What's the Yukon Territory made of?
Earth materials portrayed on a geological highway map

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ABSTRACT

The Yukon Geological Survey (YGS), in collaboration with the Geological Survey of Canada (GSC), is preparing a geological highway map (1:2 000 000 scale) of the territory with a shaded relief base. Unlike a regular geological map whose legend shows rock formations in chronological order, this map emphasizes earth materials — nine rock types and six kinds of unconsolidated deposits — with less regard for their age. This map also shows major faults, hot springs, the location of other geological features of interest to the public, as well as primary and secondary road networks, communities and parks.

The geological highway map is accompanied by a series of illustrated time-slices of the tectonic evolution and glacial history of the territory. It is intended to be a territory-wide synthesis of Yukon's geology — for residents as well as the rubber-tired tourist.

RÉSUMÉ

La Commission géologique du Yukon, en collaboration avec la Commission géologique du Canada, prépare une carte géologique routière à relief (échelle de 1:2 000 000) du Yukon représentant le relief par ombres portées. Contrairement à une carte géologique régulière dont la légende illustre les formations rocheuses en ordre chronologique, cette carte met l'accent sur les matériaux de la Terre – neuf types de roches et six types de dépôts meubles – en tenant peu compte de leur âge. Cette carte montre également les failles de premier ordre, les sources thermales, l'emplacement d'autres entités géologiques d'intérêt pour le public, de même que les réseaux routiers primaires et secondaires, les villages et les parcs.

La carte géologique et routière est accompagnée d'une série temporelle d'images représentant l'évolution tectonique et l'historique glaciaire du territoire. Elle se veut une synthèse de la géologie de l'ensemble du territoire à l'intention des visiteurs intéressés à la géologie et des yukonais.

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INTRODUCTION

Yukon Territory, smaller than all but four Canadian provinces, is traversed by eight major highways which extend to all its borders except the northwest (Fig. 1). Travelers are well served by widely available territorial road maps, maps in booklets for cities and towns, and a comprehensive road log (Department of Highways and Public Works, 2005). These freely available sources label most of the prominent geographic features, but they contain little to no information about Yukon's geological heritage. This is unfortunate because all belts of the western Canadian mountain region (the Cordilleran orogen) are crossed by Yukon's highways, which provide relatively inexpensive access to interesting geology and many geology features have nearby roadside pull-outs. The geological highway map and brochures currently being developed as an outreach initiative by Yukon Geological Survey (YGS) will enhance the traveler's experience by providing easy-to-read literature about nearby rocks and surficial deposits. The brochures recommend 'geo-stops' en route and provide a souvenir or quick reference after a trip.

Geological highway maps are a hybrid product; typically they show the distribution of simplified rock formations overlain by culturally important features – more than are typically shown on a standard geological map. Geological highway maps have been made for all Canadian provinces and most American states. They attempt to make earth science relevant to a broader audience than technical geology reports and maps, and seek to include in their audience those who have little interest in science or may not know much about geology. The geological highway map needs to be informative, comprehensible, colourful and fun. In contrast to most geological maps that are published for academic purposes, a geological highway map will often be used in recreational activities, for example, on a traveling vacation.

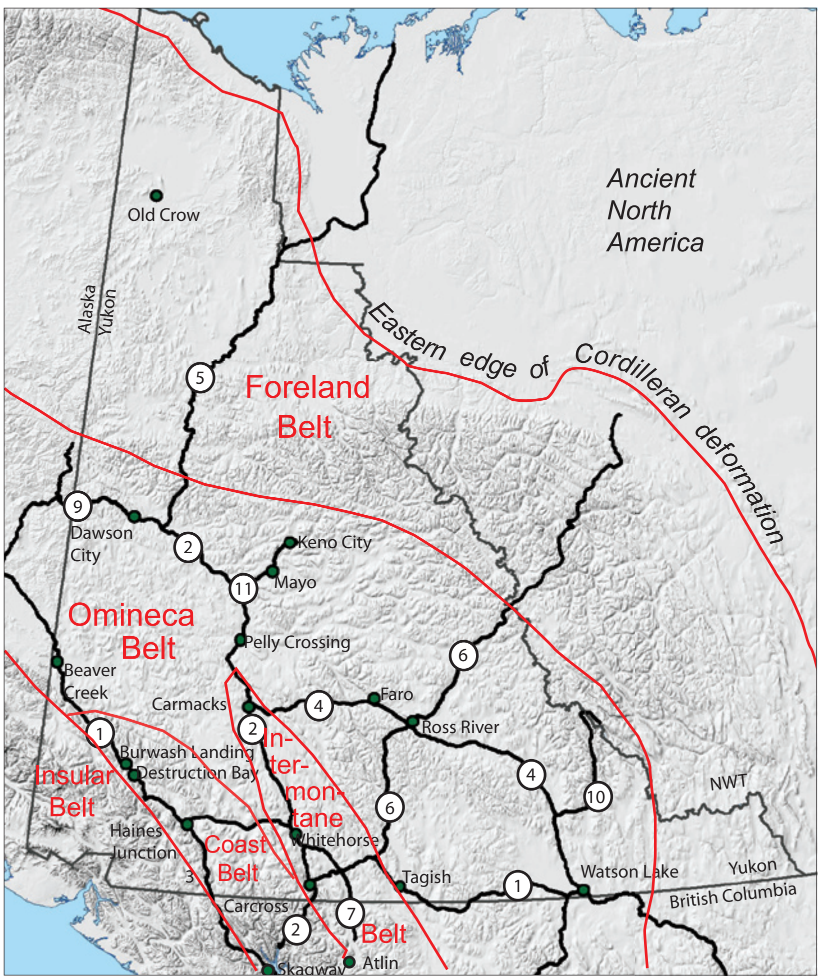


Figure 1. *Highway network of Yukon (circled numbers as denoted by Department of Highways and Public Works), with major tectonic elements (modified from Gabrielse et al., 1991).*

DIFFERENT PORTRAYALS OF YUKON GEOLOGY

As a political entity, the Yukon territory is geologically fortunate; it is well endowed with mineral resources and contains many impressive geological landscapes. Almost every vista includes hills or mountains but the underlying geology varies – from the flat-lying 'soft' rocks of the Peel Plateau in the northeast, to the steep-dipping, transposed and juxtaposed rocks of the St. Elias Mountains in the southwest. Small-scale maps which show the geology of the entire Yukon reflect many prior decisions about combining and defining rock packages in order to portray the complexity of this part of the Cordilleran orogen.

