A transect through the accreted terranes of the northern Canadian Cordillera:

From Cassiar, British Columbia to Kluane Lake, Yukon

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INTRODUCTION

This five-day geological excursion across the northern Canadian Cordillera of southern Yukon and northern B.C. will lead the participants from the parautochtonous edge of ancestral North America (Laurentia), near Cassiar, B.C., through the Intermontane (peri-Laurentian) terranes and the oceanic Cache Creek Terrane (of Tethyan affinity), and end in the exotic Insular terranes (of Arctic affinity) by Kluane Lake, in southwestern Yukon (Figs. A1, A2; Plate 1). The trip will examine the internal and external relationships of terranes that were accreted to ancestral North America in Mesozoic time and discuss models of Cordilleran evolution. Although the field trip route offers limited opportunity to examine the mineral wealth of these terranes, metallogenetic highlights will be presented within their regional tectonic context along the way. The reader is referred to Nokleberg *et al.* (2005) and Nelson and Colpron (2007) for overviews of regional metallogeny of the northern Cordillera.

This field trip constitutes the most complete geological transect across the accreted terranes of the northern Canadian Cordillera to date. It builds, in part, on an earlier trip, held in conjunction with a Nuna conference (Johnston *et al.*, 1993), but for which the focus was primarily the central portion of the present trip (Stikinia, Cache Creek Terrane, Whitehorse trough and the Coast Plutonic Complex). The 1993 Nuna field trip also took place at a time when detailed studies of the northern Cordillera were still in their early stages. Since then, regional mapping programs by the geological surveys of British Columbia, Yukon and Canada have substantially improved our knowledge of northern Cordilleran terranes. Paramount among these efforts was the Ancient Pacific Margin National Mapping Program (NATMAP; 1999-2003), an initiative of the Geological Survey of Canada that provided the foundation for collaboration amongst the geological surveys, and with university and industry partners. The Swift River to Morley Lake portion of the present field trip (Day 3) builds upon one of the many field trips that brought together NATMAP participants. This one was led by Charlie Roots, JoAnne Nelson and Tekla Harms across the southern Yukon-Tanana Terrane in 2001. Many of the relationships and ideas that will be presented along this trip originated from our involvement in this NATMAP project and are detailed in a series of papers edited by Colpron and Nelson (2006). Ongoing mapping activities in southern Yukon and northern B.C. continue to generate new data which shapes our evolving interpretation of the northern Canadian Cordillera.

The SNORCLE (Slave-NORthern Cordillera Lithospheric Evolution) transect of Lithoprobe was another important initiative that recently generated volumes of information about the northern Cordilleran lithosphere (e.g., Cook and Erdmer, 2005). During the 10 years of the SNORCLE transect, a wide range of studies were conducted, including regional geophysical investigations (seismic reflection and refraction, electromagnetics, paleomagnetism) and supporting geoscience projects (petrology, geochronology, paleontology, bedrock mapping, and others). The field trip route follows parts of two of the seismic-reflection transects that were acquired by SNORCLE (Plate 1); line 2a between Watson Lake and Cassiar on Day 2 (Fig. A3), and line 3 between Johnson's Crossing and Carcross on Days 3 and 4 (Fig. A4).

Finally, the development of GIS (geographic information systems) geological databases for Yukon (Gordey and Makepeace, 1999) and British Columbia (Massey *et al.*, 2005), and a more recent update for the Yukon-Tanana Terrane (Colpron, 2006), now provide the basis for an accurate map with which to explore the geology of northern Cordilleran terranes (Plate 1).

This field trip was originally run September 19-23, 2007 in conjunction with the Ores and Orogenesis Symposium, in honour of W. R. Dickinson, held in Tucson, Arizona, September 24-30, 2007, and organized by the Arizona Geological Society.

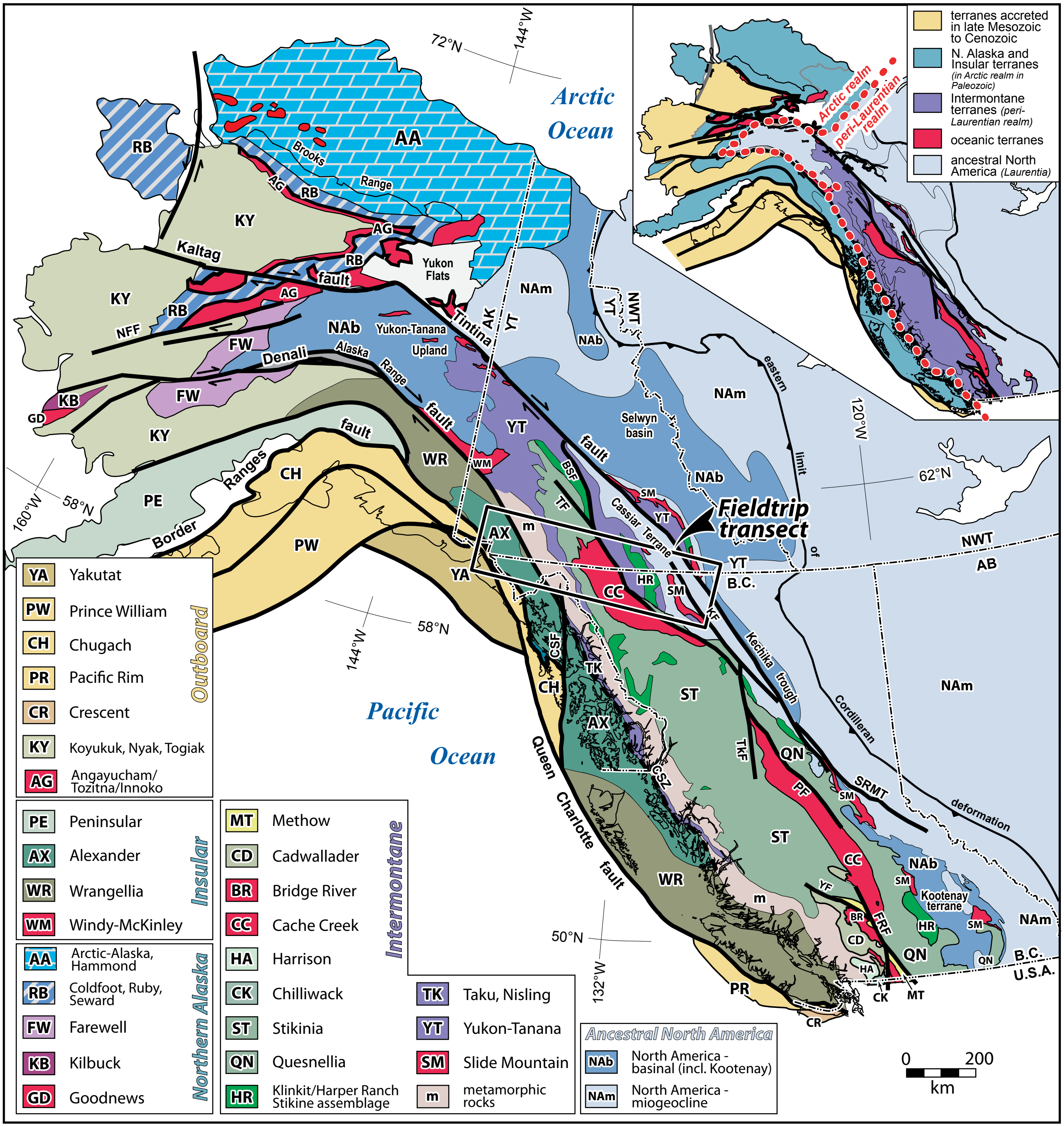


Figure A1. *Terranes of the Canadian-Alaskan Cordillera. Inset shows terrane groupings and tectonic realms. Paleozoic basinal strata of ancestral North America (NAb; e.g., Selwyn basin) were not previously included on terrane maps of the Cordillera (e.g., Wheeler et al., 1991). We include them here because they represent a first order lithotectonic belt equivalent to many terranes and correlate with some of the displaced terranes (e.g., Kootenay Terrane, Yukon-Tanana upland and northern Alaska Range).*
Abbreviations for major post-accretionary faults: BSF – Big Salmon fault; CSF – Chatham Strait fault;
CSZ – Coast shear zone; FRF – Fraser River fault; KF – Kechika fault; NFF – Nixon Fork-Iditarod fault; PF – Pinchi fault;
SMRT – southern Rocky Mountain trench; TkF – Takla-Finlay-Ingenika fault system; YK – Yalakom fault.
Other abbreviations: AB – Alberta; AK – Alaska; B.C. – British Columbia; NWT – Northwest territories; YT – Yukon.
Sources: Wheeler et al. (1991); Silberling et al. (1992); Colpron (2006).

