (1978): The Canadian System of Soil Classification; Canada Department of Agriculture, Publication 1646; *Supply and Services Canada*, Ottawa, 164 pages.

Environment Canada (1984): Canadian Climatic Normals, 1951-1980; *Environment Canada*, Ottawa.

Hora, Z.D. (1988): Sand and Gravel Study 1985; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-27, 41 pages.

Howes, D.E. and Kenk, E. (1988): Terrain Classification System for British Columbia (Revised Edition); *B.C. Ministry of Environment*, Manual 10, 90 pages.

Liverman, D.G.E. (1989): The Quaternary Geology of the Grande Prairie Area, Alberta, unpublished Ph.D. thesis; *University of Alberta*, Edmonton, Alberta, 216 pages.

Liverman, D.G.E. (in press): Sedimentology of Glaciolacustrine Deposits, Grande Prairie, Alberta; *Boreas*.

Mathews, W.H. (1978): Quaternary Stratigraphy and Geomorphology of Charlie Lake (94A) Map-area, British Columbia; *Geological Survey of Canada*, Paper 76-20, 25 pages.

Mathews, W.H. (1980): Retreat of the Last Ice Sheets in Northeastern British Columbia and Adjacent Alberta; *Geological Survey of Canada*, Bulletin 331, 22 pages.

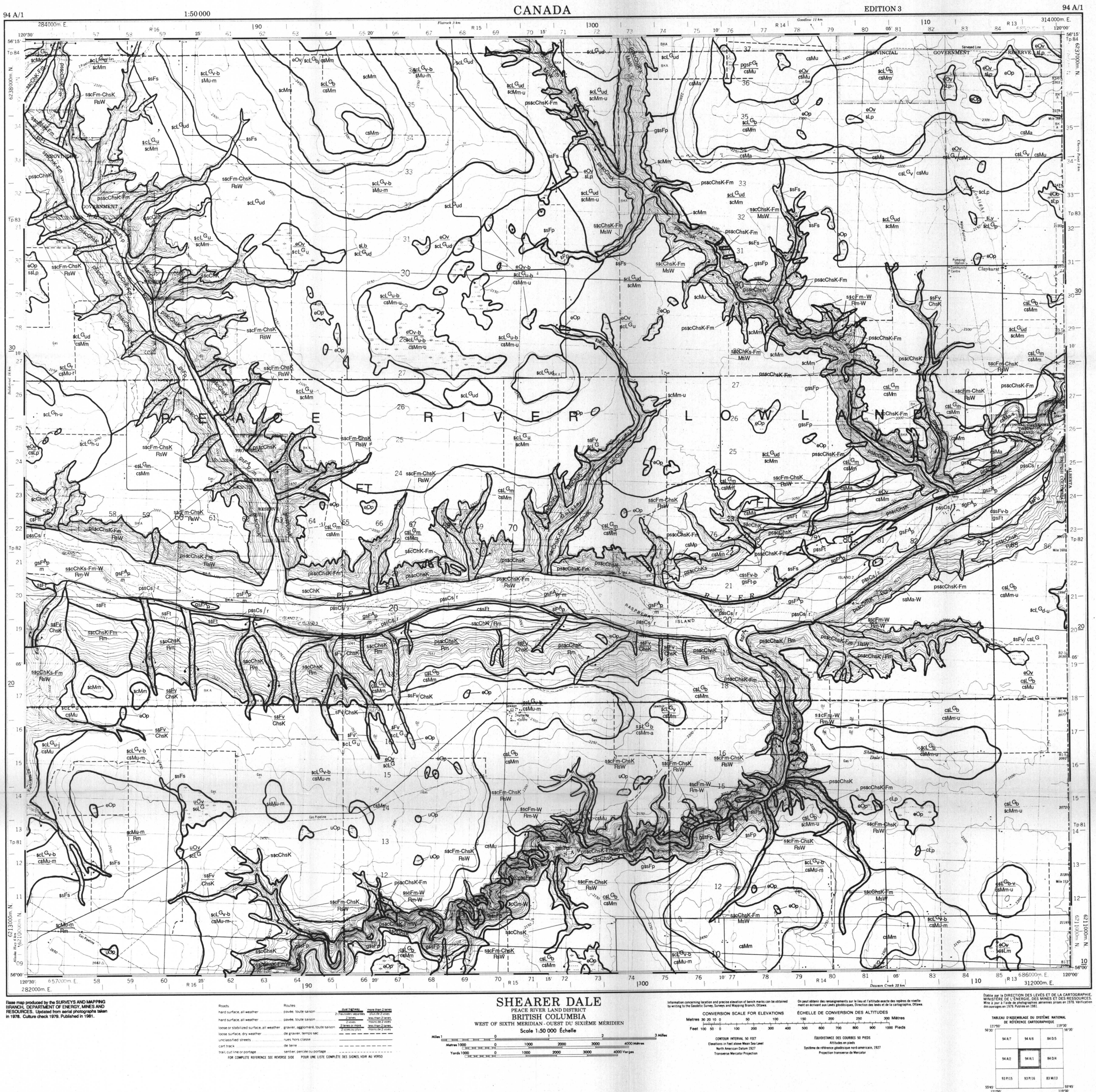
Mathews, W.H. (1986): Physiographic Map of the Canadian Cordillera; *Geological Survey of Canada*, Map 1701 A.

Maynard, D.E. (1988): Peatland Inventory of British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-33, 73 pages.

Rowe, J.S. (1972): Forest Regions of Canada; *Department of the Environment*, Canada; Canadian Forestry Service Publication 1300, 172 pages.

Seyers, W. and Buchanan, P. (1990): Assessment of Upper Left Bank Overburden Deposits – Task C9B-B03D, Peace River Site C; *Klohn-Crippen Consultants, Ltd.*, Report KC53.

Stott, D.F. (1975): The Cretaceous System in Northeastern British Columbia, *in* The Cretaceous System in the Western Interior of North America, W.G.E. Caldwell, Editor; *Geological Association of Canada*, Special Paper 13, pages 441-467.



Province of British Columbia
Ministry of Energy, Mines
and Petroleum Resources

Geological Survey Branch

OPEN FILE 1991-11

(Sheet 1 of 4)

SURFICIAL GEOLOGY OF THE PEACE RIVER AREA

NTS 94A/1, 2, 7, 8

Geology by N. Catto

1:50 000

Geology based on air photo interpretation with ground truthing in areas with road access. Fieldwork completed in 1990. Drafting by C. P. Smith.

MAP UNIT LETTER NOTATION

A terrain map unit symbol is composed of combination of letters which designate different characteristics of the terrain. The relative position of letters within the symbol indicates the characteristic that they represent.

SIMPLE TERRAIN UNIT SYSTEM

qualifying descriptor — surficial material — texture — surficial material — surface expression — qualifying descriptor — geological process

g FGt -VI
sL

This map unit consists of a gravelly glaciofluvial terrace that overlies sandy lacustrine materials and is modified by gullies that are no longer active.

Explanatory Notes

1. Units consisting of two or more types of terrain are designated by two or more groups of letters separated by slashes and/or dots (*See* Composite Units below).
2. Materials underlying the surface unit are shown by a symbol that is written beneath the surface unit symbol and separated from it by a horizontal line.

SURFACE EXPRESSION

Surface expression is the topography or form of the land surface. In general, the terms listed here are used to describe features that are not adequately shown on the topographic base map.