In one the earliest maps of this type, Young (1913) showed ten rock units in Yukon (Fig. 2). Subsequent editions of the geological map of Canada refined both the ages of sedimentary formations and the classification of metamorphic rocks (*cf.* Geological Survey of Canada 1945, 1955; Douglas, 1969; Wheeler

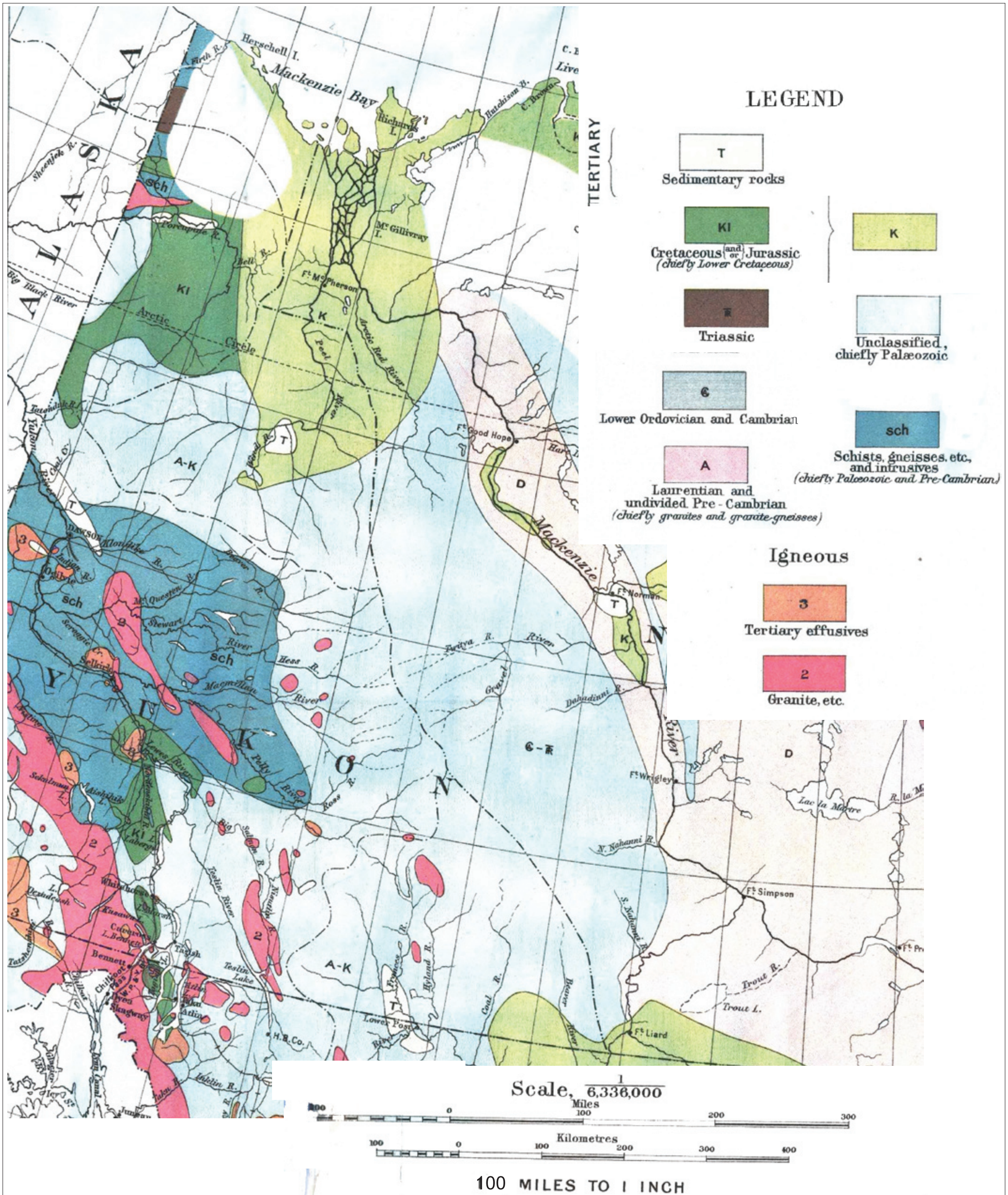


Figure 2. *Image of the Yukon portion of the Geological Map of the Dominion of Canada (Young, 1913), showing the early knowledge of the distribution of rock units in Yukon.*

(*cf.* Geological Survey of Canada 1945, 1955; Douglas, 1969; Wheeler *et al.*, 1991). These maps were distilled from the completion of systematic reconnaissance-scale (1:250 000) mapping operations. A significant step forward was the Tectonic Assemblage Map of the Canadian Cordillera (Wheeler and McFeely, 1991). On this map, metamorphosed rocks are organized according to their pre-metamorphic environment of origin (protolith). This advance continued with the Yukon bedrock geology map (Gordey and Makepeace, 1999), a digital database that enables construction of derivative maps combining other geographically referenced data, such as mineral claims and eco-regions; it is an essential tool of the YGS. The distribution of unconsolidated deposits is shown on the Glacial Limits map (Duk-Rodkin, 1999). A digitally based surficial geological map for the Yukon territory, a multi-year project, is in preparation.

The portrayal of tectonic assemblages is highly interpretive and has, in some ways, made the resulting geology map incomprehensible to persons without geological training. For example the bedrock legend of Gordey and Makepeace (1999) is a separate sheet listing about 185 map units; many of these descriptions do not represent what can be seen in an isolated outcrop. Furthermore, these maps are large sheets of paper (a 1:1 000 000 scale the map is 1.0 x 1.24 m in length) and cumbersome in the field. Unfamiliar users may find it difficult to orient themselves geographically because only major rivers, lakes and towns are shown on the base layer. For the non-specialist, a simpler and smaller map is needed. We call our new product a 'geological highway map', although it can also be used away from the road network. The map should highlight the major rock types, answer questions about local landmarks, and give useful information about the outcrop. Ideally such a map helps the user understand why geology is important (*e.g.* Donohoe *et al.*, 2003).

YUKON GEOLOGICAL HIGHWAY MAP PROJECT

A Yukon geological highway map has been a primary outreach objective in the five-year plan that resulted from the third Yukon Geoscience Planning Workshop (Abbott, 2005). Steps toward reaching this include: defining what the map will show (and not show), developing a legend, and preparing the map and derivative products. Furthermore, discussion of the terrane and glacial history requires additional explanation; we need to create schematic diagrams to supplement the map. To meet the demands of a diverse audience, we are planning to create a series of brochures that address individual highway segments. As part of the work, we are noting every roadside exposure, and compiling a Geological Road Log for Yukon Highways. These components of the Yukon geological highway map project are illustrated in Figure 3, and described below.

DEFINING THE MAP

The making of a geological highway map requires decisions on the type and complexity of geological information to portray. Typically the starting point is existing geological maps. Such maps are based upon years of research and employ units that often have characteristics too subtle for non-geologists to distinguish in the field (such as age determined by microfossils).

Units of a geological highway map should reflect features that can actually be seen; these observations then need to be hooked into the larger, geo-interpretive picture. For example, many metasedimentary and volcanic rocks in the southwestern half of Yukon comprise rock assemblages now considered to be terranes (displaced assemblages of rocks related in origin or shared deformation history); these reflect their origin as oceanic seafloor or a former arc-volcano. The geological highway map should include both rock and unconsolidated deposits — whatever earth material the user finds 'underfoot'. Many people without geological training view them together and consider both as part of 'the landscape'. This contrasts with most standard geological maps in Canada which show either the distribution of bedrock or the distribution of surficial materials. Geological highway maps are likely to be used for other purposes (perhaps unfolded from the glove compartment in less-than-ideal conditions when there is a need for route directions), therefore, cultural features such as road junctions and landmarks must not be obscured by the geology.

