INFERRED HAZARDS

Rock fall and debris flows common

Landslides generally are recurrent

in susceptible areas and may be

Areas of fine textured materials

elevations, where there is ground

solifluction rates and thermokarst

on active fans, steep slopes

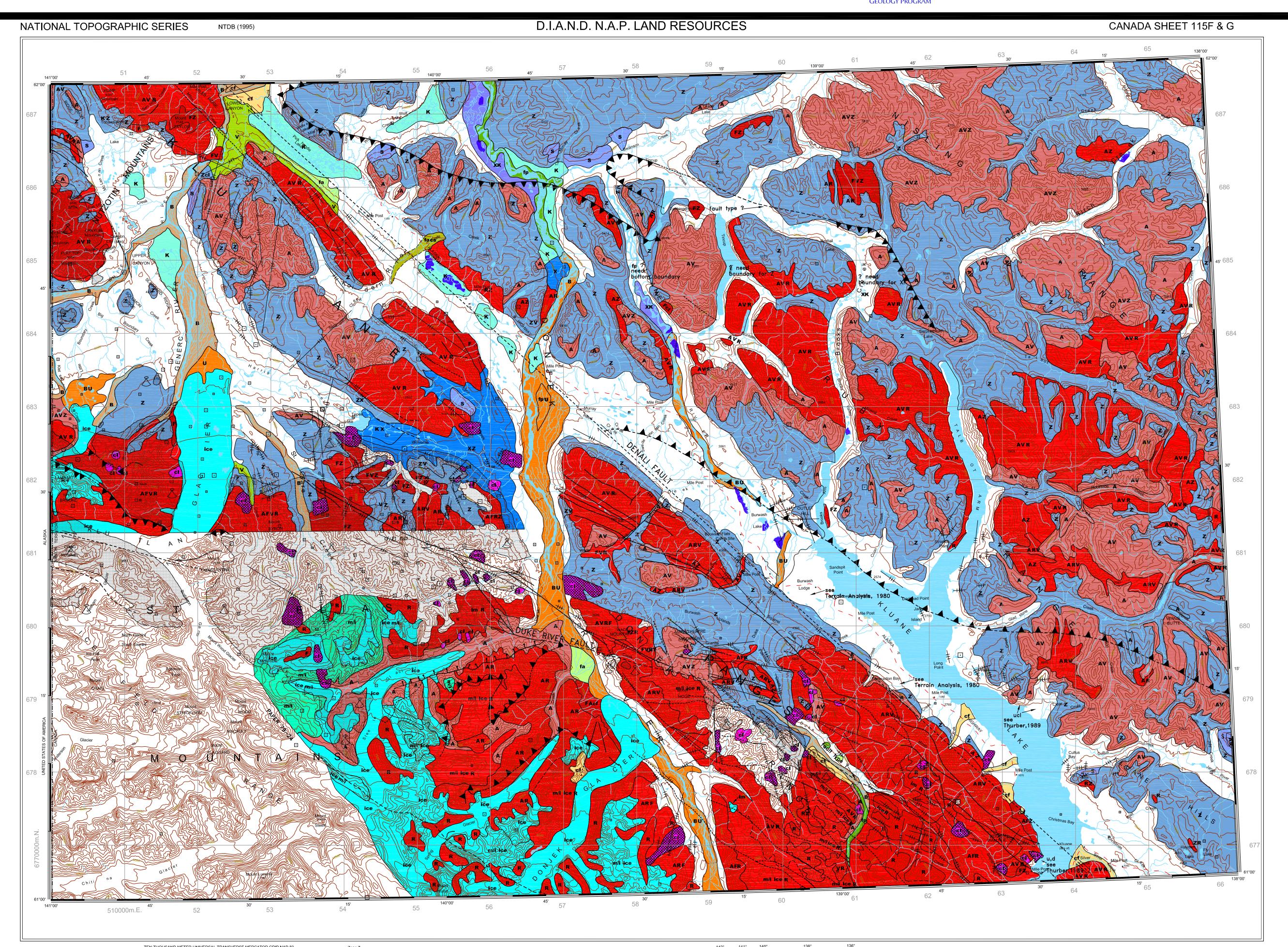
generally unstable to traffic.