Symbol	Name	Description
a	moderate slope	An unidirectional surface with a slope gradient >15° to >26°; local surface irregularities are less than 1 metre.
b	blanket	A mantle of unconsolidated materials which 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 metre thick; if the underlying unit consists of unconsolidated materials, it is shown in the unit symbol; if no underlying unit is shown, it may be assumed to be bedrock; if the underlying unit consists of unconsolidated materials of unkown origin, then only its surface expression is shown.
c	cone	A cone or segment of a cone with a relatively smooth slope gradient greater than 15°.
d	depression	Circular or irregular area of lower elevation lower than the surrounding terrain; depressions are greater than 2 metres deep.
f	fan	A smooth segment of a cone with a slope gradient up to 15°.
h	hummocky	Steep-sided hillocks and hollows that are rounded or irregular in plan; slopes of 15-35° predominate on unconsolidated materials and slopes of 15-90° predominate on bedrock; local relief is greater than 1 metre.
j	gentle slope	An unidirectional surface with a slope gradient >3° and <15°; local surface irregularities have a relief <1 metre.
k	moderately steep	Unidirectional surface with a slope gradient >26° and <35°; local surface irregularities have a relief <1 metre.
m	rolling	Elongate hillock(s) with slopes dominantly between 3 and 15° with local relief >1 metre; in plan, an assemblage of parallel or sub-parallel linear forms with subdued relief.
p	plain	A level or gently sloping unidirectional surface with gradients up to 3°; local surface irregularities have a relief <1 metre.
r	ridged	Elongate or linear, parallel or sub-parallel hillock(s) or ridges with slopes predominantly between 15 and 35° on unconsolidated materials and between 15 and 90° on bedrock; local relief is >1 metre.
s	steep	Steeply inclined slopes (scarps) with gradients >35° on both unconsolidated materials and bedrock.
t	terraced	Step-like topography; includes both scarp face and the horizontal or gently inclined surface above it.
u	undulating	Gently sloping hillock(s) and hollow(s) with slopes up to 15°; local relief is <1 metre; in plan, an assemblage of non-linear, chaotic forms.
v	veneer	A mantle of unconsolidated materials 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 metre 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.

Explanatory Notes

1. The use of two or three surface expressions symbols together implies that there is a mixing of discrete forms, not a set of intermediate forms.
2. Where more than one surface expression symbol is used, the symbols are written in order of decreasing importance based on their areal extent.

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.

For example:

- 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

TEXTURE

Clastic Terms

Symbol	Name	Size (mm)	Other Characteristics
a	blocks	>256	angular particles
b	boulders	>256	rounded and subrounded particles
k	cobbles	64-256	rounded and subrounded particles
p	pebbles	2-64	rounded and subrounded particles
s	sand	0.062-2	
$	silt	0.002-0.062	
c	clay	<0.002	
d	mixed fragments	>2	mix of rounded and angular particles
g	gravel	>2	mix of boulders, cobbles and pebbles
x	angular fragments	>2	mix of rubble and blocks
r	rubble	2-256	angular particles
m	mud	>0.062	mix of clay and silt
f	shells		shell or shell fragments

Organic Terms

Symbol	Name	Characteristics
e	fibric	least decomposed organic material; well-preserved fibre (40%) can be identified as to botanical origin after rubbing.
u	mesic	intermediate decomposition between fibric and mesic
h	humic	advanced decomposed organic material; less than 10% of fibres identified as to botanical origin after rubbing.

Explanatory 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 or from a knowledge of the bedrock geology. The reader is referred to surficial material descriptions for general textural information.
2. Where two or three textural terms are used together, they are written in reverse order of importance and indicate that either the various textures are intermixed or inter stratified.

SURFICIAL MATERIALS

Surficial materials are classified according to their mode of formation or deposition. This influences their physical characteristics such as texture, structure and compaction, which in turn control conditions of drainage and slope stability.

Each surficial material has an assumed status of activity. Status is either active or inactive. It is only indicated when the actual state of formation is contrary to the assumed state defined for each surficial material and is indicated by the Qualifying Descriptor Symbol (*see below*)

Symbol	Name (Assumed Status of Formative Process)	Description
A	anthropogenic (A)	Man-made or man-modified materials, including those associated with mineral exploitation, waste disposal and landfill.
C	colluvial (A)	Products of mass wastage; generally consists of massive to moderately well-stratified to non-sorted sediments with a variety of particle sizes and shapes; includes talus slopes, avalanche cones, mantles of weathered bedrock, landslide debris, earthflows and debris flows.
D	weathered bedrock (A)	Bedrock decomposed in situ by processes of mechanical and/or chemical weathering; the character of the bedrock debris depends on the process of formation and type of bedrock.
E	eolian (A)	Materials transported and deposited by wind action; generally consist of medium to fine sand and coarse silt that is well-sorted and poorly compacted; includes dunes and loess.
F	fluvial (I)	Materials transported and deposited by streams and rivers, alluvial materials; generally consist of gravel, sand or silt; gravels are typically well-rounded and contain interstitial sand; sediments tend to be moderately to well-sorted and stratified; includes floodplains, river terraces, deltas and some alluvial fans.
FG	glaciofluvial (I)	Fluvial materials deposited in association with glacier ice; generally consist of gravel and sand, and show evidence of ice melting such as kettles and slump structures; sorting, stratification and particle size and shape are variable; includes kettled outwash, kames, kame terraces and eskers.
I	ice (A)	Permanent snow and ice; glaciers and icefields
L	lacustrine (I)	Sediments deposited in lakes or reworked by wave action around lake shorelines; generally consist of stratified sand, silt and clay deposited on the lake floor or well-sorted littoral sand or gravel; includes beaches, spits and bars, and lacustrine terraces of silt or clay.
LG	glaciolacustrine (I)	Lacustrine materials that were deposited in association with glacier ice; generally similar to lacustrine materials but display features such as slump structures, ice-rafted stones and kettles.
M	morainal (I)	Material deposited directly by glaciers, till; generally consist of well-compacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, shapes and lithologies in a matrix of sand, silt and clay; includes moraines, till plains and drumlins.
O	organic (A)	Material resulting from the accumulation and decay of vegetative matter; generally consists of peat, although minor amounts of marl and inorganic detritus may be included; includes bogs, fens, swamps and thin organic veneers over bedrock (folisols).
R	bedrock (I)	Outcrops and rock covered by less than 10 cm of unconsolidated material.
U	undifferentiated (I)	A layered sequence of more than three types of material outcropping on a scarp slope.
V	volcanic (I)	Unconsolidated pyroclastic sediments including volcanic ash, lapilli and coarser ejecta.
W	marine (I)	Sediments deposited in marine waters, or reworked by wave action along marine shorelines; generally consist of clay, silt, sand or gravel that is sorted and stratified and may contain shells; includes spits bars, beaches and deeper water deposits.
WG	glaciomarine (I)	Sediments of glacial origin, laid down in a marine environment in close proximity to glacier ice; generally relatively poorly sorted and stratified or massive, and may contain shells; includes marine drift and stoney clays.

GEOLOGICAL PROCESSES

These terms indicate geological processes that are currently modifying or have modified surficial materials and surface expressions.

The status of all geological processes are assumed to be active. The exceptions are the processes, channeled by meltwater and kettled which have an assumed status of inactive.

Symbol	Name (Assumed Process Status)	Description
A	avalanches (A)	Slopes modified by frequent snow avalanches and by the deposition of rock debris transported by snow avalanches; sopes affected by ice falling from glaciers.
B	braiding channel (A)	A channel zone characterized by many diverging and converging channels separated by unvegetated bars and temporary islands of gravel and sand.
C	cryoturbation (A)	Unconsolidated sediments modified by frost heaving and churning due to frost action; includes patterned ground.
D	deflation (A)	The removal of sand and silt from unconsolidated materials by wind action.
E	channelled (I)	Erosion and channel formation by meltwater alongside, beneath and in front of a glacier.
F	slow mass movement (A)	Downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding.
H	kettled (I)	Depressions formed in surficial materials due to the melting of buried, or partially buried glacier ice.
I	irregular channel (A)	A single, clearly defined main channel displaying irregular turns and bends without repetition of similar features.
J	anastamosing channel (A)	A channel zone where channels diverge and converge around many islands; the islands are vegetated.
K	karst processes (A)	Processes associated with the solution of carbonates and other soluble rocks; includes underground and surface weathering and subsidence resulting from solution.
M	meandering channel (A)	A clearly defined channel characterized by a regular and repeated pattern of bends with relatively regular amplitude and wave length.
N	nivation (A)	Erosion of bedrock and surficial materials beneath and along the margin of snow patches by freeze-thaw processes, snow meltwater action and snow creep.
P	piping (A)	Subterranean erosion of surficial materials by flowing water that results in the formation of tubular underground conduits.
R	rapid mass movement (A)	Rapid downslope movement of dry, moist or saturated debris derived from surficial material and/or bedrock by falling, sliding or flowing.
S	solifluction (A)	Slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate.
U	inundation (A)	Terrain seasonally under standing water which results from high watertable.
V	gully erosion (A)	Modification of unconsolidated or consolidated surfaces by various processes such as running water, mass movement and snow avalanching that results in parallel or subparallel ravines.
W	washing (A)	Modification by wave action resulting in lag deposits formed by the removal of fines, and wave cut platforms.
X	permafrost (A)	Processes controlled by the presence of permafrost, and permafrost aggradation or degradation; permafrost is earth material whose temperature remains below 0°C for more than two continuous years.
Z	general periglacial processes (A)	Solifluction, cryoturbation and nivation occurring together within a single unit.