We reviewed geological highway maps from many provinces and determined that maps designed for minimum 'geo-literacy' suited our primary audience best. We want to make a map that is relevant to residents of Yukon, most of whom have little or no education in earth sciences (*cf.* Clague *et al.*; 1997). If the map and literature is attractive and informative it will also appeal to tourists. An example of this approach is the Geological Landscapes Highway Map of northern British Columbia (Turner *et al.*, 2007). At first glance this publication resembles a familiar road map. Upon opening it however, the cartoon figures

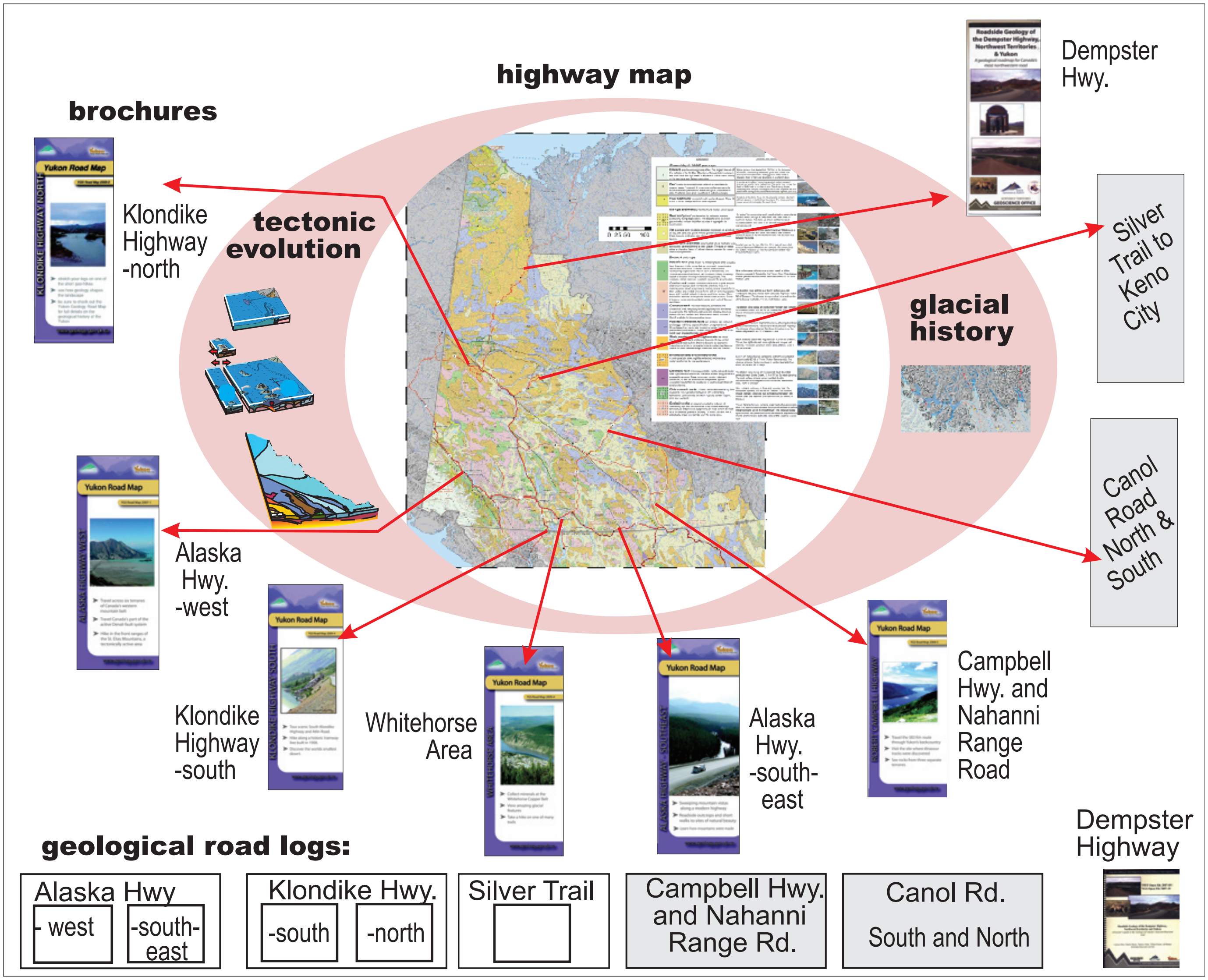


Figure 3. *Components of the Yukon geological highway map project. Items shaded grey are under construction.*

and photographs linked to the map draw the reader into a geological perspective. The subjects discussed include landscape features that people quickly recognize and earth resources that are relevant to their lives.

DEVELOPING A LEGEND

We began with the legend for the *Geoscape Canada* poster (Turner *et al.*, 2003), which depicts the earth materials at surface for all parts of the country. Map units on the poster are divided into three, broad age categories: modern sediments (up to 10 000 years old); ice-age sediments (10 000 to 2.5 million years old) and rocks (older than 2.5 million years). For each unit we emphasized broad composition first and used simple words where possible. The unit description also made a short statement about origin or use of the material, to aid in its recognition or underscore its importance (Fig. 4). Two photographs — a distant view and a close-up — of each unit were included to help the user form a mental image of the rock type. The images had to convey salient features despite reduction to less than 2 x 3 cm.

By choosing these basic rock type units, we depart from the traditional geological map, which emphasizes their age through designation of formations. Some geologists disagree with our decision. However in the Cordillera, as map scale diminishes, disparate formations are shown as groups. For example, the Triassic Lewes River Group contains both limestone (the Hancock Formation) and