become active if disturbed.

and gentle slopes at high

if disturbed.

ice will be susceptible to high



## GEOPROCESS FILE - SUMMARY REPORT KLUANE LAKE MAP AREA - NTS 115F (E1/2) and 115G

Geological Processes and Terrain Hazard Compilation Maps

The GEOPROCESS File is a compilation of information and knowledge on geological processes and terrain hazards, including mass movement processes, permafrost, flooding risks, faults, seismic activity and recent volcanism, etc. Please refer to the GEOPROCESS File User Guide for more in-depth information on how the maps were developed, which other GEOPROCESS File maps are available, how to utilize this inventory and how to interpret the legend. Special interest should be taken in the detailed description of the terrain hazard map units. Appendices in the User Guide include summary papers on the geological framework, permafrost distribution, and Quaternary geology in Yukon and a list of comprehensive GEOPROCESS File references. This report includes a brief discussion of the scope and limitations of the GEOPROCESS File compilation maps followed by summaries of the bedrock geology, surficial geology and terrain hazards for this NTS map area, and a list of references.

The GEOPROCESS File map units were drafted on the 1:250 000 topographic base maps through interpretation from bedrock geology maps, surficial geology maps and in some cases terrain hazard maps at various scales. The compilation maps have a confidence level reflecting the original source material. All materials used to produce the maps are listed in the references on each map. A file containing the documentation used to construct these maps is available at the Indian and Northern Affairs library in Whitehorse, Yukon. Areas for which no surficial geology or terrain hazard information is published were left blank. Summary reports on surficial geology and terrain hazards for these map sheets were written by extrapolating the data from adjacent map sheets or smaller scale maps. Information from small scale (e.g., 1:1 000 000) maps was used for the summary reports, but not redrafted onto the 1:250 000 GEOPROCESS

The GEOPROCESS File compilation maps are intended as a first cut planning tool; the legend on the maps describes the general aspects of terrain hazards (also see below) and associated geological processes. These maps should never replace individual site investigations for planning of site specific features, such as buildings, roads, pits, etc. Bedrock Geology Summaries

Each 1:250 000 NTS map area is described according to morphogeological belts and terranes defined by Gabrielse et al. (1991) and Wheeler et al. (1991). Bedrock geology (including structure) and mineral occurrences are briefly described and taken largely from the referenced. most recent 1:250 000 geological map with additional contributions from Wheeler and McFeely (1991), and Yukon MINFILE (1993). A summary paper ("A Geological Framework for Yukon") in Appendix A of the User Guide provides a framework and context for each of the bedrock

The level of knowledge and understanding of Yukon geology is constantly evolving with more detailed mapping and development of geological models. Names, ages and terrane affinities of rock units on the most recent 1:250 000 geological maps may, in some cases, now be considered incorrect. Thus information contained within some of the bedrock geology summaries may be out of date. Although much of the information reflects the knowledge at the time that the source map was published, additional information has been inserted whenever possible to assist the user in merging the information with current geological maps, concepts and understanding. The age ranges for similar packages of rocks may also vary between map areas since the actual rocks, or at least the constraints on their age, may vary between map

## BEDROCK GEOLOGY (Bremner, 1994; Campbell and Dodds, 1992; Muller, 1958) The Kluane Lake map area is bisected by the northwest-trending Denali Fault and its associated depression - the Shakwak Trench. The Insular Belt occurs southwest of the Trench, and is characterized by high craggy mountains (the Kluane Ranges and Saint Elias Mountains), active glaciers and icefields. The Coast Belt predominates in the area northeast of the Trench,

except for the northeasternmost portion of the map area which is part of the Omineca Belt.

These areas are characterized by rounded and float-topped mountains with high relief.