Explanatory Note

Geological process symbols are used where a relatively large portion of a terrain map unit is affected by the process. On-site symbols may be used to indicate modification of a small part of the unit by a single or a few features.

QUALIFYING DESCRIPTORS

Qualifying descriptors qualify either surficial material or geological process terms. They are used in order to supply additional information about the mode of formation and/or depositional environment of surficial materials and the status of activity of geological processes.

Symbol	Name	Description
G	glacial	Used to qualify non-glacial surficial materials where there is evidence that glacier ice affected the mode of deposition of materials (*See* surficial materials FG, LG, WG).
A	active:	There is evidence that a geological 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 surficial material is operative at the present time.
I	inactive:	There is no evidence to suggest that a geological process is continuing or recurrent; the process of formation of a surficial material has ceased.

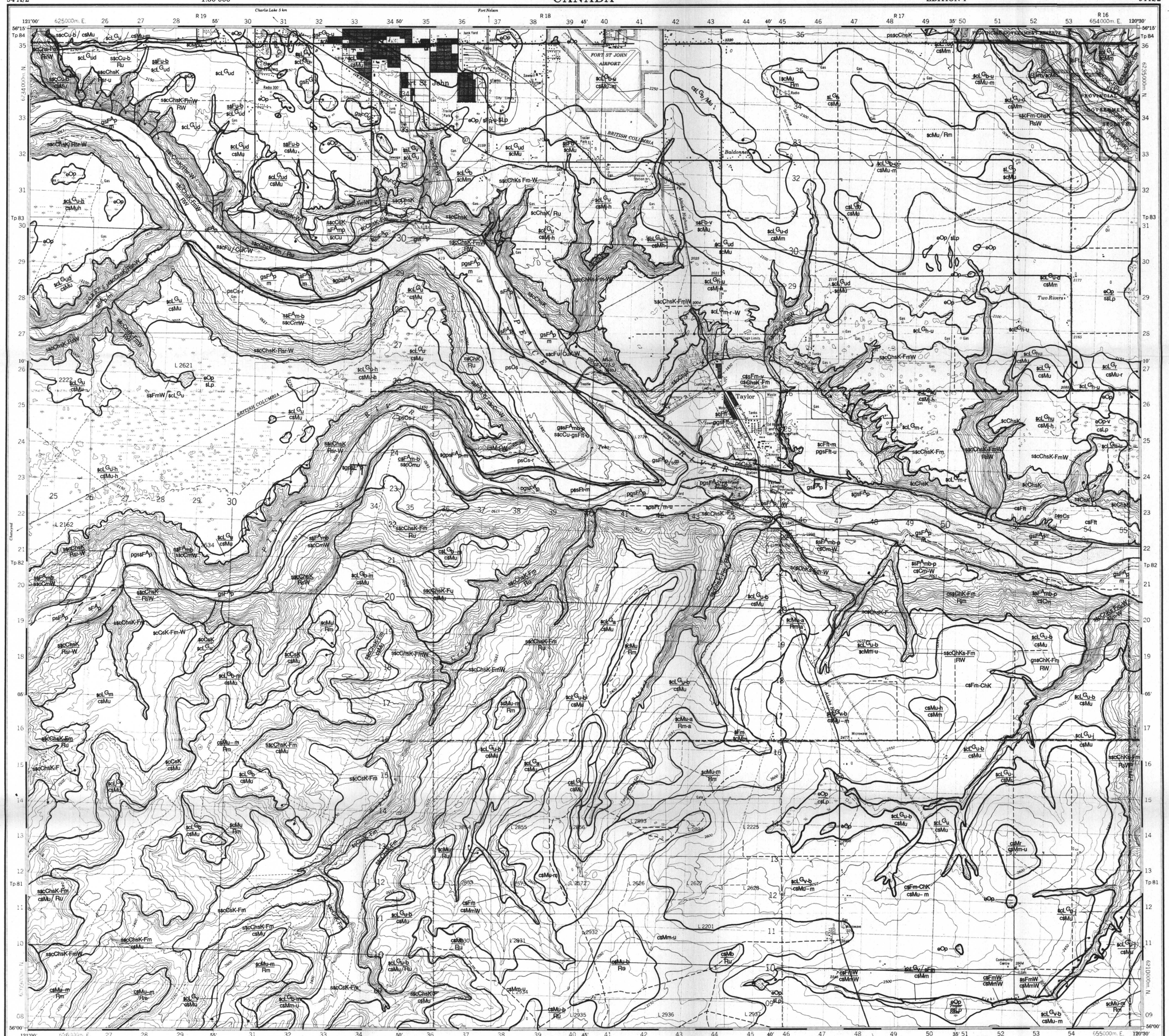
Explanatory Notes

An activity qualifying descriptor for surficial materials and geological processes are shown only in unit symbols where the current state of activity is contrary to the designated state.

ON-SITE SYMBOLS

On-site symbols used in this classification system are outlined below. An upper case letter in the notes column indicates the symbol is standard in terms of shape and size (S), or drawn to actual map scale shape or length (R).

Name	Symbol	Notes
GLACIAL FEATURES		
Drumlin		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Crag and tail		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Roches moutonnées		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Striae, grooves (ice flow direction known; unknown)		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Undifferentiated lineations and flutings		symbol is placed in the centre of the feature (S)
Moraine ridge (major)		line drawn along ridge crest (R)
Moraine ridges (minor)		lines drawn along ridge crests (R)
Esker (flow direction known; unknown)		drawn along ridge crest (R)
Kettle holes (large; small)		(R; S)
Meltwater channel (large)		arrow shown if flow direction is known (R)
Meltwater channel (small)		arrowhead shown if flow direction is known (R)
Cirques		line drawn along ridge crest (R)
Glacier flow		ice flow in the direction of the arrow (R)
PERIGLACIAL FEATURES		
Blockfield		(R)
Rock glaciers		(R)
Tors		(S)
Observation of frozen ground		(S)
OTHER LANDFORMS AND FEATURES		
Dunes (active; inactive)		(R)
Escarpment		hachures extend to base of slope (R)
Strandline		(R)
OTHER LANDFORMS AND FEATURES (continued)		
Piping depression		(S)
Karst depression (large; small)	sh sh	(R; S)
Gully		(R)
Spring		(S)
Gravel pit (active; abandoned)		(S)
Quarry or mine (active; abandoned)		(S)
Gravel occurrence	G	(S)
Cinder cone	Vc	(S)
MASS MOVEMENT SYMBOLS		
Snow avalanche		symbol follows track downslope (R)
Large Landslide:		
headwall scar only		(R)
headwall scar and area affected		(R)
Small Landslide:		
headwall scar only		(S)
headwall scar and track		symbol follows track downslope (R)
Tension cracks		(S)
Sackung (sagging slopes)		(S)
POINT OBSERVATIONS		
Quaternary fossil site	F	(S)
Observation site (ground; air)		(S)
Stratigraphic section site		(S)
14C dated site	Date / Material / Lab / Elevation	location on map with data recorded in legend (S)
Anthropogenic site	A	(S)



Base map produced by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES. Updated from aerial photographs taken in 1976. Culture check 1976. Published in 1981.