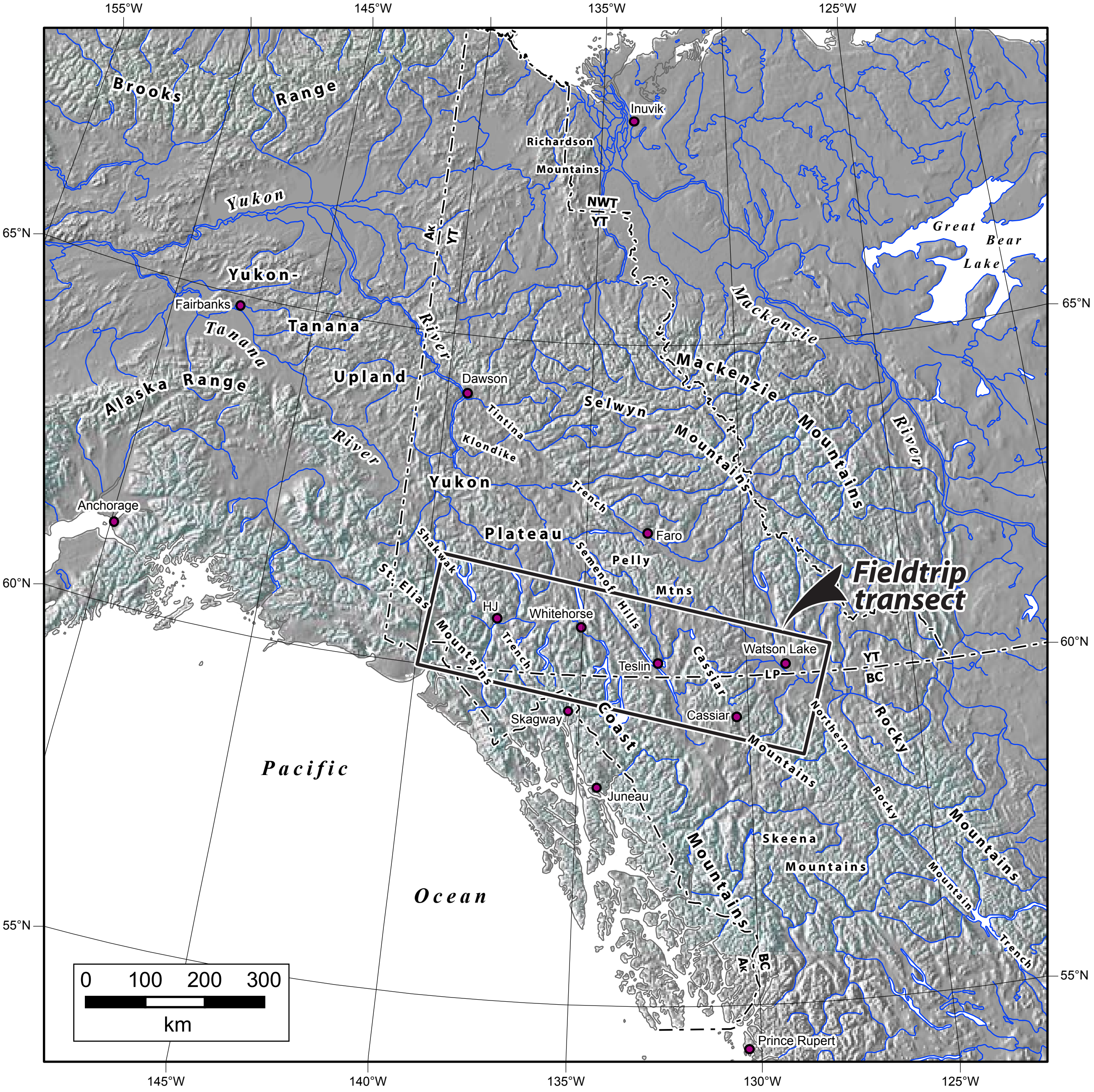


Figure A2. Physiographic map of northern B.C., Yukon and eastern Alaska. HJ = Haines Junction; LP = Liard Plain.

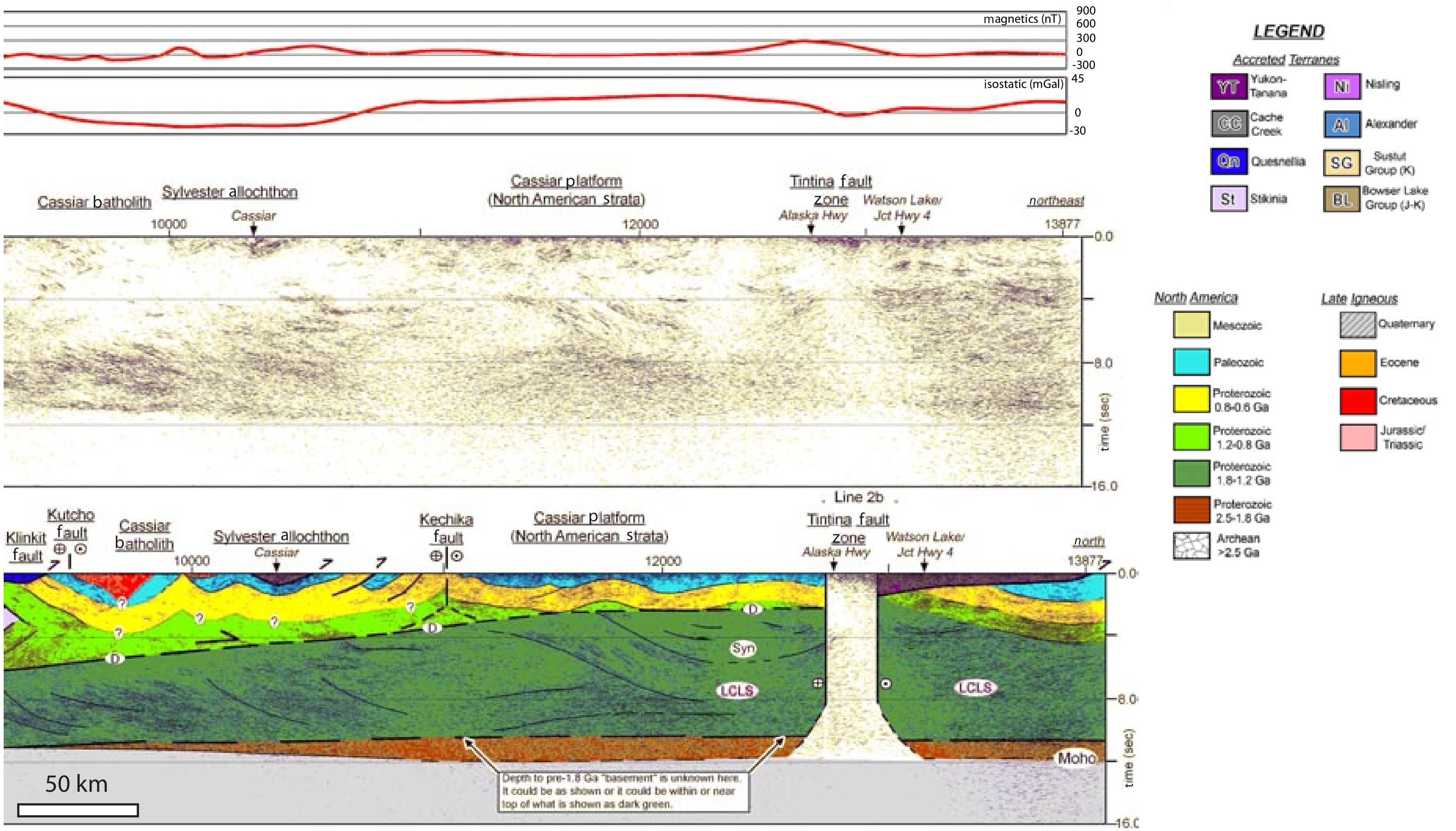


Figure A3. *Part of SNORCLE line 2a seismic transect along the Cassiar Highway (Cook et al., 2004). See Plate 1 (in pocket) for location.*