unit	description	landforms and deposits
	Present-day to 10,000 years ago:	
g	***Glacier and ice patches*** exist where winter snowfall exceeds summer melting over millenia. Remnant ice on high peaks in the Mackenie and Selwyn mountains is receding as the climate warms. Glaciers descend broad valleys from the ice fields of the St. Elias Mountains.	Alpine glaciers cloak Keele Peak (2972m), in the Mackenzie Mountains. The closeup shows the gravel and boulder-rich terminal moraine beneath a melting glacier at the head of Wheaton River in the Coast Mountains of southern Yukon.
p	***Peat*** (partly decomposed plant material) accumulates in swampy areas ('muskeg'). It thermally insulates underlying sediments, which in northern Yukon become permanently frozen (permafrost). Biological decomposition is very slow.	In central and northern Yukon, low-gradient valleys are poorly drained and peat is many metres thick. The aerial view is near the head of Wolf Creek in southern Yukon. The close-up shows collapsing peat overlying melting ground ice, the long-term result of disturbance during construction of the Dempster Highway (km 100).
r	***River sediments*** consist of mud, sand and gravel. These fill broad valleys and form deltas where the streams and rivers enter lakes.	The delta of the Slims River into Kluane Lake contains abundant silt from glaciers in the St. Elias Mountains. The close-up shows coarse gravel of the braided Burwash Creek.
	Ice-Age sediments *(10,000 to 2.5 million years ago):*	
sg	***Sand and gravel*** deposited by streams, particularly as large ice sheets and glaciers melted. These deposits contain abundant space between particles and are a good groundwater source. Deposits called 'aggregate' by the construction industry.	An 'esker' (sinuous ridge which was the bed of a sub-glacial stream) winds through a valley floor near Ibex River in southern Yukon. The close-up shows well sorted and rounded cobbles and sand in an ancient stream terrace (kame) deposit.
t	***Till,*** a general term for debris deposited by glaciers, is a mixture of clay, silt, sand and gravel. Clay content makes it poor for groundwater and construction. Some granite particles in the till release radioactive gas (radon); a hazard in confined spaces.	Viewed from above, the till plain east of downtown Whitehorse is a maze of gravel ridges and ponds. The closeup view shows an eroded till deposit in the Wheaton River valley with abundant mud between the stones.
m	***Glacial lake sediments*** are mostly silt and clay where a lake was dammed behind a melting glacial lobe. Visible as terraces on valley slopes and layers of silt and clay are eroded by down-cutting streams.	Locally known as 'the clay cliffs', the 120 m high silt layers that surround downtown Whitehorse are remnants of a former glacial lake bottom. The close-up view shows fine sand and silt near the outlet of Kusawa Lake.
	Bedrock outcroppings	
v	**Volcanic rock** *(less than 10 million years old)* includes lava flows and cinder cones still recognizeable as volcanic landforms. The rock is black, brown and dark green, commonly with gas bubble holes and minute crystals. Basalt is excellent building material and can be a good groundwater reservoir. Lava flows are exposed at Miles Canyon and near Fort Selkirk.	Nine million-year-old columnar-jointed basalt at Miles Canyon, now partly flooded by the Yukon River. The closeup shows gas-bubble filled basalt near Rancheria, 62 km W of Watson Lake.
gr	**Granitic rock** consists of interlocking crystals of white or pink feldspar, clear or grey quartz, black hornblende and shiny mica. Formed by magma cooling slowly underground, these large masses are exposed by uplift and erosion. Granite forms cliffs in formerly glaciated areas and rounded uplands elsewhere. When exposed to weather, some granite decomposes to 'grus'. Some intrusions north of Dawson and Mayo contain invisible gold.	The turreted crest and talus of the 92 million year-old Tombstone intrusion, visible from Dempster Highway, 75 km NE of Dawson. The closeup shows medium-grained granite of the Cassiar batholith, 110 km E of Watson Lake.
c	***Carbonate rock*** includes limestone, dolostone and calcareous shale. It typically forms rugged skylines and steep escarpments. Bare rock is light-coloured and steadily dissolves, leaving pits and cavities. Lichen cover is patchy and some plants grow poorly because the ground water is alkaline.	The distant view shows an overturned Permian reef complex at White Mountain, 100 km SE of Whitehorse. The close-up shows limestone containing brachipods and coral fragments.
cp	***Paleozoic carbonate rocks*** are similarly light coloured and craggy with long slopes of broken, unvegetated rock. Groundwater from carbonate formations contain calcium that precipitates ('hard water'). Crushed limestone is used near old mines to neutralize acid, and can be heated to make cement.	Aerial view of northern Ogilvie Mountains, showing Cambrian to Devonian limestone, traversed by the Dempster Highway. The closeup shows strained Cambrian limestone near the Alaska Highway 80 km W of Watson Lake.
ss	***Shale, sandstone and conglomerate*** are compressed and hardened mud, sand, and gravel deposits. They may contain precipitated metal sulfides that constitute an economic mineral occurrence. Compacted organic matter may become coal or oil shale (beneath Eagle Plains and the Peel Plateau).	Black siltstone beside the Rogue River, 120 km W of Mayo, Yukon, has light coloured iron sulphate and orange rust staining. The close-up shows folded beds of black shale in the same area.
sm	***Metamorphosed sedimentary rocks*** include quartzite, slate, argillite and schist. They were sandstone, mudstone and siltstone, transformed by heat and pressure. The rock is durable with a preferred splitting direction, thus may be suitable as facing stone for buildings and constructing walls.	Layers of metasiltstone, sandstone and tuff (consolidated volcanic ash) 80 NE of Teslin (Yukon-Tanana unit). The closeup shows a fracture surface of banded quartzite from Keno Hill, 60 km NE of Mayo.
um	***Ultramafic rocks*** include peridotite, harzburgite and dunite: dark crystalline intrusive rocks that were uplifted along faults and exposed by erosion. These rocks may contain nickel and chromium, as well as asbestos and serpentine. Few plants live on soil from this rock because it lacks sodium and potassium.	The distant view shows an iron-stained, fault -bounded peridotite near Bocks Creek, 15 km SW of Burwash Landing. The rock surface shows veined and belt-buckle serpentinization of magnesium-rich minerals; Moosehide slide, north of Dawson.
vm	***Metamorphosed volcanic rocks:*** Green and brown crystalline rock, typically interlayered with sedimentary formations. Dark coloured lava flows typically contain copper, zinc, lead and gold. Often called 'Greenstone' in old geology.	Grey volcanic outcrops of flows and breccias near the Dempster Highway 120 km NE of Dawson. The closeup shows "pillows" (vesicular lava extruded underwater) 480 million years old, near the Blackstone River, 80 km NE of Dawson.
gn	***Gneissic rocks*** are coarsely crystalline in bands of contrasting light and dark minerals; they formed under high temperature and pressure. Depending on mica content the rock is as resistant as granite or crumbly. In many cases the rock is attractively striped and can be sawn for facing stone.	Yukon Tanana Terrane contains large tracts of gneissic rock. Here the layering approximates the original sediments before metamorphism; 25 km N of Swift River. The closeup shows light coloured recrystallized quartz and feldspar separated by sheets of chlorite and actinolite, a former meta-volcanic rock.