The Insular Belt is composed of oceanic rock assemblages that are bisected by the west-northwest trending Duke River Fault. Alexander terrane occurs southwest of this fault and Wrangellia occurs northeast of the fault. Alexander terrane rocks include 570-360 million year old phyllite, greywacke, andesite and tuff overlain by thick limestone units and capped by andesitic metavolcanic rocks which resemble those of Wrangellia. Rocks of Wrangellia were likely formed in a volcanic arc setting 320 to 290 million years ago and consist of andesitic and volcanic breccias of the Station Creek Formation. Following amalgamation of Wrangellia and Alexander terranes at around 310 million years, several younger rock units were "overlapped" onto these terranes. These include a thick turbiditic sedimentary sequence including conglomerates, cherts, shale and limestones of the 290-250 million year old Hasen Creek Formation; rift basalt flows and intrusions, and limestones of the 250-210 million year old Nikolai Group; massive limestone and evaporites of the 230-210 million year old Chitistone Formation; deep marine clastic shale and sandstone of the 230 to 100 million year old Gravina assemblage;

conglomerate, sandstone, shale and coal of the 70 to 20 my old Amphitheatre Formation; the 20

TEN THOUSAND METER UNIVERSAL TRANSVERSE MERCATOR GRID NAD 83 NOTE: THIS MAP HAS BEEN PRODUCED BY THE COMPILATION OF DATA FROM VARIOUS SOURCES. IT IS NOT TO BE USED TO DEFINE LEGAL BOUNDARIES.

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT WILL ACCEPT NO RESPONSIBILITY FOR ANY ERRORS, INACCURACIES OR OMISSIONS WHATSOEVER. EDITION: 2 PRINT DATE: JULY 19, 1999

to recent vyrangeli Lavas and very recent pumice and voicanic ash deposits from vents i the White River area (100 to 800 A.D.). Several periods of intrusive activity are indicated by large plutons of granodiorite, quartz monzonite, and quartz diorite which have been grouped with the following plutonic suites; the St. Elias (130-160 my), the Kluane Ranges (105-115 my) and the Wrangell (5-15 my) suites. Rocks adjacent to the Denali fault zone have been, and still are seismically active. They are highly folded and cut by numerous thrust and strike-slip faults. Amphitheatre Formation rocks are poorly indurated, unstable and form "badland"-style

The Coast Belt is underlain mainly by granitic rocks of the Coast Plutonic Complex and metamorphic rocks of the Kluane Schist. The Coast Plutonic Complex is composed of 50-100 million year old granodiorite, quartz monzonite, quartz diorite, alaskite, granite and granodiorite gneiss of the Ruby and Nisling Ranges. Metamorphic rocks in the western part of the Coast Belt are composed mainly of 50 million year old biotite-schist of the Kluane Schist, but also include pre-550 million year old Nisling Assemblage quartz-rich metamorphic rocks. The contact between these two metamorphic packages contains several serpentinized ultramafic bodies. Because of the platy nature and biotite/chlorite composition of the Kluane schist, it is a slippery rock and locally forms small slides. Rocks of the Windy McKinley Terrane occur in the northern part of the Coast Belt and include 400-70 my oceanic clastic and volcanic rocks as well as some ultramafic intrusions The Omineca Belt is underlain by high-grade metamorphic rocks of Yukon-Tanana Terrane. These rocks include pre-550 to 320 million year old guartz mica schist, gneiss, slate, quartzite, limestone and amphibolite. Previously known as Yukon Group, these rocks are considered to be equivalent to the Nisling Terrane and Nasina assemblage which collectively form Yukon-Tanana Terrane.

Mineral Deposits and Occurrences The Kluane area is primarily noted for deposits and occurrences of copper, nickel, platinum and precious metals associated with ultramafic sills in 220 million year old Nikolai Group rocks; and of copper, molybdenum, tungsten porphyry and skarn-style mineralization associated with 100 and 50 million year old felsic intrusions. Mineral production from the Kluane area includes 2.5 million tonnes of nickel and 2.2 million tonnes of copper from the Wellgreen deposit which has remaining reserves of 42 million tonnes of 0.36 % nickel, 0.35% copper, 0.52 grams per tonne platinum and 0.34 grams per tonne palladium. The Canalask deposit has reserves of 500 000 tonnes of 1.7% nickel. Native copper occurs in basic lavas of the Nicolai Group in the White