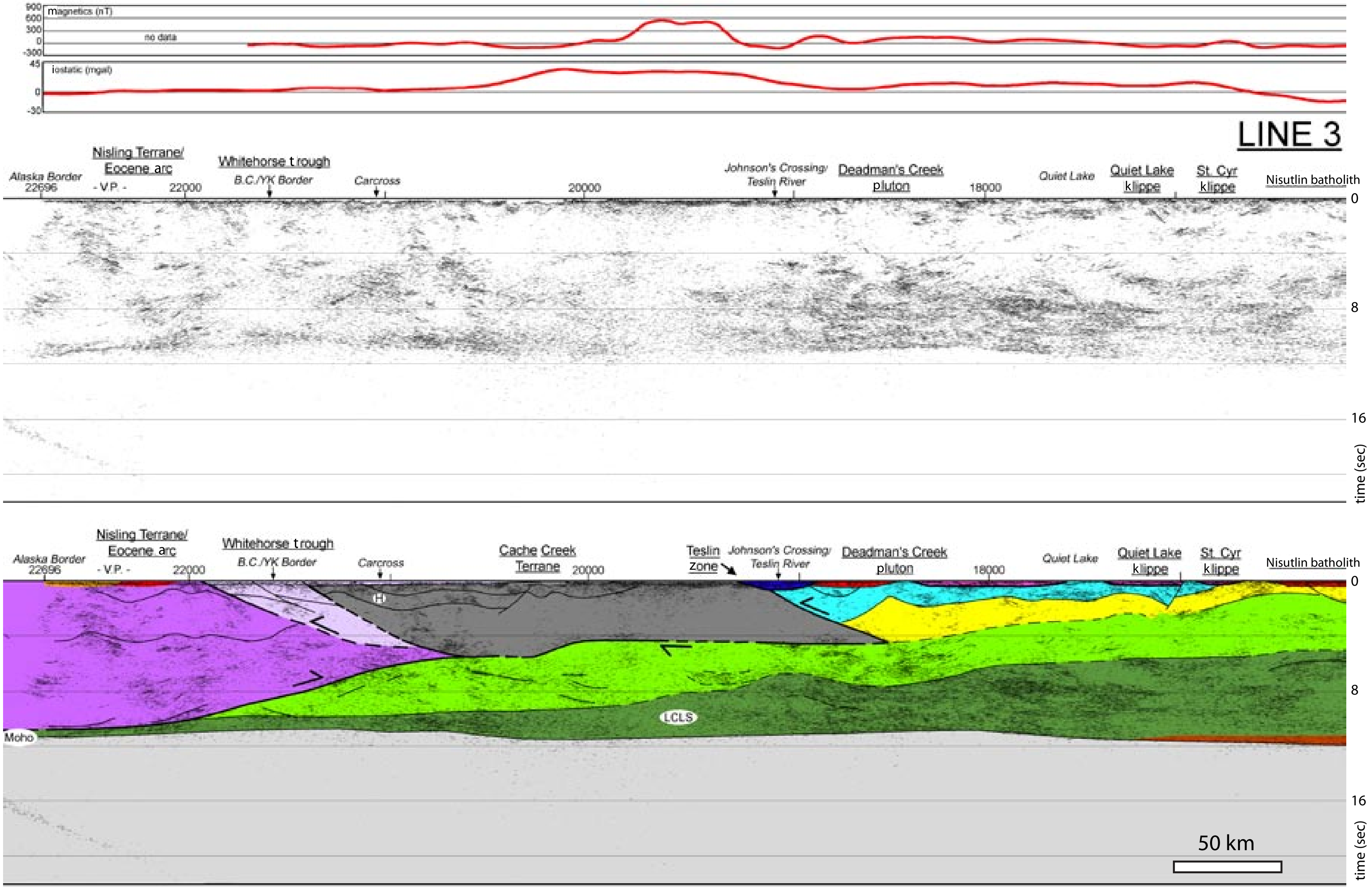


Figure A4. *Part of SNORCLE line 3 seismic transect along South Canol road, part of the Alaska Highway, the Tagish road, and the South Klondike Highway (Cook et al., 2004). See Plate 1 (in pocket) for location. Legend is given in Figure A3.*

Structure of this guidebook

This guidebook begins with a brief introduction to northern Cordilleran geology and tectonics. Details of the geology of the accreted terranes and major crustal structures are further elaborated in the introduction to each segment of the field trip (Days 1-5). The data fueling most of the interpretations presented in this guidebook are presented in the series of papers on the northern pericratonic terranes edited by Colpron and Nelson (2006). The paleogeographic evolution of the northern Cordilleran terranes, and its bearing on metallogeny, is considered in the review by Nelson and Colpron (2007) and in Colpron *et al.* (2007).

Regional geological overview

Within the northern Cordillera, Proterozoic to Triassic miogeoclinal, mainly sedimentary, platformal to basinal strata of the western Laurentian continental margin (NAm and NAb on Figure A1) extend into eastern British Columbia, Yukon and east-central Alaska. Farther west, most of British Columbia, Yukon and Alaska are made up of Paleozoic to Mesozoic volcanic, plutonic, sedimentary and metamorphic assemblages that represent magmatic arcs, microcontinents and ocean basins accreted to western Laurentia in Mesozoic and younger time. These, along with the parautochthonous deformed belt and the undisturbed platform of western Canada, are overlain by syn- and post-accretionary clastic deposits. The western and inner parts of the orogen are pierced by post-accretionary plutons and in places overlain by thick accumulations of relatively young volcanic strata.

Although the northern Cordillera has been subdivided into a multiplicity of terranes (cf. Coney *et al.*, 1980; Wheeler *et al.*, 1991, Fig. A1), it can be viewed more globally as consisting of five first-order tectonic entities (Fig. A1 inset):

1) Ancestral North America (western Laurentia), including the Yukon-Tanana upland, Alaska Range, Cassiar Terrane and Kootenay Terrane – the autochthon and parauthochthon;
2) the allochthonous marginal pericratonic terranes (Intermontane terranes) – the peri-Laurentian realm;
3) the Insular and Northern Alaska terranes, which evolved in the Arctic realm in Paleozoic time;
4) oceanic and accretionary complex terranes which evolved alongside the Intermontane and Northern Alaska-Insular terranes (shown in red on Fig. A1);
5) Mesozoic and younger arc and accretionary terranes that form a western and southern fringe to the older elements – the Outboard terranes in Figure A1.

Ancestral North America (Laurentia) includes the western craton margin, the miogeocline with its platforms and basins and its fringing, parautochthonous terranes (Cassiar, Kootenay, Selwyn basin; Fig. A1). Until recently, metamorphic rocks of the Yukon-Tanana upland and Alaska Range in east-central Alaska were considered a part of the allochthonous Yukon-Tanana Terrane (see below); they are now interpreted as part of the parautochthonous Laurentian continental margin (Dusel-Bacon *et al.*, 2006; Nelson *et al.*, 2006). The western, outboard boundary of this autochthonous to parautochthonous belt is marked by discontinuous slivers and slices of the Slide Mountain oceanic terrane. These rocks were formed in a marginal rift basin of Late Devonian to Permian age that once lay between the continent and a belt of rifted pericratonic fragments upon which successive Devonian through Jurassic arcs were formed (Yukon-Tanana Terrane, Quesnellia and Stikinia; Colpron *et al.*, 2006a; Nelson *et al.*, 2006). The belt of pericratonic terranes was originally bounded on its outer, oceanward margin by an accretionary complex, the Cache Creek Terrane that includes slivers of high-pressure/low-temperature metamorphic assemblages, as well as blocks of limestone with exotic Permian fusulinid and coral faunas of Tethyan (Asian) affinity (Ross and Ross, 1983). The present position of the exotically derived Cache Creek Terrane, enclosed within the pericratonic belt, is a constructional anomaly that may be best explained by oroclinal enclosure that developed as the Intermontane terranes amalgamated and accreted to the continent in Jurassic time (Mihalynuk *et al.*, 1994).

Monger *et al.* (1982) defined the Intermontane Superterrane as a collage of many of the peri-Laurentian and oceanic terranes that amalgamated during Triassic-Jurassic accretion. Colpron *et al.* (2007) describe initial and ongoing relationships that span the entire period of the existence of these terranes. This field trip will focus primarily on the Intermontane terranes (Fig. A1) and examine some of the evidence for linkages between adjacent terranes of the peri-Laurentian realm.

In fundamental contrast to the Intermontane terranes, the Insular terranes (Wrangellia and Alexander; Insular Superterrane of Monger *et al.*, 1982; and the Peninsular Terrane of southwestern Alaska; Plafker *et al.*, 1989) and the Farewell Terrane of central Alaska (Bradley *et al.*, 2003), although in part long-lived (Precambrian to Triassic) and in part of pericratonic origin, show no evidence of early relationships to the western margin of Laurentia. Instead, their early faunal and isotopic affinities are consistently with Siberia and Barentia (Bazard *et al.*, 1995; Nokleberg *et al.*, 2000; Bradley *et al.*, 2003). The Arctic-Alaska Terrane, although continental to pericratonic and thought to show continuity with the northernmost miogeocline, is anomalous with respect to western Laurentia (Lane, 1997). It bears stratigraphic similarities to the Chukotka peninsula of the Russian Far East (Patrick and McClelland, 1995); it has been proposed that Arctic-Alaska and Chukotka were contiguous throughout most of their history and displaced and/or rotated into their current position in Cretaceous time (Miller *et al.*, 2006). Together, the Insular, Farewell and Arctic-Alaska terranes constitute an original set of mobile to detached crustal fragments, along with subsequent Paleozoic and Mesozoic arcs and basins, which developed mainly within the Arctic realm: they are referred to here collectively as the Northern Alaska/Insular terranes (Fig. A1 inset). Within this group, some terranes amalgamated at different times than others. Early in the history of Wrangellia, a Pennsylvanian pluton linked it to the Alexander Terrane (Gardner *et al.*, 1988). By Late Triassic to Early Jurassic time, at least Wrangellia seems to have been transported to a more southerly paleolatitude west of the Laurentian margin, prior to mid-Jurassic accretion with the Intermontane terranes (Aberhan, 1999; Smith *et al.*, 2001). This set of terranes bounds the combined Laurentian margin and Intermontane (peri-Laurentian) terranes to the west (Fig. A1). On the last day, the field trip will end in the Insular terranes at Kluane Lake, facing the majestic Kluane Ranges.

The outermost belt of terranes contains relatively young, Mesozoic to Paleogene assemblages, including the accreted Koyukuk arc; the Paleocene-Eocene seamounts of the Crescent Terrane; and the Chugach, Prince Williams, Pacific Rim and Yakutat terranes, which are accretionary complexes dominated by trench sediments. These arc and accretionary assemblages developed within the eastern Pacific realm near or on the developing Cordilleran margin. Monger and Nokleberg (1996) interpret them as paired accretionary prism-arc belts; the reader is referred to their work for a clear and useful synthesis. We will not see this group of terranes on this field trip.