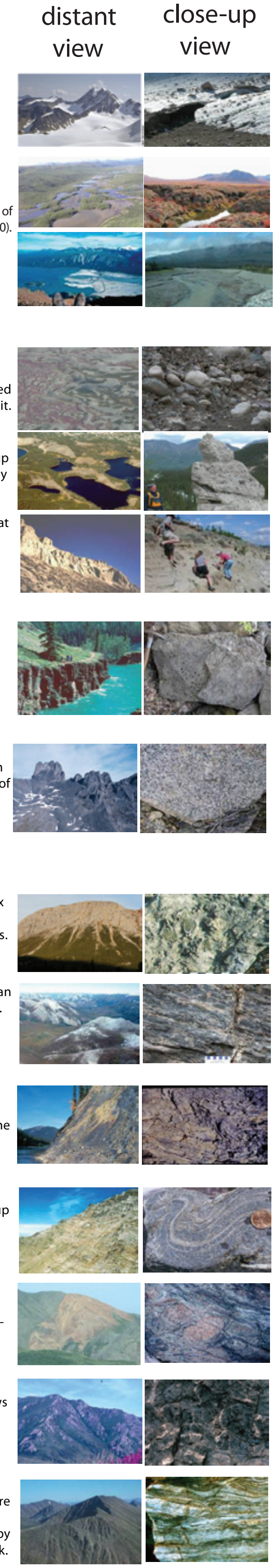


Figure 4. *Legend for the Yukon geological highway map project (draft version).*

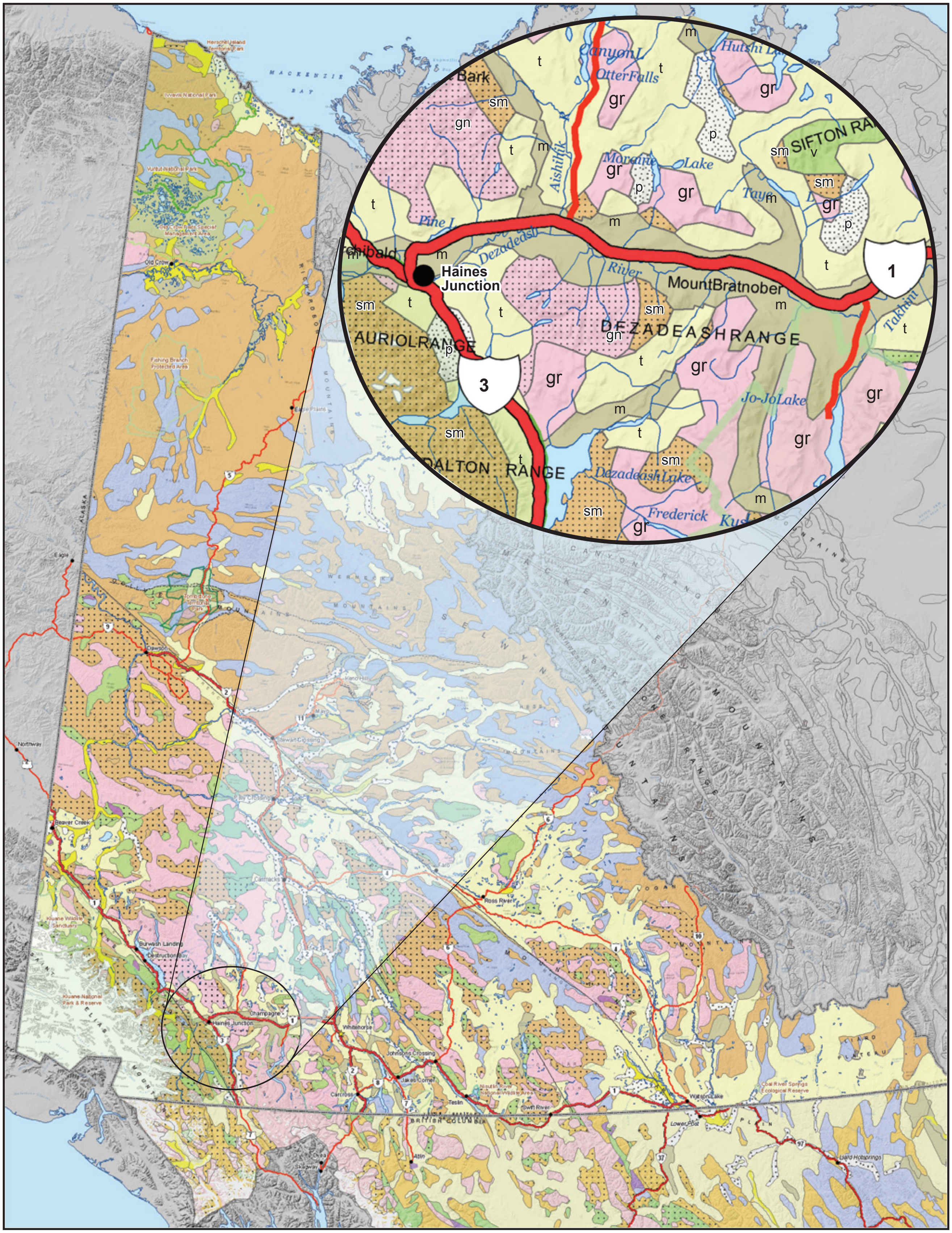


Figure 5. *Yukon geological highway map (early draft; reduced size). The inset shows detail at final scale of 1: 2 000 000.*

andesite (Povoas Formation). Both are integral to interpretation of the Lewes River Group as an island arc with volcanoes and reefs. On the geological highway map, we do not have space to explain the rational for grouping such disparate rock types. As an alternative, we present a block-diagram sequence that portrays the larger tectonic evolution of Yukon (see later section). By having the legend focus on rock types rather than age of deposition, the map portrays the composition which is most observable to the general public.

PREPARING THE MAP

A clip-out of Yukon and northern British Columbia portions of the Geoscape Canada map (*cf.* Turner *et al.*, 2003) served as our starting point. Cartographers at the Geological Survey of Canada and the Yukon Geological Survey draped these polygons over a shaded relief base and added geography information, including selected Yukon communities, roads, rivers, lakes, glaciers and national and international borders. Other information prepared includes Yukon hot springs, protected areas, parks, wildlife areas and special management areas (Fig. 5). Finally, names for Yukon geographic features were added.

Symbology for the bedrock geology was standardized across the Yukon – British Columbia border to simplify the regional geology. The rocks are symbolized by generalized rock composition. We are currently adjusting colours, fonts and label placements to achieve the best cartographic product possible.

SUPPLEMENTARY IMAGES TO SURROUND THE MAP

We intend that the map and legend will be complemented by diagrams that place the geology in time and tectonic contexts. The goal is to answer the user's logical questions: "How do these rocks fit together?" and "Why are the rocks distributed as they are?". The solution is to portray current interpretations of deposition, deformation, terrane accretion and the glacial (and de-glacial) history through block diagrams. For the bedrock story, a series of block diagrams will have coloured elements that can be followed from one diagram to the next, ending with the present-day scenario. The cross-sectional fronts of the blocks show that "what's on the surface does not go all the way down", encouraging consideration of the third dimension (depth). An obvious application is that a valley filled with glacial deposits is underlain by bedrock, and study of the nearby mountainside may be useful in predicting what rock type lies beneath the till.

Tectonic story

The block diagrams are at an early stage and diagrams for some time intervals are not yet constructed. We began with a simplified terrane map — the Yukon portion of the Canadian–Alaskan Cordilleran terranes map (Colpron *et al.*, 2007b; his Fig. 1) and first de-constructed it along major transcurrent faults to give a schematic impression of the mid-Cretaceous distribution of terrane elements (Fig. 6; space constraints preclude showing the cumulative displacement accurately). For earlier periods of time, depositional environments and terrane relationships (rifting, subduction, or far-travelled terranes) are shown schematically. For example, a recent interpretation for the source of Alexander terrane, which has zircon ages similar to the Baltic craton and may have drifted across the top of Northern America since Permian time (Colpron and Nelson, in press) is included. The objective is to give the user a visual impression that in the past some parts of Yukon lay under oceans, some were parts of active volcanoes, and some were parts of other continents.

As a source of general geological information, the Internet surpasses what is possible to achieve on a small paper map. The reader will find explanations there for classic geologic environments such as volcanic arcs or spreading oceanic ridges using any Internet search engine. Furthermore, the block diagrams show tectonic evolution as static; they cannot portray the fourth (time) dimension. Websites provide numerous animated plate reconstructions (e.g. ODSN, 1999; Scotese, 2003; Atwater, 2008).

Glacial story

Most of Yukon's road network occurs in valleys containing thick glacial deposits. These are cut through where the road right-of-way traverses steep slopes, exposing sediment deposited during past ice ages. Vistas from the highway include horizontal terraces left by lakes, cirques where glaciers formerly accumulated, and many other glacial features. We intend that the highway traveler will better appreciate the geological processes that sculpted the valley through pictures and diagrams.

The boundary between glaciated and unglaciated parts of Yukon is important for interpreting the geological landscape. For geologists, the 'ice limit' or 'edge of