River area and has been exploited by the Tlingit peoples for thousands of years. Industrial minerals located to date in the Kluane area include gypsum occurrences in Mush Lake Group limestone; lignite coal seams in the Amphitheatre Formation; and a few asbestos

Placer gold occurs in a number of creeks on both sides of Kluane Lake. Arch Creek, Burwash Creek, Reed Creek, Squirrel Creek, Swede Johnson Creek and Porcupine Creek on the west side of the lake and Gladstone and 4th of July Creek on the east side of the lake are historically and currently active areas. Between 1978 and 1990, some 145 400 g were reported from the Kluane area. The Quill Creek area contains platinum in the placers as well as gold.

SURFICIAL GEOLOGY A large portion of the Kluane map area is still covered by large alpine glaciers and rock glaciers. Rampton (1981) provides a good general description of the Kluane map area as "a complex of steep slopes and cliffs, which have been modified by mass wastage, stream erosion and glacial scouring, and which have a veneer of unconsolidated materials. High relief, oversteepened slopes and moderately competent rock have led to the formation of talus fans and aprons and the occurrence of landslides".

Most of the landforms in this area are the result of the most recent glaciation, the Kluane Glaciation which took place 29,000 to 12,500 years ago. During that period of time, alpine glaciers coalesced in the valleys with the larger ice streams, disrupting stream flow and

depositing large moraines. Most high mountain peaks stood above the ice as nunataks. During deglaciation, a huge amount of meltwater was released and resulted in the deposition of glaciofluvial sand and gravel and of glaciolacustrine fine-grained sediments. The main source of information for this map sheet is the Terrain Hazards mapping study

undertaken by Thurber Consultants Ltd. (1989). Their report and maps include descriptions and formed. The drainage of such a lake would cause a catastrophic flood and this eventuality should be the distribution of terrain hazards within the perimeter of the Kluane Regional Planning area which covers approximately 75 % of the 115F and G map sheets. These series of maps at the

## **KLUANE LAKE**

**North American Datum 1983 Transverse Mercator Projection** Universal Transvers Mercator Grid ZONE 7 1:50 000 scale shows detailed terrain hazard units which are assessed in terms of three risk ੴੴsual change 10.7'westerly This study is the result of detailed air photo interpretation focusing on terrain hazards and is considered the dominant source of information for the Kluane map area. Secondary sources of information include Rampton (1980 - GSC map 79-24) and Terrain Analysis and Mapping Services (1981) and Geo-physi-con Co. Ltd. (1977 - Foothills Pipelines Ltd., south Yukon). These maps contain information on the surface geology, and landforms or terrain types from which terrain hazard potential can be inferred. Areas with a high density of potentially serious hazards should be investigated at the site level prior to development.

TERRAIN HAZARDS Geological processes active in the Kluane map area which present the most immediate hazard to human activity are related to the extreme topography of the Kluane ranges. Slope failure resulting in rock slides and slumps are commonly associated with the Amphitheatre Formation and the St. Clare Group; particularly when these formations outcrop near the Duke River fault. Discussions with Keith Everard, who is completing a thesis at The University of British Columbia on landslides in the Kluane ranges, have indicated that the vertical jointing in these younger volcanics is probably the most likely cause for the number of rock slides mapped in the area. Most mapped slide areas, except the Sheep Creek and Congden Creek slides, are west of the Kluane Front Ranges.

CONTOUR INTERVAL 500 FEET Elevations in Feet above Mean Sea Level

A total of 224 seismic events have been recorded in the Kluane map area between 1920 and 1991. This is by far the most seismically active area in the Yukon. The majority of epicentres are located southwest of the Denali fault system and are clustered about the Duke River Fault. Most of the larger magnitude earthquakes in the region also occur near the Duke River Fault. This same area is the locus of most mapped landslides but this may be related more to the distribution of the Amphitheatre Formation than to the seismic activity.

