GEOPROCESS FILE
SUMMARY REPORT

KLUANE LAKE MAP AREA
N.T.S. 115F (E1/2) and 115G

INTRODUCTION

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 Introduction and User's 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's 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 and summaries followed by summaries of the bedrock geology, surficial geology and terrain hazards for this N.T.S. map area, and a list of references.

Geological Processes and Terrain Hazard Compilation Maps

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 attached to each map. A file containing the documentation used to construct these maps is available at Exploration and Geological Services Division, Indian and Northern Affairs Canada 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 FILE maps.

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 N.T.S. map area is described according to morphogeological belts and terranes defined by Gabrielse *et al.* (1991) and Wheeler *et al.* (1991). Bedrock geology, geological structures 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 provides a framework and context for each of the bedrock summaries.

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 areas.

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 my to recent Wrangell Lavas and very recent pumice and volcanic ash deposits from vents in 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 topography.

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 quartz 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 showings.

Placer gold occurs in a number of creeks on both sides of Kluane Lake. Arch Creek, Burwask 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 grams 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 with 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 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 1:50,000 scale shows detailed terrain hazard units which are assessed in terms of three risk levels. 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 - terrain maps for 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 Kieth Everard, a graduate student at UBC currently completing a thesis 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.

Seismicity

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.

Mass Movement Processes

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 Clague (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

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 thermokarsting 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 resulting form 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 would form behind the ice dam. The drainage of such a lake would cause a catastrophic flood and this eventuality should be 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.

References

Kluane Lake Map Area
N.T.S. 115F(E 1/2) and 115G

Note: To be thorough, check the references for adjacent N.T.S. map sheets and the General Reference List.

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