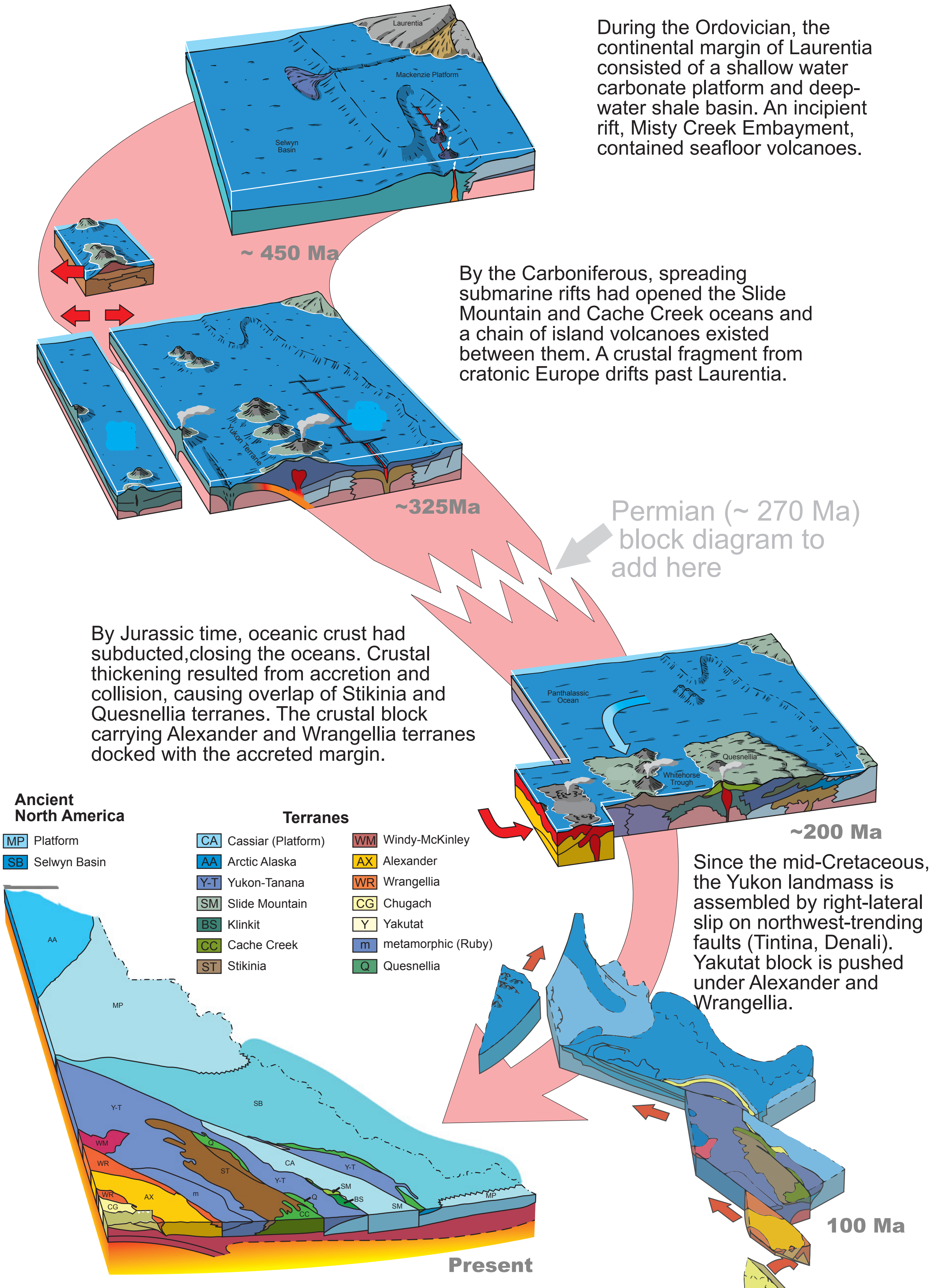


Figure 6. *Block diagrams to illustrate some stages in the tectonic evolution of Yukon (early draft).*

Beringia' changed with time: there is a maxima (generally about 2.3 million years ago), intermediate glaciations and the most recent (McConnell; which began to recede about 15 000 years ago) across central Yukon. In northern Yukon, the encroachment of the Laurentide Ice Sheet and interactions with local rivers led to interesting glacial drainage features. For the audience of outreach who are mostly traveling the roads of southern Yukon, we will illustrate the glacial lakes of southern Yukon (Fig. 7). Bond (2004) resolved the deglaciation sequence for the Whitehorse area and emphasized that many of the southern lakes such as Teslin, Tagish, Marsh, Kusawa lakes, and Lake Lebarge are shrunken remnants of these great ephemeral deglacial waterways.

BROCHURES FOR HIGHWAY SEGMENTS

Geological field guides have a long history in Yukon. Visiting geologists (and royalty; Bostock, 1958) were traditionally given tours of the mining districts and areas where regional geology mapping projects were nearing completion. During the International Geological Congress held in Montreal, field trips were made to all corners of Canada, including Yukon. When the Dempster Highway was completed from Dawson to Inuvik, it became a popular route for sedimentary and petroleum geologists (Norris *et al.*, 1992; Pyle *et al.*, 2007). New terrane interpretations have encouraged geological tours of Yukon-Tanana and other terranes (Johnston *et al.*, 1993; Colpron and Reinecke, 2000, Appendix; Colpron *et al.*, 2007a). Although some of these earlier field trip records are difficult to locate, they provide abundant information for the roving geologist. Most require familiarity with current geological and tectonic terms, and these passages are like a foreign language to most Yukon residents.

Previous public outreach initiatives completed by the YGS reveal several types of audiences among Yukon residents. Some people enjoy scientific investigation and wish to know how scientists see the world. Those who find geology interesting will likely choose the geological highway map for its depiction of the entire territory. Others, including tourists passing through en route to Alaska or the Beaufort Sea, will only care for the geological highlights along their route. We anticipate a significant population of the latter. For them, we are preparing fold-out pamphlets of segments of the Yukon highway system. For each segment, a self-titled brochure will contain an enlarged and annotated clip-out of the Yukon highway map, surrounded by photographs and short descriptions of selected points of geological interest (Fig. 8). The brochure will provide a quick synopsis of the geology along the route, encouraging the traveller to make two or three stops and thus experiencing Yukon

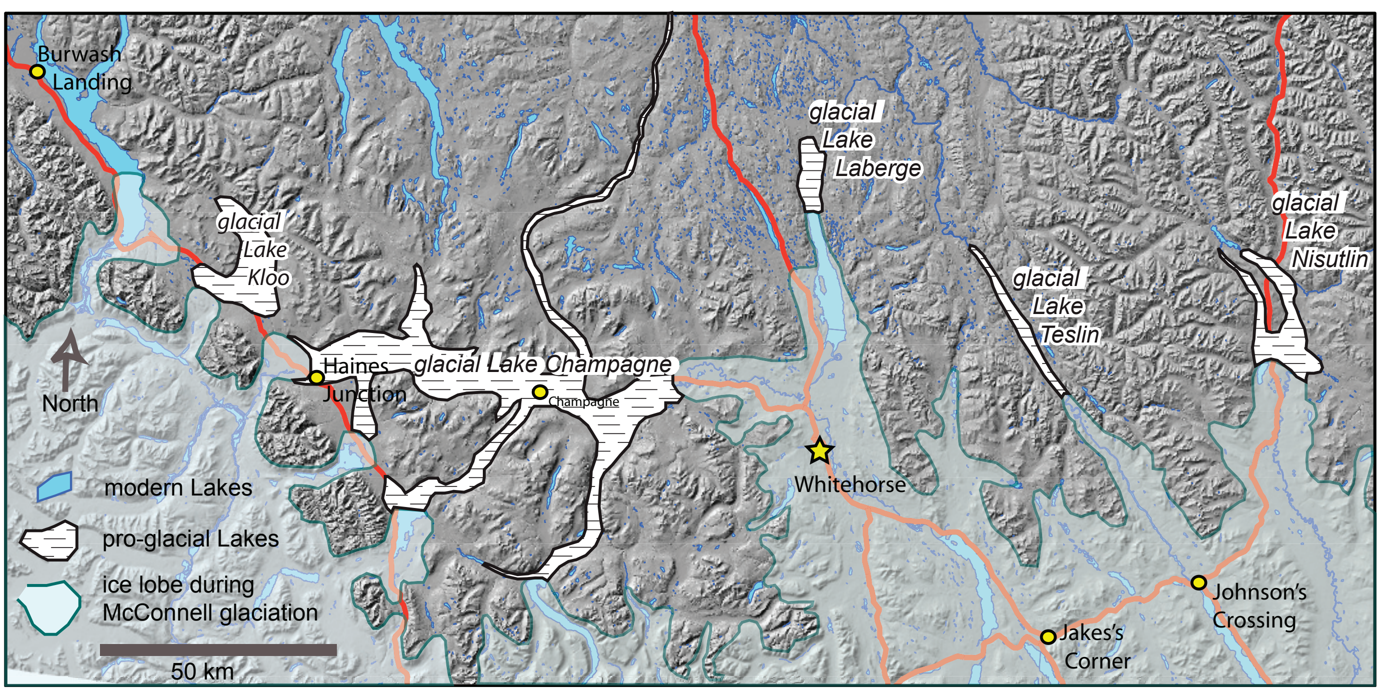


Figure 7. *Extent of glacial lakes in southern Yukon, 12 000 to 16 000 years ago. These lakes were created when receding ice lobes blocked valley drainages.*

away from the population centres. They will also provide a low-cost souvenir of their trip. In time, up to eight pamphlets will be available and will complement the geological highway road map.