Rock slides, avalanches, debris flows, landslides and mudslides are all common in the Kluane area The large slide at Sheep Mountain is a good example of the large volume of material set in motion when such a failure occurs. Factors contributing to landslides in the eastern Kluane Ranges include high seismicity, presence of steep slopes in pervasively fractured and faulted rocks, an abundance of talus and glacial sediments available for remobilization as debris flows and debris torrents, and the occurrence of intense rainstorms. John Claque (1981) warns of other possible rock slides and landslides as well as the less known threat posed by debris flows: "A greater hazard to future development in the south Kluane Lake area is posed by debris torrents and debris flows on fans and aprons fronting the Kluane Ranges. Abundant loose colluvium occurs on rock slopes and in gullies in the source areas of these fans and aprons. During storms, or as a consequence of earthquakes, streams channels in mountain gullies and ravines may be plugged. As water backs up behind or overtops these plugs, failure may occur and a slurry or remobilized colluvium may flow down the gully and spread out. Such debris flows and debris torrents are commonly accompanied or followed by localized flooding. Debris torrents on active alluvial fans and aprons are probably greater potential hazards to economic development of this region". Thus highly fractured and faulted bedrock, seismic activity, increases in water content due to storm events such as heavy rainfall or snow melt, and type of surface Quaternary deposits act collectively to initiate debris flow and debris torrent hazards.

Permafrost distribution in the Kluane map area is described as continuous with a low to moderate ice content, present as veins and lenses at shallow depth, increasing with depth. The Duke River, Donjek River, Kluane River and White River valleys have low ice content which is restricted to isolated patches of frozen material (Heginbottom and Radburn, 1992). Solifluction, soil creep, nivation and hermokarsting are common in this map area. Flooding and Other Risks

The rivers in the Kluane area are subjected to seasonal flooding most years, due to snowmelt runoff, rainstorm events, and ice jams. In addition to these expected seasonal flow variations, the Donjek, White, and Slims River valleys are also affected by glacier ice melt, jokhlaups (floods due to the rapid draining of glacier-dammed lakes), and floods of high gradient streams entering the Shakwak Valley (Clague, 1979). For example, the Donjek River could be blocked by the Donjek Glacier and a lake considered in any land use plan affecting this part of the valley (Clague, 1979). Careful examination of glacial front and their relationship with rivers will help determine the possibility of river damming by the ice. This possibility must be taken into consideration when dealing with heavily glaciated areas. NOTE: A new digital compilation of Yukon Geology is now available by Steve Gordey and Andrew Makepeace (GSC Open File D3826 and/or DIAND Open File 1999-1(D)), and more recent MINFILE updates should also be verified (Yukon MINFILE, 2001).