FORT ST JOHN
PEACE RIVER LAND DISTRICT
BRITISH COLUMBIA
WEST OF SIXTH MERIDIAN-OUEST DU SIXIÈME MÉRIDIEN
Scale 1:50 000 Échelle

Province of British Columbia
Ministry of Energy, Mines
and Petroleum Resources

Geological Survey Branch

OPEN FILE 1991-11
(Sheet 2 of 4)

SURFICIAL GEOLOGY OF THE PEACE RIVER AREA

NTS 94A/1, 2, 7, 8

Geology by N. Catto

1:50 000

Geology based on air photo interpretation with ground truthing in areas with road access. Fieldwork completed in 1990. Drafting by C. P. Smith.

MAP UNIT LETTER NOTATION

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SIMPLE TERRAIN UNIT SYSTEM

This map unit consists of a gravelly glaciofluvial terrace that overlies sandy lacustrine materials and is modified by gullies that are no longer active.

Explanatory Notes

1. Units consisting of two or more types of terrain are designated by two or more groups of letters separated by slashes and/or dots (*See* Composite Units below).
2. Materials underlying the surface unit are shown by a symbol that is written beneath the surface unit symbol and separated from it by a horizontal line.

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Symbol	Name	Description
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d	depression	Circular or irregular area of lower elevation lower than the surrounding terrain; depressions are greater than 2 metres deep.
f	fan	A smooth segment of a cone with a slope gradient up to 15°.
h	hummocky	Steep-sided hillocks and hollows that are rounded or irregular in plan; slopes of 15-35° predominate on unconsolidated materials and slopes of 15-90° predominate on bedrock; local relief is greater than 1 metre.
j	gentle slope	An unidirectional surface with a slope gradient >3° and <15°; local surface irregularities have a relief <1 metre.
k	moderately steep	Unidirectional surface with a slope gradient >26° and <35°; local surface irregularities have a relief <1 metre.
m	rolling	Elongate hillock(s) with slopes dominantly between 3 and 15° with local relief >1 metre; in plan, an assemblage of parallel or sub-parallel linear forms with subdued relief.
p	plain	A level or gently sloping unidirectional surface with gradients up to 3°; local surface irregularities have a relief <1 metre.
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t	terraced	Step-like topography; includes both scarp face and the horizontal or gently inclined surface above it.
u	undulating	Gently sloping hillock(s) and hollow(s) with slopes up to 15°; local relief is <1 metre; in plan, an assemblage of non-linear, chaotic forms.
v	veneer	A mantle of unconsolidated materials 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 metre 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.

Explanatory Notes

1. The use of two or three surface expressions symbols together implies that there is a mixing of discrete forms, not a set of intermediate forms.
2. Where more than one surface expression symbol is used, the symbols are written in order of decreasing importance based on their areal extent.

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.

For example:

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

TEXTURE

Clastic Terms

Symbol	Name	Size (mm)	Other Characteristics
a	blocks	>256	angular particles
b	boulders	>256	rounded and subrounded particles
k	cobbles	64-256	rounded and subrounded particles
p	pebbles	2-64	rounded and subrounded particles
s	sand	0.062-2	
$	silt	0.002-0.062	
c	clay	<0.002	
d	mixed fragments	>2	mix of rounded and angular particles
g	gravel	>2	mix of boulders, cobbles and pebbles
x	angular fragments	>2	mix of rubble and blocks
r	rubble	2-256	angular particles
m	mud	>0.062	mix of clay and silt
f	shells		shell or shell fragments

Organic Terms

Symbol	Name	Characteristics
e	fibric	least decomposed organic material; well-preserved fibre (40%) can be identified as to botanical origin after rubbing.
u	mesic	intermediate decomposition between fibric and mesic
h	humic	advanced decomposed organic material; less than 10% of fibres identified as to botanical origin after rubbing.

Explanatory 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 or from a knowledge of the bedrock geology. The reader is referred to surficial material descriptions for general textural information.
2. Where two or three textural terms are used together, they are written in reverse order of importance and indicate that either the various textures are intermixed or inter stratified.

ON-SITE SYMBOLS

On-site symbols used in this classification system are outlined below. An upper case letter in the notes column indicates the symbol is standard in terms of shape and size (S), or drawn to actual map scale shape or length (R).

Name	Symbol	Notes
GLACIAL FEATURES		
Drumlin		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Crag and tail		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Roches moutonnées		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Striae, grooves (ice flow direction known; unknown)		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Undifferentiated lineations and flutings		symbol is placed in the centre of the feature (S)
Moraine ridge (major)		line drawn along ridge crest (R)
Moraine ridges (minor)		lines drawn along ridge crests (R)
Esker (flow direction known; unknown)		drawn along ridge crest (R)
Kettle holes (large; small)		(R; S)
Meltwater channel (large)		arrow shown if flow direction is known (R)
Meltwater channel (small)		arrowhead shown if flow direction is known (R)
Cirques		line drawn along ridge crest (R)
Glacier flow		ice flow in the direction of the arrow (R)
PERIGLACIAL FEATURES		
Blockfield		(R)
Rock glaciers		(R)
Tors		(S)
Observation of frozen ground		(S)
OTHER LANDFORMS AND FEATURES		
Dunes (active; inactive)		(R)
Escarpment		hachures extend to base of slope (R)
Strandline		(R)

SURFICIAL MATERIALS

Surficial materials are classified according to their mode of formation or deposition. This influences their physical characteristics such as texture, structure and composition, which in turn control conditions of drainage and slope stability.

Each surficial material has an assumed status of activity. Status is either active or inactive. It is only indicated when the actual state of formation is contrary to the assumed state defined for each surficial material and is indicated by the Qualifying Descriptor Symbol (see below).

Symbol	Name (Assumed Status of Formative Process)	Description
A	anthropogenic (A)	Man-made or man-modified materials, including those associated with mineral exploitation, waste disposal and landfill.
C	colluvial (A)	Products of mass wastage; generally consists of massive to moderately well-stratified to non-sorted sediments with a variety of particle sizes and shapes; includes talus slopes, avalanche cones, mantles of weathered bedrock, landslide debris, earthflows and debris flows.
D	weathered bedrock (A)	Bedrock decomposed in situ by processes of mechanical and/or chemical weathering; the character of the bedrock debris depends on the process of formation and type of bedrock.
E	eolian (A)	Materials transported and deposited by wind action; generally consist of medium to fine sand and coarse silt that is well-sorted and poorly compacted; includes dunes and loess.
F	fluvial (I)	Materials transported and deposited by streams and rivers, alluvial materials; generally consist of gravel, sand or silt; gravels are typically well-rounded and contain interstitial sand; sediments tend to be moderately to well-sorted and stratified; includes floodplains, river terraces, deltas and some alluvial fans.
FG	glaciofluvial (I)	Fluvial materials deposited in association with glacier ice; generally consist of gravel and sand, and show evidence of ice melting such as kettles and slump structures; sorting, stratification and particle size and shape are variable; includes kettled outwash, kames, kame terraces and eskers.
I	ice (A)	Permanent snow and ice; glaciers and icefields
L	lacustrine (I)	Sediments deposited in lakes or reworked by wave action around lake shorelines; generally consist of stratified sand, silt and clay deposited on the lake floor or well-sorted littoral sand or gravel; includes beaches, spits and bars, and lacustrine terraces of silt or clay.
LG	glaciolacustrine (I)	Lacustrine materials that were deposited in association with glacier ice; generally similar to lacustrine materials but display features such as slump structures, ice-rafted stones and kettles.
M	morainal (I)	Material deposited directly by glaciers, till; generally consist of well-compacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, shapes and lithologies in a matrix of sand, silt and clay; includes moraines, till plains and drumlins.
O	organic (A)	Material resulting from the accumulation and decay of vegetative matter; generally consists of peat, although minor amounts of marl and inorganic detritus may be included; includes bogs, fens, swamps and thin organic veneers over bedrock (folisols).
R	bedrock (I)	Outcrops and rock covered by less than 10 cm of unconsolidated material.
U	undifferentiated (I)	A layered sequence of more than three types of material outcropping on a scarp slope.
V	volcanic (I)	Unconsolidated pyroclastic sediments including volcanic ash, lapilli and coarser ejecta.
W	marine (I)	Sediments deposited in marine waters, or reworked by wave action along marine shorelines; generally consist of clay, silt, sand or gravel that is sorted and stratified and may contain shells; includes spits bars, beaches and deeper water deposits.
WG	glaciomarine (I)	Sediments of glacial origin, laid down in a marine environment in close proximity to glacier ice; generally relatively poorly sorted and stratified or massive, and may contain shells; includes marine drift and stoney clays.