Crustal structure

Terranes of the northern Canadian Cordillera were emplaced to their current positions, above the western edge of the ancestral North American craton, during Mesozoic to early Cenozoic orogenesis. From Jurassic to Early Cretaceous time, the accreted terranes were mainly converging (most likely obliquely) with western North America. By mid-Cretaceous to Eocene, deformation was dominated by dextral transcurrent faulting (transpressional in the north; transtensional in the south). As a result, the crustal structure of the northern Canadian Cordillera, as imaged on SNORCLE seismic transects (Figs. A3, A4), is one of a thin-skinned thrust belt, dissected by a few crust-penetrating transcurrent faults (Cook *et al.*, 2004). Prominent features in the SNORCLE seismic reflection profiles are:

1) fairly flat, well-defined Mohorovicic discontinuity (Moho; sharp decrease in reflectivity) at approximately 12 sec (35-40 km ; Figs. A3 and A4);
2) westward-tapering layering (zero edge below Alaska border; Fig. A4) that is interpreted as Proterozoic rocks of ancestral North American affinity (LCLS in Figs. A3 and A4), but for which details of interpretation are controversial (see below);
3) eastward-tapering wedge of upper Proterozoic and Paleozoic parautochthonous strata of ancestral North American affinity (including Cassiar platform, Selwyn basin, and the northern Rocky Mountains) – the Laurentian miogeocline;
4) the accreted terranes are typically less than 15 km thick (<4-5 sec) and commonly only a few kilometres thick (~1 sec);
5) Stikinia (and its pericratonic roots – labeled Nisling Terrane in Fig. A4) is a notable exception; its entire lithosphere appears to be juxtaposed against the western edge of ancestral North America (see Fig. A4; and Foldout 3 in Cook *et al.*, 2004);
6) the mantle is generally devoid of reflections, with the exception of a series of well-defined, east-dipping reflectors at the west end of Line 3 (16-20 sec in Fig. A4) that are interpreted as a relict subduction surface of the Kula plate (Cook *et al.*, 2004).

The strong, westward-tapering middle- to lower-crustal layering (LCLS in Fig. A3 and A4) has been variably interpreted as 1) a sedimentary prism of Proterozoic strata (~1.8-0.7 Ga; Mackenzie Mountains Supergroup, Muskwa assemblage and Wernecke Supergroup; Snyder *et al.*, 2002; Cook *et al.*, 2004); or 2) a westward-tapering wedge of crystalline basement (~1.8 Ga and older; Evenchick *et al.*, 2005).

The thin-skinned nature of the accreted terranes imaged in seismic-reflection profiles confirms inferences of the crustal structure as derived from geological mapping (a prominent example on this field trip will be the Sylvester allochthon on Day 2; see also the map of the Finlayson Lake area by Murphy *et al.*, 2001). It is also corroborated by a more recent seismic-reflection survey acquired along the Robert Campbell Highway, approximately 200 km north of the Alaska Highway (D. White and M. Colpron, unpublished data, 2004). It is important to remember that many of the terranes that are interpreted to be only a few kilometres thick at present (e.g., Yukon-Tanana Terrane, Figs. A3 and A4) have been moderately to deeply exhumed since their accretion in early Mesozoic time. In places, up to 15-20 km of rocks were removed by tectonic processes and/or erosion. Evidence for this lies in the rapid unroofing of Early Jurassic batholiths intruding the Yukon-Tanana Terrane (e.g., Aishihik, Granite Mountain and Tatchun batholiths; Johnston and Erdmer, 1995; Johnston *et al.*, 1996a; Colpron *et al.*, 2003) and in the widespread Early Jurassic mica cooling ages of surrounding metamorphic rocks (Fig. A5; Breitsprecher and Mortensen, 2004).

The surface structures along the field trip route vary from east-verging, thrust-and-fold structures in the northern Rockies and Cassiar Mountains, to recumbent, polyphase folds and ductile shear zones in the Yukon-Tanana Terrane, and to west-verging thrust-and-fold structures in Quesnellia, Stikinia and Cache Creek Terrane. The axis of this regional zone of structural divergence occurs in the eastern Yukon-Tanana Terrane, near Swift River. The pattern of west-verging (or, at least, east-dipping) structures persists into southwestern Yukon to the Denali fault (Johnston and Canil, 2007).

Evidence for development of pre-accretionary structures is locally well-preserved in the Yukon-Tanana Terrane. Deformational episodes of Devonian, late Early Mississippian, Pennsylvanian

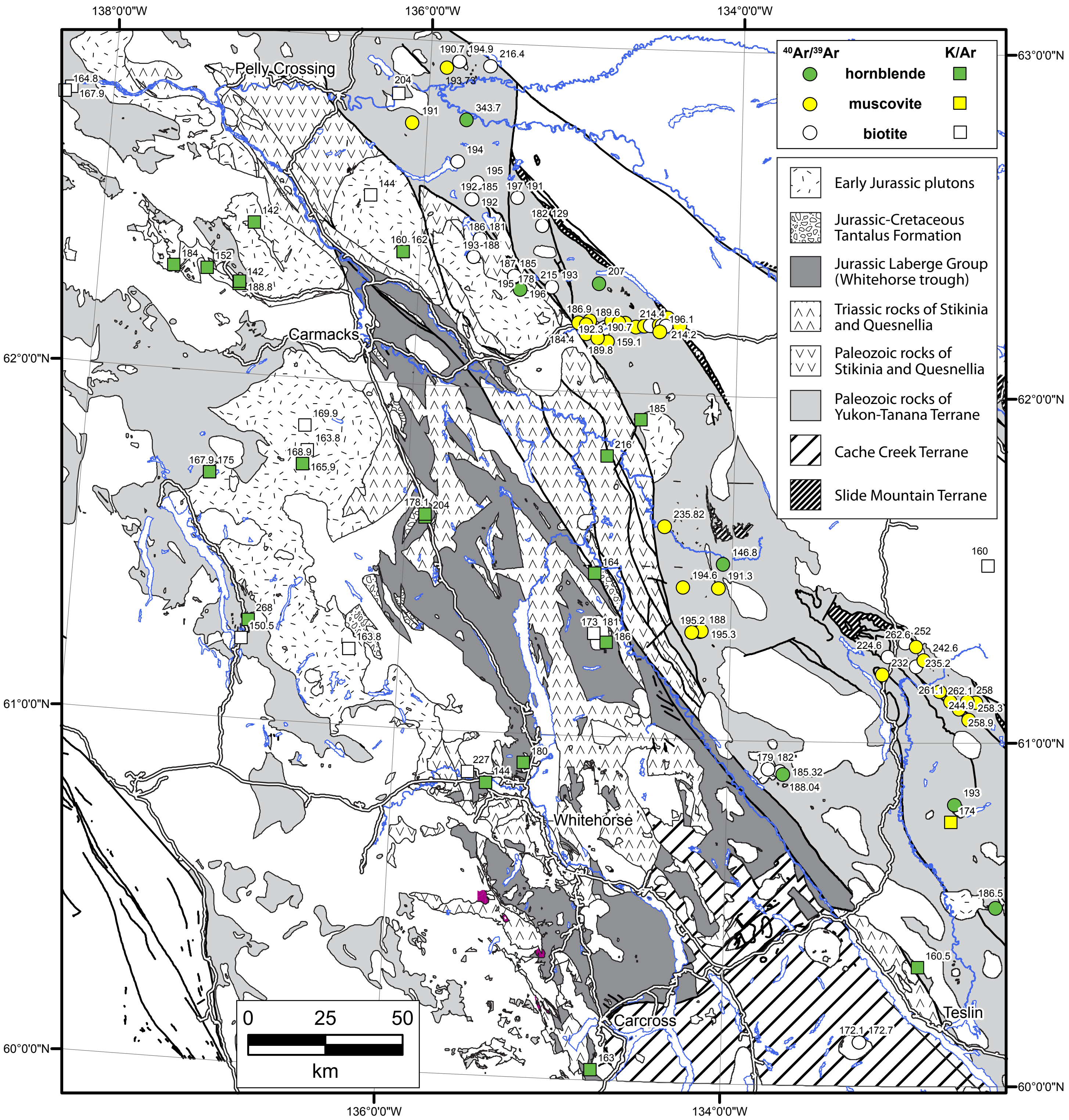


Figure A5. *^{40}Ar/^{39}Ar and K/Ar cooling ages from the Yukon-Tanana Terrane and Jurassic intrusions surrounding the Whitehorse trough, in southern Yukon. Data is from the compilation of Breitsprecher and Mortensen (2004) and unpublished data by M. Colpron and M. Villeneuve.*

and Late Permian ages have been documented (Colpron *et al.*, 2006a, b; Murphy *et al.*, 2006; Mackenzie *et al.*, 2007). At least the Mississippian and Permian episodes appear to be of regional extent.

Dextral transcurrent faults and the Cordilleran paleomagnetic dilemma

The Canadian Cordillera is dissected by a series of late Early Cretaceous to Cenozoic, orogen-parallel, dextral strike-slip faults (Fig. A6; Gabrielse, 1985; Gabrielse *et al.*, 2006). The younger faults (mainly Eocene in age) are the most obvious as they correspond to well-defined morphogeological trenches; prominent examples being the Tintina-Northern Rocky Mountain Trench (NRMT), underlain by the fault of the same name, and the Shakwak Trench in southwest Yukon, which is underlain by the Denali fault (Fig. A2). The Tintina fault has a well-constrained post-Late Cretaceous dextral displacement of 400-430 km (Gabrielse *et al.*, 2006; see Introduction to Day 3 for further description of the Tintina-NRMT Fault). Eocene strike-slip displacement along the Tintina fault in the northern Cordillera was likely kinematically linked with widespread extension and exhumation of metamorphic core complexes in the southern Canadian Cordillera (Price and Carmichael, 1986). Eocene (to recent) dextral displacement on the Denali fault is not as well constrained but estimated at ~370 km (Lowey, 1998).