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115C & B

MOUNT ST ELIAS

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Subject to shifts in channel and Thermokarst present. Alluvial fan, active. bar positions, occasionally subject to flooding. Soliflucted. low to intermediate Subject to shift in channel and Grouped, cryoturbated, soliflucted, nivated. low to intermediate bar positions, occasionally subject to flooding. Fluvial Processes Braided, unstable channels, risk of flooding. intermediate to high Crevasses. Fluvial erosion, deposition and low risk of flooding. Avalanches, ice and rock falls, low to intermediate Mountain ice caps. and crevasses. intermediate to high Avalanches, ice and rock falls. intermediate to high Flooded regularly. Silt and clay, usually susceptible Lacustrine or glaciolacustrine sediments. Miscellaneous Erosion Processes to frost heaving and, if permafrost present, to thermokarsting when intermediate disturbed. intermediate to high Ice at depth make surface Rock glacier, debris covered glacier. susceptible to thermokarst, low to intermediate unstable slopes. On Site Symbols Risk Level Thick organic matter is often underlain by permafrost. Disturbance Unit boundary (defined, approximate). of permafrost may cause poor drainage and thermokarsting. Erosional escarpment. Landslide escarpment defined, approximate, assumed, Landslide (includes source and runout areas). extrapolated beneath overburden Solid circle indicates downthrown side Arrows indicate relative movement Spring or saline seep. Observation of frozen soil or ground ice. Thrust Fault (teeth indicate upthrust side) Airphoto Lineament source. Limits of runout not implied by symbol. **LEGEND QUATERNARY VOLCANISM** Slow mass movement (earth flow) with landslide, escarpment source. Limits of landslide runout not Unit shown is Miocene to Pliocene and (?) younger Wrangell Lava Note: White River ash source is a vent a short distance west of the Alaska-Yukon border. The ash is 1500 years old. (see references) 4.0 to 4.999 2.0 to 2.999 3.0 to 3.999 NOTE: Where areas have more than one identified process or hazard, the colour of the encompassing polygon is assigned based on a hierarchical scheme relating to the severity of the hazard. The relative order of severity is: Terrain Hazards (Mass Movement Processes then Fluvial Processes then Arctic, Alpine and Periglacial Processes) followed by Geological Processes. **Glacial Limits** Unglaciated Terrain **Ancestral North America** Undifferentiated nonglacial deposits Mackenzie Platform Foreland **Glaciated Terrain** Cassiar Platform Omineca Selwyn Basin Omineca Hungry Creek or Buckland glacial deposits McConnell glacial deposits Acreted Terranes Reid glacial deposits pre-Reid glacial deposits Yukon-Tanana Omineca Slide Mountain Omineca Icefield glaciers Omineca & Intermontane Omineca & Intermontane Quesnel Cache Creek Intermontane Glacial ice flow direction Omineca & Coast Windy-Mckinley Omineca & Coast Alexander Insular Wrangellia Insular Chugach Insular metamorphic undivided Coast After: Gordey, S.P. and Makepeace, A.J. (compilers), 1999. Yukon Digital Geology After: Hughes, O.L. in Morison, S.R. and Smith, C.A.S. (editors), 1987, XII th INQUA Congress Field Excursions A20, p12 to 16 - Research in Yukon, National Research Council of Canada, Ottawa, Canada, 110p Geological Survey of Canada Open File D3826. Exploration and Geological Services Division Yukon, Indian and Northern Affairs, Open File 1999-1 (D) **B1** Eutric Brunisol **B2** Dystric Brunisol C1 Turbic Cryosol C2 Static Cryosol C3 Organic Cryosol R Rockland I Ice Field Soil Boundary After: Morison, S.R. and Smith, C.A.S. (editors), 1987, XII th INQUA Congress Field Excursions A20a and A20b - Research in Yukon, National Research Council of Canada, Ottawa, Canada, 110 After: Brown, R.J.E., 1978, Permafrost: Plate 32, Hydrological Atlas of Canada, Fisheries and Environment, Canada. 34 plates Exploration and Geological Services Division Indian and Northern Affairs Canada **Yukon GEOPROCESS File Geological Processes and Terrain Hazards** Doherty, R.A., Mougeot, C.M. and vanRanden, J.A. Copies of this map may be obtained from Geoscience and Information Sales c/o Whitehorse Mining Recorder, Indian and Northern Affairs Canada, Room 102, 300 Main Street, Whitehorse, Yukon Y1A 2B5 (867) 667-3266; FAX; (867) 667-3267 Recommended citation: Doherty, R.A., Mougeot, C.M., and vanRanden, J.A., 1994 North American Datum 1927, Universal Transverse Mercator Projection ZONE 7 Yukon GEOPROCESS File (2002), Geological Processes and Terrain Hazards of Kluane Lake, 115G & 115F (E1/2) Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, 1:250 000 scale.

**LEGEND** 

MAP SYMBOL TERRAIN HAZARDS

Mass Movement Processes

or rock slump, debris or rock slide.

avalanche, rockfall, rock avalanche.

Arctic, Alpine and Periglacial Processes

bedrock, including soil creep, rock creep, earthflow, soil

Moderate to extremely rapid rates of failure in soil and bedrock (1.5 m/d to >3 m/s), including rock slump.

debris slide, rock slide, debris flow, debris torrent, debris

Snow Avalanched

Permafrost present.

MAP SYMBOL

DESCRIPTION

Talus fan or apron, moderate to steep

sources are often areas of rapidly

blocks of bedrock to finer material.

Colluvium covered slope, gentle to

moderate slope, underlain by unsorted

rubble, solifluction and other periglacial

disintegrating bedrock.

features common.

slope, coarse angular bedrock fragments,

Landslide, moderate slope, varies from large