GEOLOGICAL PROCESSES

These terms indicate geological processes that are currently modifying or have modified surficial materials and surface expressions.

The status of all geological processes are assumed to be active. The exceptions are the processes, channeled by meltwater and kettled which have an assumed status of inactive.

Symbol	Name (Assumed Process Status)	Description
A	avalanches (A)	Slopes modified by frequent snow avalanches and by the deposition of rock debris transported by snow avalanches; slopes affected by ice falling from glaciers.
B	braiding channel (A)	A channel zone characterized by many diverging and converging channels separated by unvegetated bars and temporary islands of gravel and sand.
C	cryoturbation (A)	Unconsolidated sediments modified by frost heaving and churning due to frost action; includes patterned ground.
D	deflation (A)	The removal of sand and silt from unconsolidated materials by wind action.
E	channelled (I)	Erosion and channel formation by meltwater alongside, beneath and in front of a glacier.
F	slow mass movement (A)	Downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding.
H	kettled (I)	Depressions formed in surficial materials due to the melting of buried, or partially buried glacier ice.
I	irregular channel (A)	A single, clearly defined main channel displaying irregular turns and bends without repetition of similar features.
J	anastamosing channel (A)	A channel zone where channels diverge and converge around many islands; the islands are vegetated.
K	karst processes (A)	Processes associated with the solution of carbonates and other soluble rocks; includes underground and surface weathering and subsidence resulting from solution.
M	meandering channel (A)	A clearly defined channel characterized by a regular and repeated pattern of bends with relatively regular amplitude and wave length.
N	nivation (A)	Erosion of bedrock and surficial materials beneath and along the margin of snow patches by freeze-thaw processes, snow meltwater action and snow creep.
P	piping (A)	Subterranean erosion of surficial materials by flowing water that results in the formation of tubular underground conduits.
R	rapid mass movement (A)	Rapid downslope movement of dry, moist or saturated debris derived from surficial material and/or bedrock by falling, sliding or flowing.
S	solifluction (A)	Slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate.
U	inundation (A)	Terrain seasonally under standing water which results from high watertable.
V	gully erosion (A)	Modification of unconsolidated or consolidated surfaces by various processes such as running water, mass movement and snow avalanching that results in parallel or subparallel ravines.
W	washing (A)	Modification by wave action resulting in lag deposits formed by the removal of fines, and wave cut platforms.
X	permafrost (A)	Processes controlled by the presence of permafrost, and permafrost aggradation or degradation; permafrost is earth material whose temperature remains below 0°C for more than two continuous years.
Z	general periglacial processes (A)	Solifluction, cryoturbation and nivation occurring together within a single unit.

Explanatory Note

Geological process symbols are used where a relatively large portion of a terrain map unit is affected by the process. On-site symbols may be used to indicate modification of a small part of the unit by a single or a few features.

QUALIFYING DESCRIPTORS

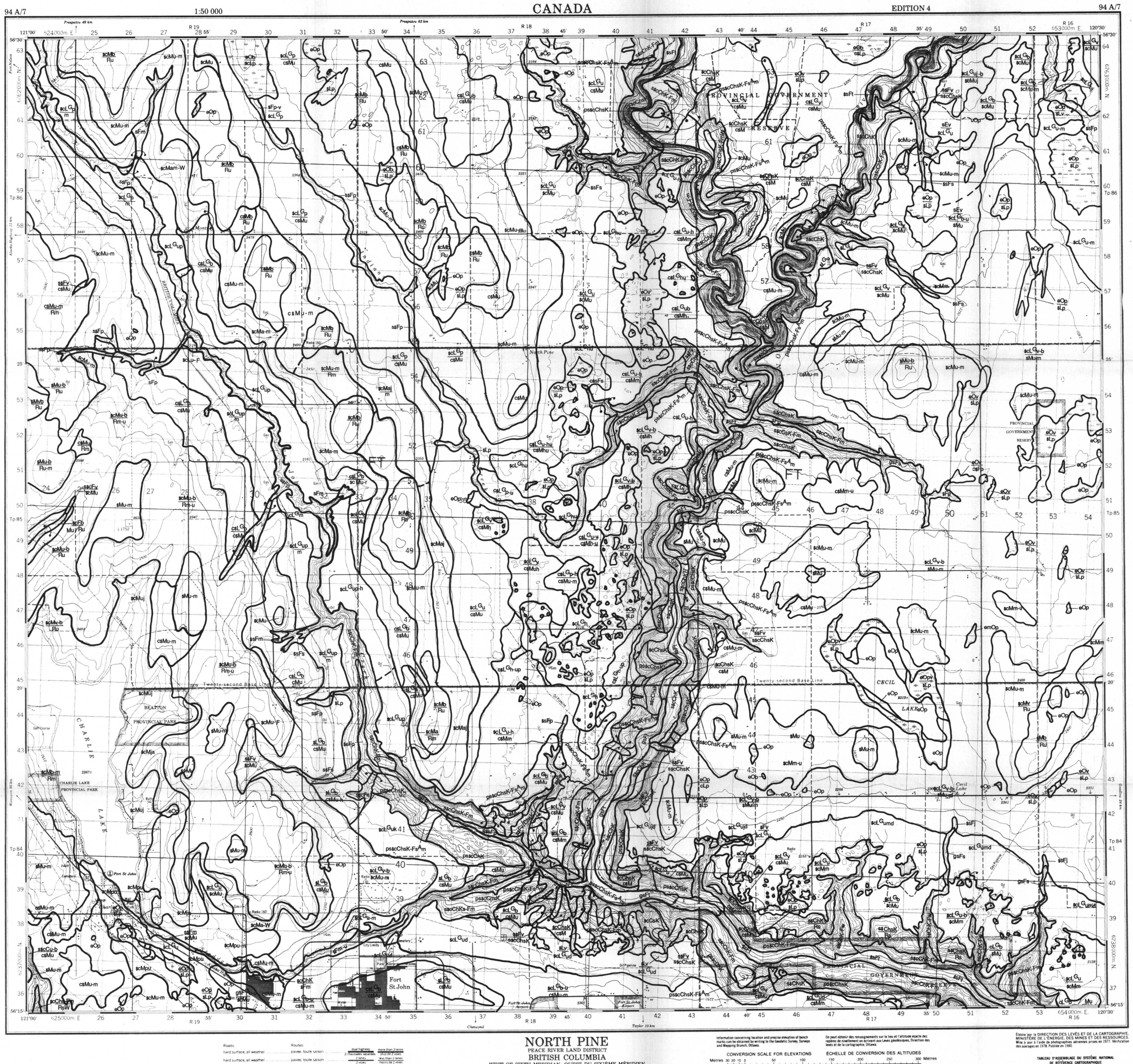
Qualifying descriptors qualify either surficial material or geological process terms. They are used in order to supply additional information about the mode of formation and/or depositional environment of surficial materials and the status of activity of geological processes.