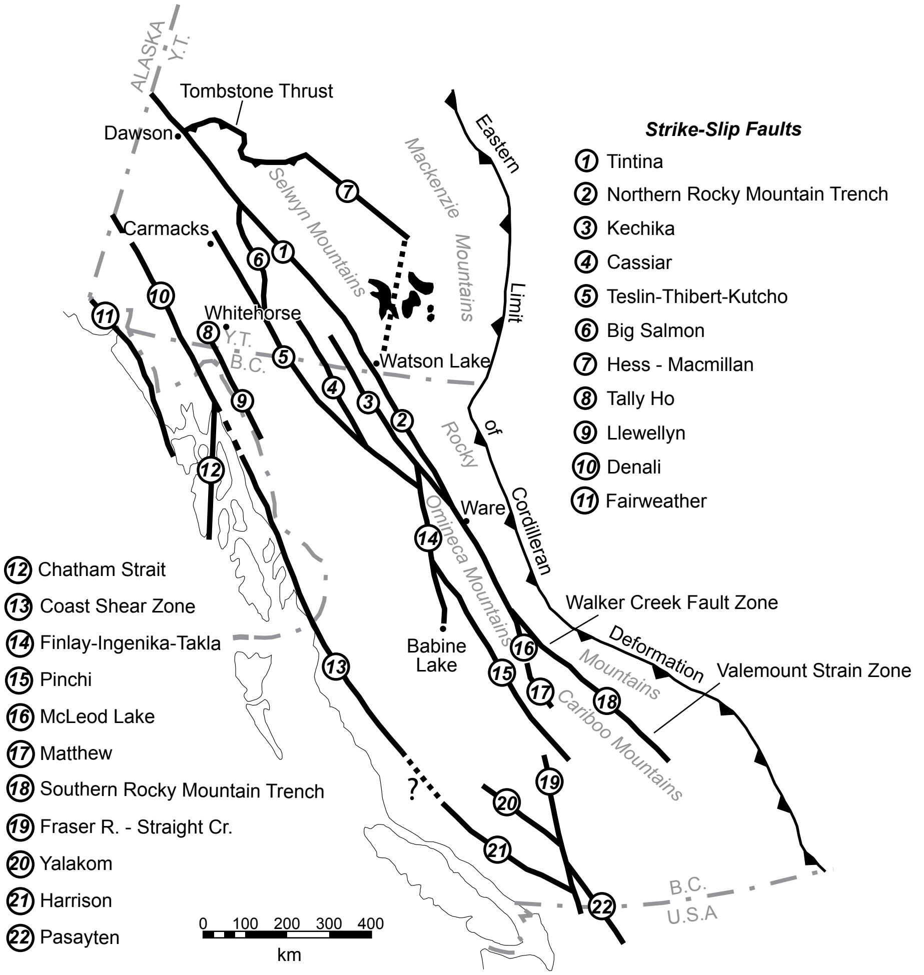


Figure A6. *Major transcurrent faults of the Canadian Cordillera (after Gabrielse et al., 2006). Black areas north of Watson Lake represents voluminous mid-Cretaceous plutons inferred to be emplaced in a zone of late Early Cretaceous extension (dashed line).*

The late Early Cretaceous transcurrent faults form a complex array of linked faults (as opposed to a few well-defined large Eocene faults) and are typically associated with voluminous syn-tectonic magmatism (Gabrielse *et al.*, 2006). These include the Kechika, Kutcho, Thibert and Teslin faults, and related splays such as the Cassiar, Big Salmon and d'Abbadie faults (Fig. A6). Prior to Eocene displacement on the Tintina fault, the late Early Cretaceous faults likely constituted a series of linear strike-slip faults which connected northward with a broad zone of extension and voluminous magmatism in southeast Yukon and northwesterly directed thrust faults (Tombstone and Robert Service faults) in western Yukon (Gabrielse *et al.*, 2006; Fig. A7). The NRMT fault was also likely the locus of Early Cretaceous displacement, although the total amount of offset is uncertain (Gabrielse, 1985). The overall post-accretion northward translation of the Intermontane terranes by dextral strike-slip faults, mainly in Cretaceous and younger times, is geologically constrained to be on the order of 860 km (Gabrielse *et al.*, 2006).

In contrast, paleomagnetic data from Late Cretaceous rocks require northward latitudinal displacement on the order of 2000+ km (Irving *et al.*, 1996). Originally, anomalously shallow paleomagnetic inclinations from the Insular terranes were interpreted to require large latitudinal displacements on intra-Cordilleran faults such as the Coast shear zone (CSZ in Fig. A1; 13 in Fig. A6; Irving *et al.*, 1996). Subsequently, shallow paleomagnetic inclinations have been measured at more inboard sites along the eastern edge of the Intermontane terranes, such as the Upper Cretaceous Carmacks Group volcanic rocks in Yukon (Johnston *et al.*, 1996b; Wynne *et al.*, 1998; Enkin *et al.*, 2006), and in the southern Rocky Mountains (Enkin, 2006). In the case of the Carmacks Group, the Tintina fault is the only large transcurrent fault available to accommodate the anomalous paleomagnetic inclinations and, as discussed above, its post-Late Cretaceous displacement is well constrained at 400-430 km (Gabrielse *et al.*, 2006).

In an attempt to explain the anomalous paleomagnetic data from the Carmacks Group, it has been suggested that a large fault (with three times the displacement on the Tintina fault) must lie in miogeoclinal strata of Selwyn basin (Johnston, 2001) or even farther east in the Rocky Mountains (Enkin, 2006); concepts that are difficult to reconcile with the well-established geological frameworks of Selwyn basin and the foreland fold-and-thrust belt. It is hard to conceive that a Late Cretaceous transcurrent fault with thousands of kilometres of displacement would be concealed in miogeoclinal strata when slightly younger faults, with only hundreds of kilometres of displacement, such as the Tintina-NRMT, correspond to well-defined physiographic trenches (Fig. A2) and have pronounced geophysical signatures (Fig. A3; Cook *et al.*, 2004; Snyder *et al.*, 2005). Butler *et al.* (2001) offer a moderate translation alternative (~1000 km), which is more in line with geological constraints, and account for the shallow paleomagnetic inclinations in part by tilting and compaction shallowing.

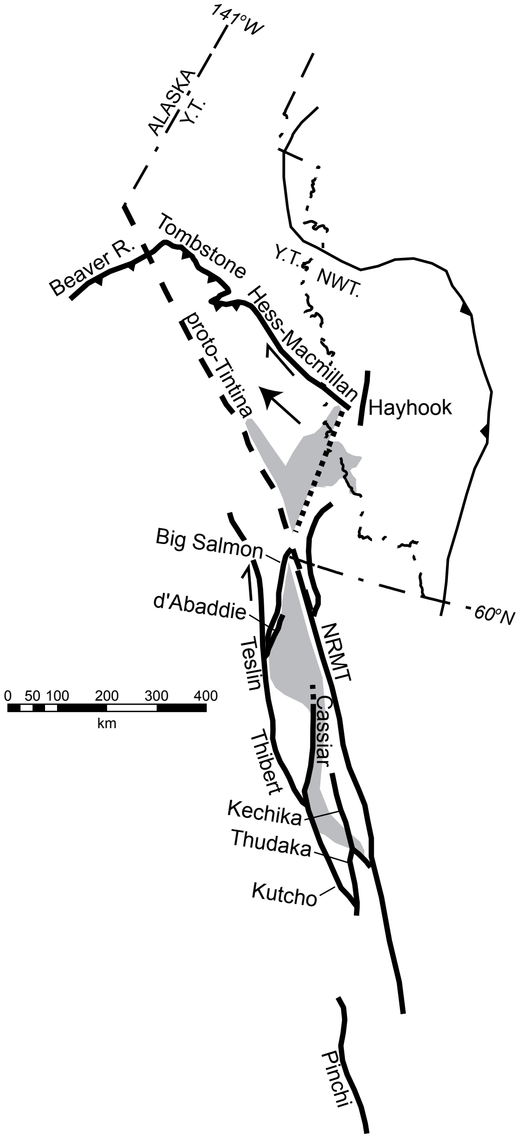


Figure A7. *Restoration of northern and southern domains of late Early Cretaceous faults and magmatism to a pre-Tintina fault configuration. Light grey areas are regions of voluminous mid-Cretaceous magmatism. The heavy dashed line in southeastern Yukon indicates axis of inferred regional extension linking the strike-slip faults in the southern domain with the Hess-Macmillan strike-slip fault system and northwest-directed thrusting along the Tombstone thrust (modified after Gabrielse et al., 2006). NRMT – Northern Rocky Mountain Trench.*

Neotectonics

Today, the northern Cordillera remains an active orogen with ongoing subduction along the Alaska trench (and corresponding arc volcanoes of the Aleutian chain) and right-lateral transform faulting along the Queen Charlotte-Fairweather fault system. Recent seismic activity is focused along the Denali fault and in the St. Elias and Chugach Mountains, along the modern continental margin (Fig. A8), within the fold-and-thrust belt of the Mackenzie Mountains, and along strike-slip faults in the Richardson Mountains, some 600-800 km to the northeast (Hyndman *et al.*, 2005). Global Positioning System (GPS) measurements indicate that the northern Cordillera is currently moving northeasterly at a velocity of ~5 mm/yr relative to the North American craton (Mazzotti and Hyndman, 2002). Seismicity and GPS velocities are explained by oblique collision of the Yakutat Terrane with the continental margin (Fig. A1) and far-field transfer of stress to the mountain front along a lower crustal detachment (Mazzotti and Hyndman, 2002; Hyndman *et al.*, 2005). The Yakutat collision and uplift of the St. Elias-Chugach Mountains probably began in mid-Miocene time and possibly as early as late Oligocene (Plafker *et al.*, 1994).