Care and consideration of non-geological features is involved in selecting a few suitable stopping sites to feature in each brochure (Fig. 9). Most importantly, the site must be safe to visit. Although the Alaska and Klondike highways have wide shoulders along much of their lengths, stopping is not recommended because traffic continues to pass at highway speed. Crossing the traveled portion of the roadway with a group, or if accompanied by younger people, is very unsafe on these highways during the summer season. We therefore choose pullouts and parking areas away from the highway and favor those which have reasons in addition to geology, to interest other members of a traveling group. Furthermore, we assess the inherent hazards of the geology. Un-guarded precipices, steep riverbanks and unstable slopes make some sites unsuitable. A good spot has an interesting outcrop near a pullout and a view that (with a geologist's eye) reveals an aspect of the geological history. Bonuses might include a maintained latrine, interpretive signage and a well designed trail. Interpretive signage is increasing along Yukon highways through the efforts of the Historic Sites Branch of the Department of

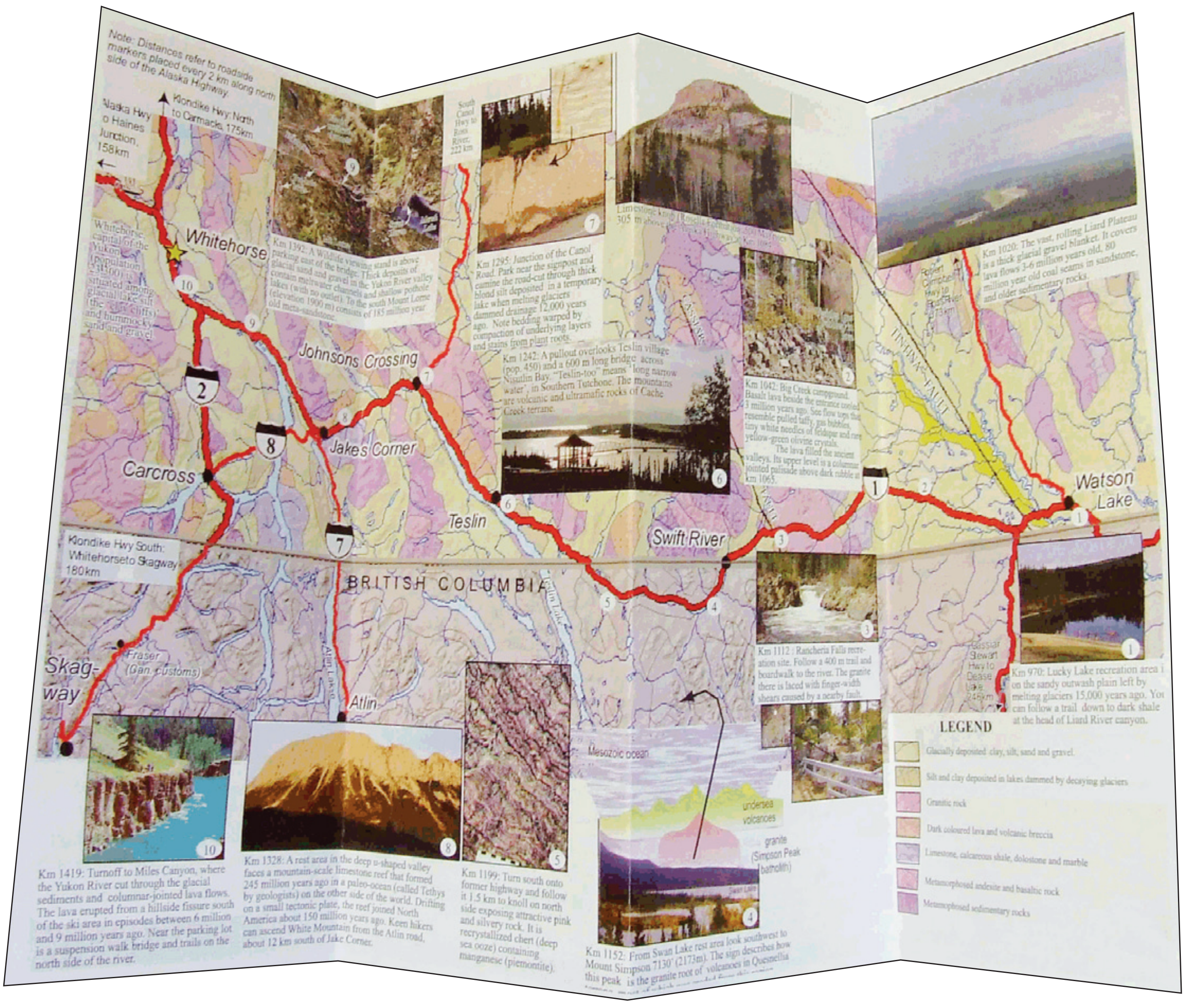
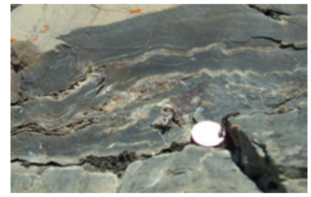


Figure 8. *Example: Alaska Highway-southeast brochure (map side, 2007 draft).*

ALSEK HIKING TRAIL (5)

5a. The first outcrop along the trail is phyllitic black shale and thin bedded sandstone of the Dezadeash Formation. The sediments have been deformed – look at the tiny folds (crenulations). High strain is also indicated by abundant pods and veinlets of white quartz. Approximately 2 km further along the trail are outcrops of black to green weathering meta-basalt of the Nikolai Formation. The point where the trail first intersects a rock outcrop (on the left) is a bend in the trail with a panoramic view of the Alsek River valley. From here you can leave the trail towards the right to see glacier-scratched ('striated') outcrops of meta-basalt. The original lava has been altered and now contains quartz and epidote, which makes the yellow-green patches. Pillow textures, which form when lava cools underwater, and folded quartz veins are present.



5b. Just after the long phyllite outcrop, a right branch in the trail leads to loose cliffs of glacial sand and gravel. At the base of the cliff are rare golfball-to basketball-sized spheres of sand cemented by lime. These are 'concretions' and form where an impurity (such as a pyrite crystal, or decayed plant debris) in the sand acts as a nucleus for the precipitation of mineral-rich groundwater.

Note: although the concretions have no monetary value, the terrace has been staked under the Yukon Placer Mining Act.
It is not legal to collect from this site without permission of the owner.