Symbol	Name	Description
G	glacial	Used to qualify non-glacial surficial materials where there is evidence that glacier ice affected the mode of deposition of materials (*See* surficial materials FG, LG, WG).
A	active:	There is evidence that a geological 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 surficial material is operative at the present time.
I	inactive:	There is no evidence to suggest that a geological process is continuing or recurrent; the process of formation of a surficial material has ceased.

Explanatory Notes

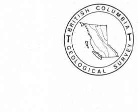
An activity qualifying descriptor for surficial materials and geological processes are shown only in unit symbols where the current state of activity is contrary to the designated state.

OTHER LANDFORMS AND FEATURES (continued)		
Piping depression		(S)
Karst depression (large; small)		(R; S)
Gully		(R)
Spring		(S)
Gravel pit (active; abandoned)		(S)
Quarry or mine (active; abandoned)		(S)
Gravel occurrence		(S)
Cinder cone		(S)
MASS MOVEMENT SYMBOLS		
Snow avalanche		symbol follows track downslope (R)
Large Landslide:		
headwall scar only		(R)
headwall scar and area affected		(R)
Small Landslide:		
headwall scar only		(S)
headwall scar and track		symbol follows track downslope (R)
Tension cracks		(S)
Sackung (sagging slopes)		(S)
POINT OBSERVATIONS		
Quaternary fossil site		(S)
Observation site (ground; air)		(S)
Stratigraphic section site		(S)
^{14}C dated site	Date / Material / Lab / Elevation	location on map with data recorded in legend (S)
Anthropogenic site		(S)



NORTH PINE

PEACE RIVER LAND DISTRICT
BRITISH COLUMBIA
WEST OF SIXTH MERIDIAN - OUEST DU SIXIÈME MÉRIDIEN
Scale 1:50 000 Échelle



Province of British Columbia
Ministry of Energy, Mines
and Petroleum Resources

Geological Survey Branch

OPEN FILE 1991-11
(Sheet 3 of 4)

SURFICIAL GEOLOGY OF THE PEACE RIVER AREA

NTS 94A/1, 2, 7, 8

Geology by N. Catto

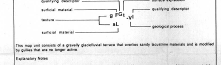
1:50 000

Geology based on air photo interpretation with ground truthing in areas with road access. Fieldwork completed in 1990. Drafting by C. P. Smith.

MAP UNIT LETTER NOTATION

A terrain map unit symbol is composed of combination of letters which designate different characteristics of the terrain. The relative position of letters within the symbol indicates the characteristic that they represent.

SIMPLE TERRAIN UNIT SYSTEM



This map unit consists of a gravelly glaciofluvial terrace that overlies sandy lacustrine materials and is modified by gullies that are no longer active.

Explanatory Notes

1. Units consisting of two or more types of terrain are designated by two or more groups of letters separated by slashes and/or dots (*See* Composite Units below).
2. Materials underlying the surface unit are shown by a symbol that is written beneath the surface unit symbol and separated from it by a horizontal line.

SURFACE EXPRESSION

Surface expression is the topography or form of the land surface. In general, the terms listed here are used to describe features that are not adequately shown on the topographic base map.

Symbol	Name	Description
a	moderate slope	An unidirectional surface with a slope gradient >15° to >26°; local surface irregularities are less than 1 metre.
b	blanket	A mantle of unconsolidated materials which 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 metre thick; if the underlying unit consists of unconsolidated materials, it is shown in the unit symbol; if no underlying unit is shown, it may be assumed to be bedrock; if the underlying unit consists of unconsolidated materials of unkown origin, then only its surface expression is shown.
c	cone	A cone or segment of a cone with a relatively smooth slope gradient greater than 15°.
d	depression	Circular or irregular area of lower elevation lower than the surrounding terrain; depressions are greater than 2 metres deep.
f	fan	A smooth segment of a cone with a slope gradient up to 15°.
h	hummocky	Steep-sided hillocks and hollows that are rounded or irregular in plan; slopes of 15-35° predominate on unconsolidated materials and slopes of 15-90° predominate on bedrock, local relief is greater than 1 metre.
j	gentle slope	An unidirectional surface with a slope gradient >3° and <15°, local surface irregularities have a relief <1 metre.
k	moderately steep	Unidirectional surface with a slope gradient >26° and <35°; local surface irregularities have a relief <1 metre.
m	rolling	Elongate hillock(s) with slopes dominantly between 3 and 15° with local relief >1 metre; in plan, an assemblage of parallel or sub-parallel linear forms with subdued relief.
p	plain	A level or gently sloping unidirectional surface with gradients up to 3°; local surface irregularities have a relief <1 metre.
r	ridged	Elongate or linear, parallel or sub-parallel hillock(s) or ridges with slopes predominantly between 15 and 35° on unconsolidated materials and between 15 and 90° on bedrock; local relief is >1 metre.
s	steep	Steeply inclined slopes (scarps) with gradients >35° on both unconsolidated materials and bedrock.
t	terraced	Step-like topography; includes both scarp face and the horizontal or gently inclined surface above it.
u	undulating	Gently sloping hillock(s) and hollow(s) with slopes up to 15°; local relief is <1 metre; in plan, an assemblage of non-linear, chaotic forms.
v	veneer	A mantle of unconsolidated materials 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 metre 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.

Explanatory Notes

1. The use of two or three surface expressions symbols together implies that there is a mixing of discrete forms, not a set of intermediate forms.
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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.

For example:

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

TEXTURE

Clastic Terms

Symbol	Name	Size (mm)	Other Characteristics
a	blocks	>256	angular particles
b	boulders	>256	rounded and subrounded particles
k	cobbles	64-256	rounded and subrounded particles
p	pebbles	2-64	rounded and subrounded particles
s	sand	0.062-2	
$	silt	0.002-0.062	
c	clay	<0.002	
d	mixed fragments	>2	mix of rounded and angular particles
g	gravel	>2	mix of boulders, cobbles and pebbles
x	angular fragments	>2	mix of rubble and blocks
r	rubble	2-256	angular particles
m	mud	>0.062	mix of clay and silt
f	shells		shell or shell fragments

Organic Terms

Symbol	Name	Characteristics
e	fibric	least decomposed organic material; well-preserved fibre (40%) can be identified as to botanical origin after rubbing.
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h	humic	advanced decomposed organic material; less than 10% of fibres identified as to botanical origin after rubbing.

Explanatory 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 or from a knowledge of the bedrock geology. The reader is referred to surficial material descriptions for general textural information.
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ON-SITE SYMBOLS

On-site symbols used in this classification system are outlined below. An upper case letter in the notes column indicates the symbol is standard in terms of shape and size (S), or drawn to actual map scale shape or length (R).

Name	Symbol	Notes
GLACIAL FEATURES		
Drumlin		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Crag and tail		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Roches moutonnées		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Striae, grooves (ice flow direction known; unknown)		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Undifferentiated lineations and flutings		symbol is placed in the centre of the feature (S)
Moraine ridge (major)		line drawn along ridge crest (R)
Moraine ridges (minor)		lines drawn along ridge crests (R)
Esker (flow direction known; unknown)		drawn along ridge crest (R)
Kettle holes (large; small)		(R; S)
Meltwater channel (large)		arrow shown if flow direction is known (R)
Meltwater channel (small)		arrowhead shown if flow direction is known (R)
Cirques		line drawn along ridge crest (R)
Glacier flow		ice flow in the direction of the arrow (R)
PERIGLACIAL FEATURES		
Blockfield		(R)
Rock glaciers		(R)
Tors		(S)
Observation of frozen ground		(S)
OTHER LANDFORMS AND FEATURES		
Dunes (active; inactive)		(R)
Escarpment		hachures extend to base of slope (R)
Strandline		(R)

SURFICIAL MATERIALS

Surficial materials are classified according to their mode of formation or deposition. This influences their physical characteristics such as texture, structure and composition, which in turn control conditions of drainage and slope stability.

Each surficial material has an assumed status of activity. Status is either active or inactive. It is only indicated when the actual state of formation is contrary to the assumed state indicated for each surficial material and is indicated by the Qualifying Descriptor Symbol (see below).