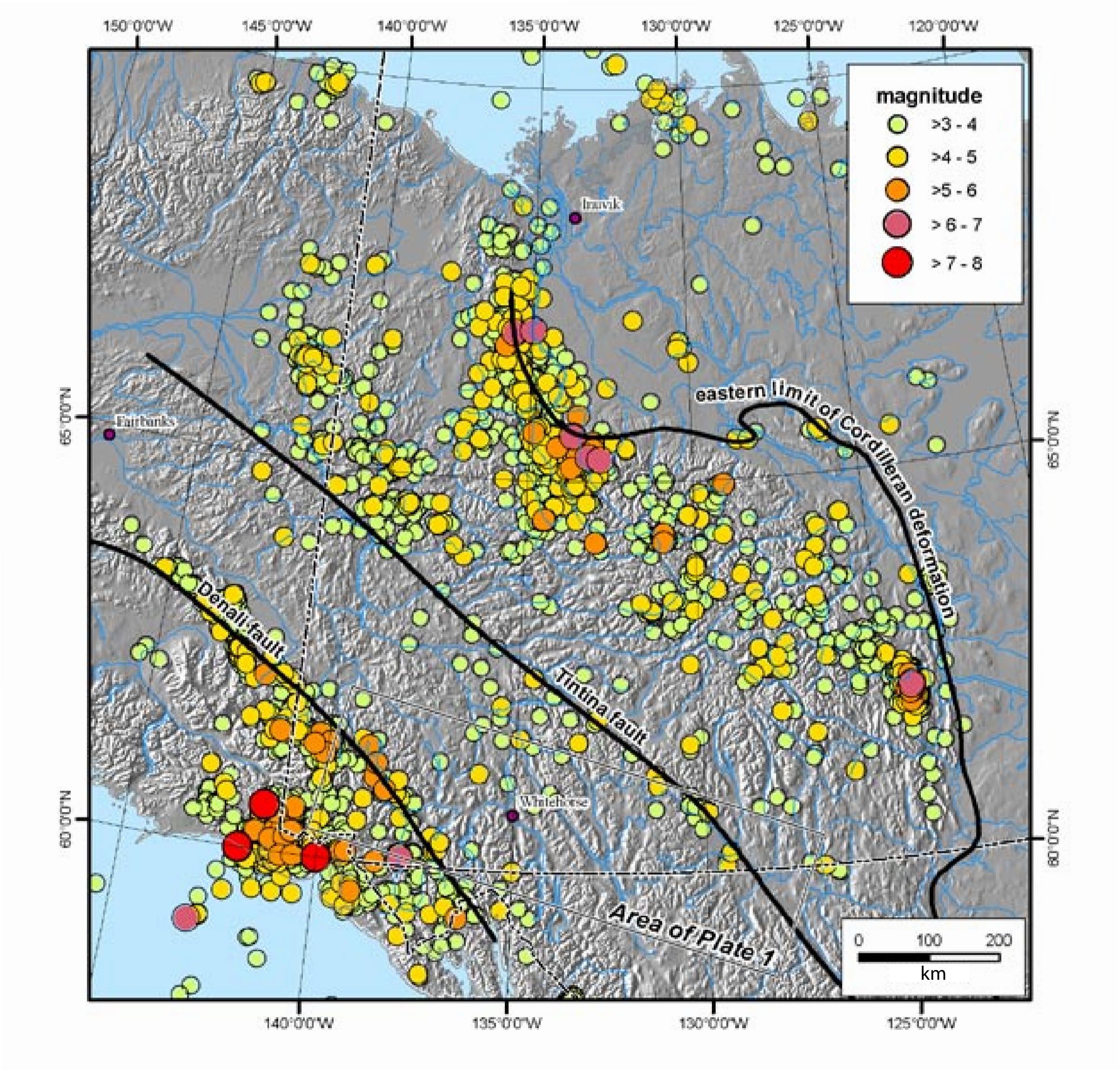


Figure A8. Earthquake activity map, 1897 to 2006 (magnitude 3 and greater). Data from Natural Resources Canada's earthquake database (http://earthquakescanada.nrcan.gc.ca/stnsdata/nedb/index_e.php).

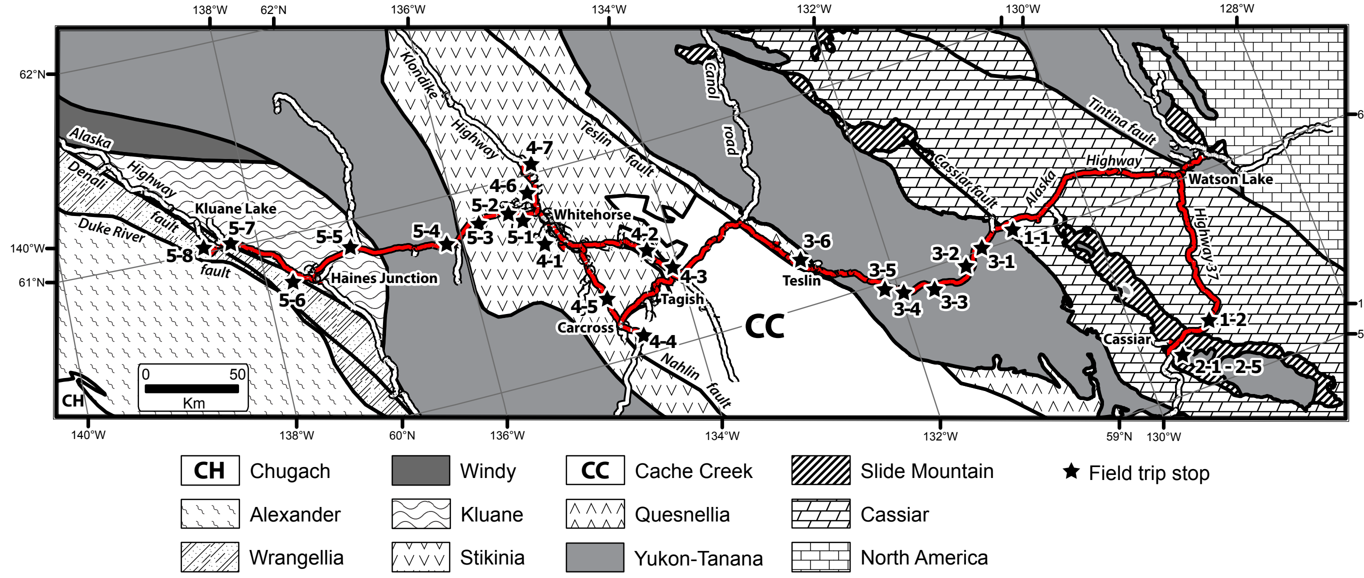


Figure A9. *Details of terranes and location of field trip stops along the geological transect. A simplified version of this map is reproduced on the first page for each day.*

The northern Cordillera is characterized by very high heat-flow values of ~105 mW/m^2 north of 59°N, compared to ~73 mW/m^2 south of 59 °N (Lewis *et al.*, 2003). This is reflected by widespread recent alkaline volcanism in the northern Canadian Cordillera (Edwards and Russell, 1999). Examples along this transect are the Rancheria basalts (Day 3) and the Miles Canyon basalts, near Whitehorse.

Field trip transect

Although the road trip begins in Whitehorse, Yukon, the actual start of the geological transect is near Cassiar, B.C., where we will examine the geology of the Sylvester allochthon (part of the Slide Mountain Terrane, the most inboard of the accreted terranes), and review the regional character of the ancestral North American margin (Cassiar Terrane or platform). At the end of the second day, we will drive Highway 37 north to Watson Lake, Yukon. The remainder of the trip, from Watson Lake to Kluane Lake, generally follows the Alaska Highway (Yukon route 1; B.C. route 97), with a few side excursions along the Klondike Highway (route 2) and the Tagish road (route 8) on Day 4 (Fig. A9 and Plate 1). Although we will technically be driving 'north' along the Alaska Highway, this portion of the highway provides essentially an east-west transect across the Intermontane terranes and the Coast Plutonic Complex, starting near 60°N at Watson Lake and ending just above 61°N at Kluane Lake, but crossing nearly 10° of longitude. The trip ends at the foot of the majestic Kluane Ranges, where we will discuss the geology of the Insular terranes and the present-day tectonics of the northern Cordillera. The Kluane Ranges are the front ranges of the St. Elias Mountains, which include Mt. Logan (5959 m), Canada's highest peak and second only to Denali (Mt. McKinley) in North America.

As many of the legs of this field trip involve long distance travel (Table 1), and because the Alaska Highway corridor offers limited access to the geology of some terranes, our choice of stops is necessarily selective. We hope that these selected outcrops and the northern Cordilleran landscape will provide an adequate backdrop to discussions of the regional geology and tectonics. Several additional points of interests are also highlighted in the field trip log and are recommended for the leisurely traveller. Many of the relationships presented along this transect are extrapolated from relationships mapped in detail throughout southern Yukon and northern British Columbia. These detailed maps, reports and related databases are readily available from the Yukon Geological

Survey (*www.geology.gov.yk.ca*) and the British Columbia Geological Survey (*http://www.em.gov.bc.ca/Mining/Geolsurv/default.htm*) websites.

The trip log is keyed to the green kilometre posts that are placed every 2 km along the north (or east) side of the major highways. Coordinates in Universal Transverse Mercator (UTM) NAD83 projection are provided for the field trip stops (Table 2) and other notable features along the transect. All distances are in kilometres.