SOLDIERS SUMMIT HIKING TRAIL (6)

The first outcrop is black siliceous shale with minor sandstone and limestone of the Skolai Formation (upper right photo). Although there are no outcrops along the rest of the trail, there is an excellent view of the mountain to the north showing a small granitic intrusion and a prominent thrust fault (reddish zone and arrows on photo to left).

Back at the beginning of the trail, a 2nd path that veers off to the right leads past thickly bedded basalt flows, locally with calcite-filled amydules, of the Nikolai Formation. There is an age difference of 100 million years between the Nikolai and Skolai formations, and the contact between them is an unconformity (signaling a period of non-deposition or erosion in the rock record). Upslope from the basalt is blocky rock rubble from a geologically young land-slide, carbon isotopic dating from tree trunks killed by the slide indicate that it happened betwen 1200 and 490 years before present (lower right photo).

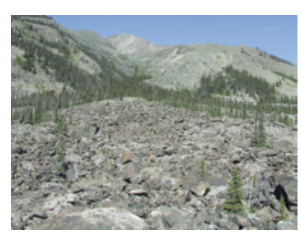


Figure 9. *Example: Excerpt from the Alaska Highway-west brochure, description of geology hikes (draft).*

Tourism and Culture in cooperation with the Department of Highways and Public Works (See *http://www.yukonheritage.com/Sign*).

To date we have prepared four brochures, which draw attention to the following sites:

Alaska Highway East (Watson Lake to Whitehorse)

Km 1042: Big Creek – Rancheria basalt flows

Km 1112: Rancheria Falls (Cassiar Fault mylonite)

Km 1199: Andrew Creek (purple metamorphosed chert and phyllite)

Km 1295: Canol Road terminus (glaciolacustrine silt)

Alaska Highway West

Km 1443: Mailbox stop, (Lewes River Group sediments)

Km 1476: Takhini Deformation zone, (Stikinia)

Km 1487: Takhini Burn outcrop (Yukon-Tanana terrane)

Km 1547: Canyon Creek, (Kluane Schist)

Km 1589: Alsek hiking trail (Wrangellia terrane)

Km 1707: Soldiers Summit hiking trail (Wrangellia terrane, see Figure 9)

Km 1864: Pickhandle Lake (Windy-McKinley terrane)

Km 1936: Gravel Pit (Windy-Mckinley terrane)

Klondike Highway South (and the Atlin Road)

Km 36: Fraser (Coast Plutonic Complex)

Km 64: Tutshi Lake (Lewellyn fault zone)

Km 82: Montana Mountain (Carmacks volcanics and historic mill site)

Km 95: Bove Island rest stop (Cache Creek Group limestone)

Km 107.7: Carcross Desert rest stop (glacial lake sediments)

Km 117.6: Emerald Lake rest stop (Laberge Group sandstone/conglomerate)

Klondike Highway North

Km 202: Vista Road (Laberge Group volcanic rocks)

Km 225: Lake Laberge campground (Laberge Group siltstone and sandstone)

Km 298: Whitehorse trough rest stop (Laberge Group conglomerate)

Km 365: Cliffside Agate Road (Carmacks Group volcanic rocks)

Km 380: Five Finger Rapids (Laberge group conglomerate)

Km 535: Stewart Crossing – Roadcut north of bridge (biotite schist)

Km 713: Midnight Dome (ultramfic klippe)

We are also planning brochures for: Whitehorse area, the Silver Trail, the Robert Campbell Highway and the Canol and Nahanni Range roads. Literature for the Dempster Highway is completed (see next section).

GEOLOGICAL ROAD LOGS

Since 2006, we have been conducting field work to record most outcrops along the highway right-of-way. This is on-going: Yukon highways are constantly upgraded which creates new exposures in some places, and closes others. Our objective is to provide a roll-call of outcrops with GPS location points and photographs for those worthy of visiting. Descriptions will emphasize rock features, leaving interpretation to the leaders of future field trips and consultation of the digital Yukon Geology map site (www.geology.gov.yk.ca).

The road logs employ geological terminology (Fig. 10). It is baseline information for use within government science departments. Selected sections, possibly with links to photographs, may be made available on the YGS website as pdf files.

COMPLETED: DEMPSTER HIGHWAY – TRAVELER'S GUIDE AND GEOLOGICAL ROADMAP

The geology of Canada's most northwestern road, which extends from near Dawson northeastward, across the Arctic Circle to Inuvik, Northwest Territories (717 km) is published as a booklet (Pyle *et al*., 2007) and folded brochure (Jones and Pyle, 2007). The book was co-produced by the YGS and the NTGO (Northwest Territories Geoscience Office) with assistance of Geological Survey of Canada geologists in 2005 and 2006. The guidebook uses geological language with nine page-size maps, a stratigraphic table, photographs and sidebars that highlight features along the route. The brochure, a simplified geological map (1:600 000 scale), is surrounded by photographs and short descriptions of 18 sites of geological interest and will suit non-geological travelers.

SUMMARY

"What's that rock I saw back there?" spoken by a traveler, belies natural curiosity, but also a missed opportunity – the opportunity to tell a geological story, or perhaps an outdoor moment between Yukon communities. The Yukon Geological Survey Outreach initiative seeks to create products that will use that opportunity: attractive, informative literature and a knowledge bank of the most accessible geology exposures in the territory. These products include a map which shows the extent of surficial materials and rock types across Yukon, companion brochures for segments of the highway network, and a sequential road log. We will have succeeded if more residents and tourists take the time to appreciate our geological landscape by getting out of their cars to experience the rocks in their natural setting and lingering a while in their journey, enjoying the Yukon's geological heritage.

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76.2 km, south side: pullout on north side of Halfway Lakes, at entrance of the Silver Trail Inn.

Geo-STOP 5 : interpretive sign "The edge of Beringia". Side-road to west (at 75.9 km) leads 2.8 km to parking lot and trail up Mt. Haldane. This hike to top and return takes about 6 hours.

At north entrance to Silver Trail Inn (150 m north) is a road-cut exposing McConnell moraine on the north side. At the height of the McConnell glaciation (18,000 years ago), a valley glacier flowing from north to south terminated here. A large glacial outwash stream poured off the glacier depositing the flat gravelly plain to the south. Massive ice blocks were buried in the terminal moraine and later melted leaving depressions now occupied by Halfway Lakes.

77.7 km, west side: pull-out with emergency shelter for winter survival.
(These are left from the 1980s, when the Keno Hill ore-trucks used the road regularly)

80.2 km, east side: small outcrop of grey-green schist (similar at next exposure)

80.8 km: Geo-STOP 6 :463349 7076931 764 m
Pullout to a scenic viewpoint on west side; despite the vegetation, the view of Mount Haldane is impressive. You are standing near the margin of the former valley glacier that filled the valley below during the last glaciation. Much of Mount Haldane would have been exposed above the glacier marking the line between vast ice-covered terrain to the east and Beringia to the west.

On the east side of the road is an excavation of silvery-brown weathering muscovite-quartz phyllite (deformed Yusezyu Fm., Hyland Group, of Late Proterozoic to Early Cambrian age). A prominent foliation dips moderately southward, and rubble breaks in thick slabs. Slab surfaces show two intersecting crenulations. These orientations may result from northward thrusting (area is near the base of the hanging wall of the Robert Service thrust sheet) overprinted by northwestward translation (area is near the top of the Tombstone strain zone; Murphy, 1997).

The Silver Trail continues northeast along the topographic bench on the gentle northwest slope…

Figure 10. *An excerpt from the Geological road log (Silver Trail, about 20 km north of Mayo).*

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