Symbol	Name (Assumed Status of Formative Process)	Description
A	anthropogenic (A)	Man-made or man-modified materials, including those associated with mineral exploitation, waste disposal and landfill.
C	colluvial (A)	Products of mass wastage; generally consists of massive to moderately well-stratified to non-sorted sediments with a variety of particle sizes and shapes; includes talus slopes, avalanche cones, mantles of weathered bedrock, landslide debris, earthflows and debris flows.
D	weathered bedrock (A)	Bedrock decomposed in situ by processes of mechanical and/or chemical weathering; the character of the bedrock debris depends on the process of formation and type of bedrock.
E	eolian (A)	Materials transported and deposited by wind action; generally consist of medium to fine sand and coarse silt that is well-sorted and poorly compacted; includes dunes and loess.
F	fluvial (I)	Materials transported and deposited by streams and rivers, alluvial materials; generally consist of gravel, sand or silt; gravels are typically well-rounded and contain interstitial sand; sediments tend to be moderately to well-sorted and stratified; includes floodplains, river terraces, deltas and some alluvial fans.
$_{F}G$	glaciofluvial (I)	Fluvial materials deposited in association with glacier ice; generally consist of gravel and sand, and show evidence of ice melting such as kettles and slump structures; sorting, stratification and particle size and shape are variable; includes kettled outwash, kames, kame terraces and eskers.
I	ice (A)	Permanent snow and ice; glaciers and icefields
L	lacustrine (I)	Sediments deposited in lakes or reworked by wave action around lake shorelines; generally consist of stratified sand, silt and clay deposited on the lake floor or well-sorted littoral sand or gravel; includes beaches, spits and bars, and lacustrine terraces of silt or clay.
$_{L}G$	glaciolacustrine (I)	Lacustrine materials that were deposited in association with glacier ice, generally similar to lacustrine materials but display features such as slump structures, ice-rafted stones and kettles.
M	morainal (I)	Material deposited directly by glaciers, till; generally consist of well-compacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, shapes and lithologies in a matrix of sand, silt and clay; includes moraines, till plains and drumlins.
O	organic (A)	Material resulting from the accumulation and decay of vegetative matter, generally consists of peat, although minor amounts of marl and inorganic detritus may be included; includes bogs, fens, swamps and thin organic veneers over bedrock (folisols).
R	bedrock (I)	Outcrops and rock covered by less than 10 cm of unconsolidated material.
U	undifferentiated (I)	A layered sequence of more than three types of material outcropping on a scarp slope.
V	volcanic (I)	Unconsolidated pyroclastic sediments including volcanic ash, lapilli and coarser ejecta.
W	marine (I)	Sediments deposited in marine waters, or reworked by wave action along marine shorelines; generally consist of clay, silt, sand or gravel that is sorted and stratified and may contain shells; includes spits bars, beaches and deeper water deposits.
$_{W}G$	glaciomarine (I)	Sediments of glacial origin, laid down in a marine environment in close proximity to glacier ice; generally relatively poorly sorted and stratified or massive, and may contain shells; includes marine drift and stoney clays.

GEOLOGICAL PROCESSES

These terms indicate geological processes that are currently modifying or have modified surficial materials and surface expressions.

The status of all geological processes are assumed to be active. The exceptions are the processes, channeled by meltwater and kettled which have an assumed status of inactive.

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H	kettled (I)	Depressions formed in surficial materials due to the melting of buried, or partially buried glacier ice.
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K	karst processes (A)	Processes associated with the solution of carbonates and other soluble rocks; includes underground and surface weathering and subsidence resulting from solution.
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N	nivation (A)	Erosion of bedrock and surficial materials beneath and along the margin of snow patches by freeze-thaw processes, snow meltwater action and snow creep.
P	piping (A)	Subterranean erosion of surficial materials by flowing water that results in the formation of tubular underground conduits.
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S	solifluction (A)	Slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate.
U	inundation (A)	Terrain seasonally under standing water which results from high watertable.
V	gully erosion (A)	Modification of unconsolidated or consolidated surfaces by various processes such as running water, mass movement and snow avalanching that results in parallel or subparallel ravines.
W	washing (A)	Modification by wave action resulting in lag deposits formed by the removal of fines, and wave cut platforms.
X	permafrost (A)	Processes controlled by the presence of permafrost, and permafrost aggradation or degradation; permafrost is earth material whose temperature remains below 0°C for more than two continuous years.
Z	general periglacial processes (A)	Solifluction, cryoturbation and nivation occurring together within a single unit.

Explanatory Note

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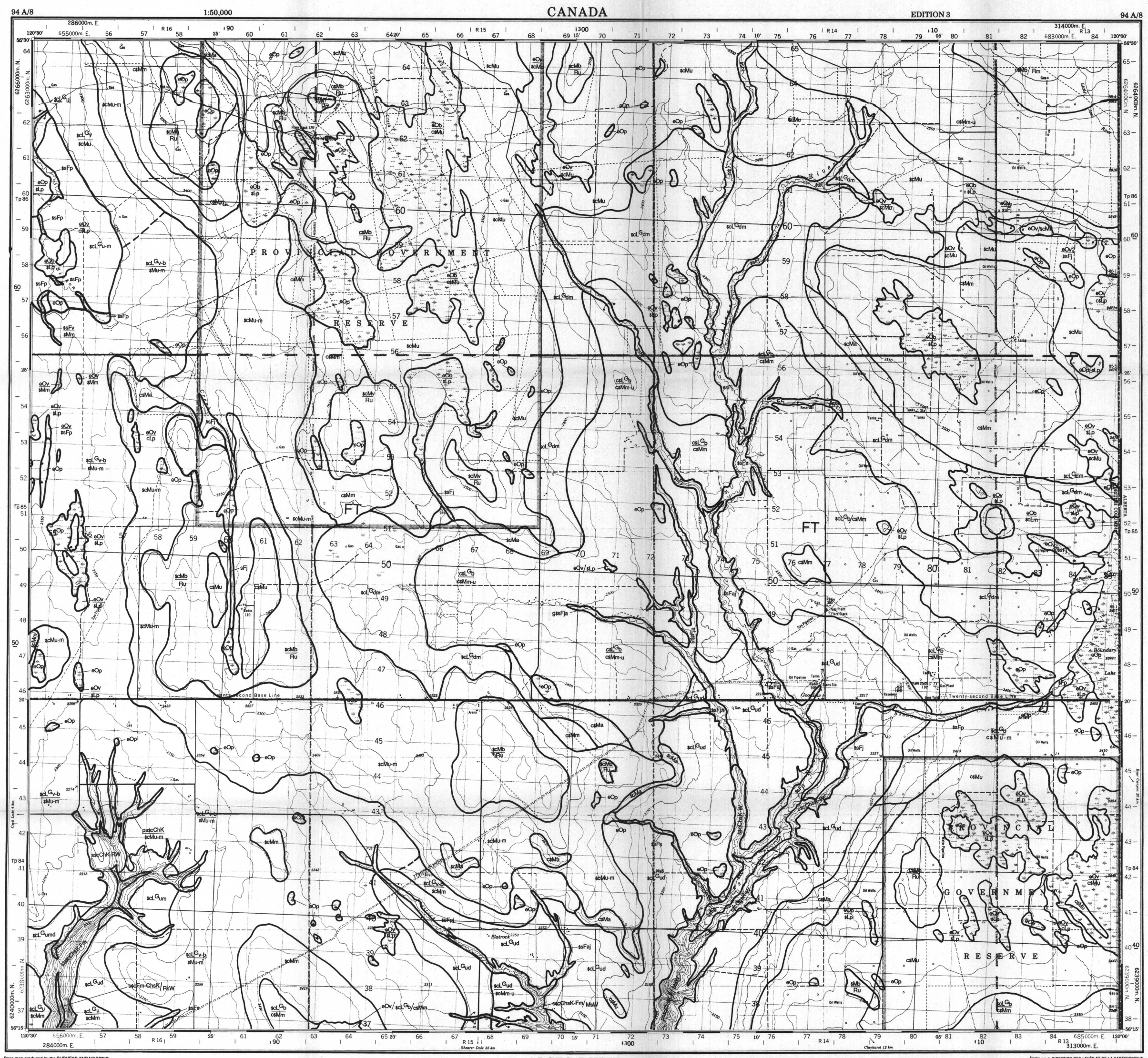
Symbol	Name	Description
G	glacial	Used to qualify non-glacial surficial materials where there is evidence that glacier ice affected the mode of deposition of materials (*See* surficial materials $_{F}G$, $_{L}G$, $_{W}G$).
A	active:	There is evidence that a geological process is either operating continuously or is of a recurrent nature at the present time; there is evidence that the process of formation of a surficial material is operative at the present time.
I	inactive:	There is no evidence to suggest that a geological process is continuing or recurrent; the process of formation of a surficial material has ceased.