Table 1. *Summary distances travelled.*

Distance per day		
Day 1	Whitehorse-Cassiar	550 km
Day 2	Table Mountain area (Cassiar)	160 km
Day 3	Watson Lake-Teslin (and Whitehorse)	450 km
Day 4	Whitehorse area	250 km
Day 5	Whitehorse-Kluane (return)	500 km
Length of geological transect		1020 km
Average daily distance (Days 2-5)		255 km
Total distance travelled		1960 km

Table 2. *Location of fieldtrip stops.*

STOP	UTM zone	UTME	UTMN	Elevation	Kilometre	Road	Description
1-1a	9	397763	6661428	955	1113.5	Alaska	Cassiar fault on Hwy - alternate
1-1	9	398402	6661493	930	1112.5	Alaska	Rancheria Falls
1-2	9	484231	6574067	775	627.6	Cassiar	Good Hope Lake
2-1	9	459643	6561643	1195	9.1	Cusac	basalt and Jill vein
2-2	9	460978	6561170	1295	10.7	Cusac	Cusac portal
2-3	9	465410	6562271	1560			Huntergroup Range
2-4	9	463177	6563669	1600			Triassic
2-5	9	462247	6563616	1655			Mississippian grit
3-1	9	380659	6655272	935	1133.1	Alaska	Klinkit volcaniclastic
3-2	9	371945	6646430	1260	1148.2	Alaska	Swan Lake
3-3	9	350079	6644980	880	1172.4	Alaska	Big Salmon
3-4	9	334798	6647717	875	1189.5	Alaska	Hazel pluton
3-5	8	662667	6651698	870	1198.8	Alaska	Old Highway metachert
3-6	8	621030	6676841	1085	1254.1	Alaska	Quesnellia north of Teslin
4-1	8	493605	6725078	910	1418.9	Alaska (Lobird)	Arctic Chief - Whitehorse copper
4-2	8	539355	6705661	668	1365.8	Alaska	Cache Creek chert
4-3	8	551296	6691395	780	1346.8	Alaska	Cache Creek greenstone
4-4	8	524601	6664145	772	95	S. Klondike	Bove Island
4-5	8	514091	6681287	750	117.5	S. Klondike	Emerald Lake
4-6	8	487871	6753552	1075	202.2	N. Klondike (Vista)	Nordienskold
4-7	8	489370	6771381	635	225	N. Klondike (Deep Ck)	Richthofen
5-1	8	483090	6742250	760	1443	Alaska	Mandanna
5-2	8	476497	6746461	720	1452	Alaska	Laberge conglomerate
5-3	8	452869	6745060	737	1476.2	Alaska	Takhini assemblage
5-4	8	438606	6736033	711	1493.6	Alaska	Annie Ned pluton
5-5	8	387927	6748881	650	1547.4	Alaska	Kluane Schist @ Otter Creek
5-6	8	353293	6740713	605	1589.1	Alaska	Dezadeash @ Bear Creek
5-7	7	644934	6767722	920	1634.4	Alaska	Denali fault - Kluane Lake
5-8	7	634812	6768234	810	1650.6	Alaska	Wrangellia

Climate and other considerations

The Alaska Highway portion of this trip can be done from May to early October most years, although variable snow cover on high peaks in spring and fall may limit the geological experience at some stops. Although the highway is driveable year-round, visiting these field trip stops between late October and May is not recommended as cold temperature, snow and/or mud are likely to limit access to some outcrops. The best viewing season for stops along the Table Mountain road and traverse to the Huntergroup Range, south of Cassiar, is between late June and September. Other secondary roads travelled along this trip are also subject to seasonal closures. During summer months, traffic along the Alaska and Klondike highways can be frequent and fast. Care should be taken to park vehicles well off the road and in a visible location. Watch for traffic before crossing the highway.

Wildlife is commonly sighted along the field trip route. Moose, elk, and caribou are common along much of the route. Dall sheep can be encountered between Teslin and Jakes Corner and near Kluane Lake. Bison may be seen along the Alaska Highway between Whitehorse and Haines Junction. Grizzly and black bears are present throughout the area.

Acknowledgments

Lauren Blackburn provided assistance in the preparation of the trip logs. Lesley Hunt, of Cusac Gold Mines, contributed to the preparation of Figure 2-1 and graciously provided logistics for Day 2. Luke Beranek tagged along for much of the trip preparation in the Sylvester allochthon (Day 2) and assisted with the trip log along Highway 37. Charlie Roots provided much of the material for Day 3. Don Murphy contributed electronic versions of Figures A6 and A7. Editorial comments by Grant Abbott, Lee Pigage, Diane Emond and Rod Hill, Yukon Geological Survey, helped improve the presentation of this guidebook. Wynne Krangle and Peter Long, of K-L Services in Whitehorse, were able to complete the page design on short notice. Financial contribution by the Yukon Geological Survey helped cover the costs of preparation of the trip logs, design of the guidebook and transportation for the original trip. Bob Cummings and Claudia Stone, Arizona Geological Society, arranged for advertising, registration and printing of the guidebook in Tucson. Unless otherwise indicated, all photographs were taken by Maurice Colpron or JoAnne Nelson.

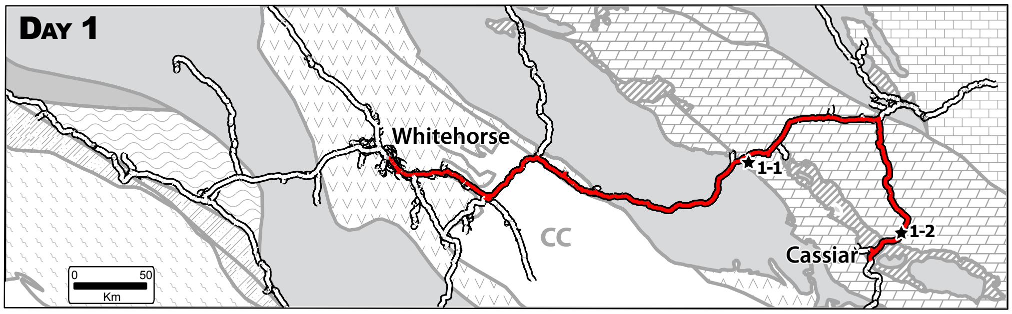
DAY 1 – WHITEHORSE TO CASSIAR

The first day of the field trip will be essentially spent driving to the start of the transect at Cassiar, B.C., a ~550-km distance. Our trip will take us south along the Alaska Highway to the junction with Highway 37 that will take us to the Cassiar mining camp.

The Alaska Highway

The Alaska Highway (or Alcan Highway) was built in eight months, between March and October, 1942, by the U.S. Army to provide an overland supply route to Alaska in the event of Japanese attacks on the west coast of North America during World War II. The 'highway' started seeing convoy traffic in 1943. Its historical length at completion time was 1523 miles (2451 km). The highway runs from Dawson Creek, B.C. to Delta Junction, Alaska, via Whitehorse, Yukon. Its original route was fairly tortuous with many abrupt curves and steep grades that were in part dictated by the mountainous landscape, but also designed as protection against potential air attacks on the convoys. The difficult land conditions in the north, particularly permafrost, required constant maintenance and upgrading of the road.

After the war, the U.S. government transferred control of the B.C. and Yukon portions of the highway to the Canadian government in April, 1946. After considerable reconstruction, the highway was opened to unrestricted traffic in 1947. Since then, the Alaska Highway has seen almost continuous rerouting and upgrading such that its current length is approximately 35 miles (55 km) shorter than its 1947 length. To take this shortening of the route into account, kilometre posts, placed at 2-km intervals along the highway (and used as markers in this guidebook), were recalibrated along the B.C. portion of the highway in 1990, and in Yukon, between the B.C.-Yukon border, near Watson Lake, and the east shore of Kluane Lake, at the end of this geological transect, in 2002 and 2005. Continued reconstruction along the Alaska Highway will likely bring future recalibrations of the kilometre posts and thus require adjustments to markers and distances in this guidebook.



TRIP LOG

km 1419.4 From Whitehorse, drive south on the Alaska Highway for more than 300 km to the first scheduled stop. We will reserve the geological commentaries for that part of the trip until we return on Days 3 and 4. On this first day, we will only make a few rest stops (with geology) along the way.

Stop 1-1a – Cassiar fault (alternate stop)

UTM 9v, 397763E, 6661428N, elev. 955

km 1113.5: Park well off the road on the hill near the west end of the outcrop, immediately after Porcupine Creek. Our planned stop is at the Rancheria Falls rest area approximately 1 km east of this outcrop (see Stop 1-1 below). If time and weather permit, this outcrop provides a better look at some of the ductile fabrics related to dextral displacement along the Cassiar fault.

This outcrop consists of K-feldspar augen granite sheets interleaved with metasedimentary rocks (quartzite, pelite and marble). The granite contains biotite (and locally hornblende) and K-feldspar augen (deformed phenocrysts) are up to 1 cm long. Local, more felsic phases are muscovite-bearing. These rocks are part of the Cassiar batholith (see Stop 1-1 below for more discussion of Cassiar batholith). Gritty quartzite and argillite are the most common metasedimentary rocks. Massive grey marble also occurs near the east end of the roadcut. The rocks have a well-developed foliation dipping moderately to the southwest. Steeply plunging periclinal folds are evident in one metasedimentary panel near the centre of the outcrop. The granite is characterized by a protomylonitic fabric with a shallow north-plunging elongation lineation; C/S fabrics and shear bands indicate dextral strike-slip faulting (Fig. 1-1). The top of the outcrop offers some of the best views of the protomylonitic fabric.