Explanatory Notes

An activity qualifying descriptor for surficial materials and geological processes are shown only in unit symbols where the current state of activity is contrary to the designated state.

OTHER LANDFORMS AND FEATURES (continued)		
Piping depression		(S)
Karst depression (large; small)	sh	(R; S)
Gully		(R)
Spring		(S)
Gravel pit (active; abandoned)		(S)
Quarry or mine (active; abandoned)		(S)
Gravel occurrence	G	(S)
Cinder cone	Vc	(S)
MASS MOVEMENT SYMBOLS		
Snow avalanche		symbol follows track downslope (R)
Large Landslide:		
headwall scar only		(R)
headwall scar and area affected		(R)
Small Landslide:		
headwall scar only		(S)
headwall scar and track		symbol follows track downslope (R)
Tension cracks		(S)
Sackung (sagging slopes)		(S)
POINT OBSERVATIONS		
Quaternary fossil site	F	(S)
Observation site (ground; air)		(S)
Stratigraphic section site		(S)
^{14}C dated site	Date / Material / Lab / Elevation	location on map with data recorded in legend (S)
Anthropogenic site	A	(S)



Province of British Columbia
Ministry of Energy, Mines
and Petroleum Resources

Geological Survey Branch

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(Sheet 4 of 4)

SURFICIAL GEOLOGY OF THE PEACE RIVER AREA

NTS 94A/1, 2, 7, 8

Geology by N. Catto

1:50 000

Geology based on air photo interpretation with ground truthing in areas with road access. Fieldwork completed in 1990. Drafting by C. P. Smith.

MAP UNIT LETTER NOTATION

A terrain map unit symbol is composed of combination of letters which designate different characteristics of the terrain. The relative position of letters within the symbol indicates the characteristic that they represent.

SIMPLE TERRAIN UNIT SYSTEM

qualifying descriptor — surficial material — texture — g FGt -VI — surface expression — qualifying descriptor — geological process — sL — surficial material

This map unit consists of a gravelly glaciofluvial terrace that overlies sandy lacustrine materials and is modified by gullies that are no longer active.

Explanatory Notes

1. Units consisting of two or more types of terrain are designated by two or more groups of letters separated by slashes and/or dots (*See* Composite Units below).
2. Materials underlying the surface unit are shown by a symbol that is written beneath the surface unit symbol and separated from it by a horizontal line.

SURFACE EXPRESSION

Surface expression is the topography or form of the land surface. In general, the terms listed here are used to describe features that are not adequately shown on the topographic base map.

Symbol	Name	Description
a	moderate slope	An unidirectional surface with a slope gradient >15° to >26°; local surface irregularities are less than 1 metre.
b	blanket	A mantle of unconsolidated materials which 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 metre thick; [illegible]

COMPOSITE UNITS

TEXTURE

Organic Terms

Symbol	Name	Characteristics
e	fibric	least decomposed organic material; well-preserved fibre (40%) can be identified as to botanical origin after rubbing.
u	mesic	intermediate decomposition between fibric and mesic
h	humic	advanced decomposed organic material; less than 10% of fibres identified as to botanical origin after rubbing.

Explanatory 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 or from a knowledge of the bedrock geology. The reader is referred to surficial material descriptions for general textural information.
2. Where two or three textural terms are used together, they are written in reverse order of importance and indicate that either the various textures are intermixed or inter stratified.

SURFICIAL MATERIALS

GEOLOGICAL PROCESSES

Symbol	Name (Assumed Process Status)	Description
W	washing (A)	Modification by wave action resulting in lag deposits formed by the removal of fines, and wave cut platforms.
X	permafrost (A)	Processes controlled by the presence of permafrost, and permafrost aggradation or degradation; permafrost is earth material whose temperature remains below 0°C for more than two continuous years.
Z	general periglacial processes (A)	Solifluction, cryoturbation and nivation occurring together within a single unit.

Explanatory Note

Geological process symbols are used where a relatively large portion of a terrain map unit is affected by the process. On-site symbols may be used to indicate modification of a small part of the unit by a single or a few features.

QUALIFYING DESCRIPTORS

Qualifying descriptors qualify either surficial material or geological process terms. They are used in order to supply additional information about the mode of formation and/or depositional environment of surficial materials and the status of activity of geological processes.

Symbol	Name	Description
G	glacial	Used to qualify non-glacial surficial materials where there is evidence that glacier ice affected the mode of deposition of materials (*See* surficial materials FG, LG, WG).
A	active:	There is evidence that a geological 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 surficial material is operative at the present time.
I	inactive:	There is no evidence to suggest that a geological process is continuing or recurrent; the process of formation of a surficial material has ceased.

Explanatory Notes

An activity qualifying descriptor for surficial materials and geological processes are shown only in unit symbols where the current state of activity is contrary to the designated state.

ON-SITE SYMBOLS

On-site symbols used in this classification system are outlined below. An upper case letter in the notes column indicates the symbol is standard in terms of shape and size (S), or drawn to actual map scale shape or length (R).

Name	Symbol	Notes
GLACIAL FEATURES		
Drumlin		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Crag and tail		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Roches moutonnées		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Striae, grooves (ice flow direction known; unknown)		ice flow is in the direction of the arrow; symbol is placed in the centre of the feature (S)
Undifferentiated lineations and flutings		symbol is placed in the centre of the feature (S)
Moraine ridge (major)		line drawn along ridge crest (R)
Moraine ridges (minor)		lines drawn along ridge crests (R)
Esker (flow direction known; unknown)		drawn along ridge crest (R)
Kettle holes (large; small)		(R; S)
Meltwater channel (large)		arrow shown if flow direction is known (R)
Meltwater channel (small)		arrowhead shown if flow direction is known (R)
Cirques		line drawn along ridge crest (R)
Glacier flow		ice flow in the direction of the arrow (R)
PERIGLACIAL FEATURES		
Blockfield		(R)
Rock glaciers		(R)
Tors		(S)
Observation of frozen ground		(S)
OTHER LANDFORMS AND FEATURES		
Dunes (active; inactive)		(R)
Escarpment		hachures extend to base of slope (R)
Strandline		(R)
OTHER LANDFORMS AND FEATURES (continued)		
Piping depression		(S)
Karst depression (large; small)	sh	(R; S)
Gully		(R)
Spring		(S)
Gravel pit (active; abandoned)		(S)
Quarry or mine (active; abandoned)		(S)
Gravel occurrence	G	(S)
Cinder cone	Vc	(S)
MASS MOVEMENT SYMBOLS		
Snow avalanche		symbol follows track downslope (R)
Large Landslide:		
headwall scar only		(R)
headwall scar and area affected		(R)
Small Landslide:		
headwall scar only		(S)
headwall scar and track		symbol follows track downslope (R)
Tension cracks		(S)
Sackung (sagging slopes)		(S)
POINT OBSERVATIONS		
Quaternary fossil site	F	(S)
Observation site (ground; air)		(S)
Stratigraphic section site		(S)
^{14}C dated site	Date / Material / Lab # / Elevation	location on map with data recorded in legend (S)
Anthropogenic site	A	(S)