Stop 1-1 – Rancheria Falls: Cassiar fault and batholith

UTM 9v, 398402E, 6661493N, elev. 930 m

km 1112.5: Turn right (south) into Rancheria Falls rest area (with picnic shelter and pit toilets). From the west side of the parking lot, a marked, graded footpath trail and boardwalk leads 0.4 km to an overlook of Rancheria Falls, a 4-m cataract.

The very large mid-Cretaceous Cassiar batholith is an elongate body that measures only 10 to 30 km across, but extends nearly 300 km northwesterly. Over most of its length, south of the Alaska Highway, it lies along and east of the dextral strike-slip Cassiar fault, a splay of the Kutcho fault (Fig. A6). North of the highway, the fault occurs within the batholith. Strong development of protomylonitic fabrics occurs along the western margin of the batholith and decreases eastward to a weakly foliated interior, grading into massive quartz monzonite. Here, granite of the Cassiar batholith displays anastomosing shear planes that dip steeply to the west and southwest. A lineation is poorly developed.

These fabrics within the batholith, along with cross-cutting, late- to post-tectonic phases, suggest that it was emplaced during dextral strike-slip faulting. K-Ar muscovite dates on sheared rocks and U-Pb dates from the batholith coincide at 95-110 Ma (Gabrielse *et al.*, 2006). Emplacement of the batholith was likely controlled by the Cassiar fault. Displacement on the fault is about 100 km in the south (displacement of Kutcho fault), but decreases northward to about 50 km in southern Yukon (offset of northern end of the batholith). On seismic reflection profiles, the Cassiar and other Cretaceous batholiths appear to be sill-like or laccolithic because reflectors continue under them at depth (Figs. A3, A4). Geochemical and isotopic studies of the Cassiar batholith suggest that it was derived from melting of a predominantly (or exclusively?) crustal source region (Driver *et al.*, 2000). Magma was most likely generated as a consequence of crustal thickening and possibly emplaced during subsequent extension (de Keijzer, 2000; Driver *et al.*, 2000).

Resume travel east on the Alaska Highway.

Figure 1-1. *Protomylonitic fabric in granite of the Cassiar batholith near Rancheria Falls. Field of view is approximately 10 cm.*

km 1001.5 Junction with Highway 37 to Cassiar - Turn right and drive south on Highway 37. Kilometre posts along Highway 37 are placed every 5 km along the east side of the road, starting at *km 723.6*. Distances from this point on are measured along the Cassiar Highway (Highway 37) and shown in italic (*km*). Our first and only stop along this leg of the trip will be at Good Hope Lake, approximately 97 km from Junction 37.

Stop 1-2 – Good Hope Lake

UTM 9v, 484231E, 6574067N, elev. 775 m.

km 627.6: Pull over in rest area with refuse bin on the left side of the highway, just before entering the hamlet of Good Hope Lake.

This location offers a spectacular view of strata of the North American (western Laurentian) margin, which occur here in a northeast-vergent thrust duplex related to Jurassic-Cretaceous allochthon emplacement (Fig. 1-2). The overall structural geometry of miogeoclinal rocks is of two separate thrust duplexes that developed above and below thin-bedded, argillaceous Ordovician-Silurian strata. This duplex involves late Neoproterozoic and Cambrian strata of the Ingenika and Atan groups. In the upper part of the Neoproterozoic Ingenika Group, exposed here, there are two formations, the carbonate Espee and overlying fine-grained siliciclastic rocks of the Stelkuz Formation. A prominent redbed marker in the Stelkuz is visible in the cliffs particularily on the north side of the road. It consists of calcareous breccia with chips of red limestone, dolostone and slate, cross-bedded red and green siltstone, and red slate (Mansy, 1978). The base of the Lower Cambrian Atan Group is placed at the base of the lowest thick sandstone bed of the Boya Formation. The Precambrian-Cambrian boundary is inferred at the minor disconformity at the base of the Boya on the basis of trace fossil assemblage (Fritz and Crimes, 1985). The archeocyathid-bearing limestone of the Rosella Formation (late Early Cambrian) overlies the Boya Formation; it is the highest unit in these thrust panels.

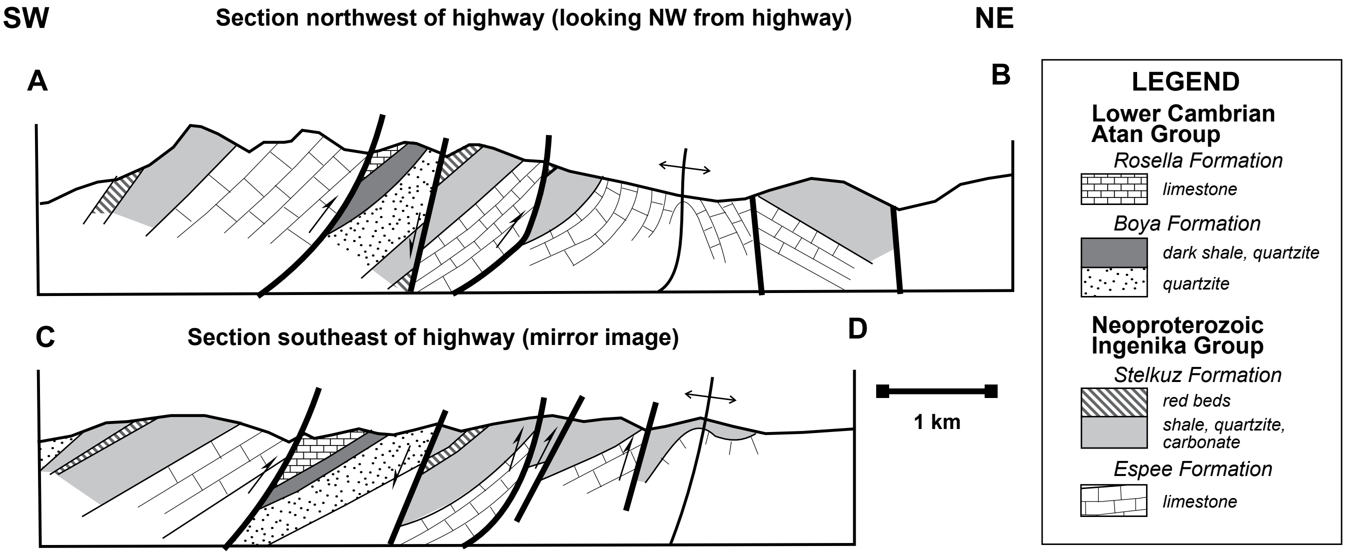


Figure 1-2. *Structural cross-sections of Neoproterozoic to Silurian strata of Cassiar platform near Good Hope Lake, B. C. (after Mansy, 1978). Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2007 and Courtesy of Natural Resources Canada, Geological Survey of Canada.*

Continue driving south along Highway 37.

From Good Hope Lake, we will drive west, and generally stratigraphically up-section, through thrust-imbricated Kechika Group (Cambro-Ordovician pale, thin-bedded calcareous shales), black shales of the Ordovician-Silurian Road River Group, carbonate strata of the Silurian-Devonian Ramhorn and McDame groups, and soft grey argillites of the Earn Group.

km 611.8 We cross into the Sylvester allochthon at the 3rd North Fork Creek. Looming dark basalt mountains on either side of the road provide an abrupt change of scenery and mood from the bright carbonates and quartzites at Good Hope Lake (Fig. 1-3).

km 604.5 Road leading to the historic Cassiar mine - An old, faded sign at the start of the road says 'Cassiar Closed'. Trip log for Day 2 starts at the Cassiar chrysotile mine, approximately 14.4 km from this junction.

The Cassiar mining camp is located at the western edge of the Sylvester allochthon (see Day 2; Fig. 1-3). The Cassiar asbestos mine operated from 1953 to 1990. Chrysotile fibres occur along veins in serpentinite near the base of the Sylvester allochthon. The mine produced 37 million tons of 7.23% asbestos over its life. Today, only part of the mining town remains. It provides housing for miners at the Cusac Gold mines and other exploration projects in the region.

Figure 1-3. *Looking north at the Sylvester allochthon (Slide Mountain Terrane; dark brown) overlying Paleozoic strata of Cassiar Terrane at Cassiar, B.C. The prominent carbonate unit in the footwall of the allochthon is the Middle Devonian McDame Group. The recessive interval above the McDame limestone is underlain by clastic rocks of the Upper Devonian to Early Mississippian Earn Group.*

DAY 2 – SYLVESTER ALLOCHTHON

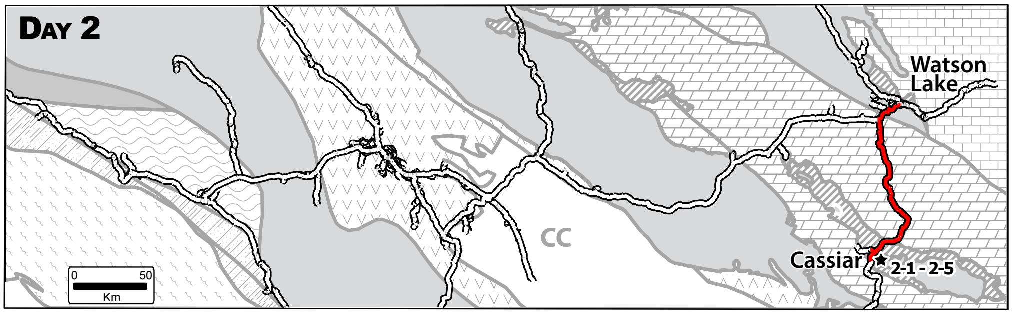
The second leg of this excursion will focus on examining the Slide Mountain Terrane and its relationships to pericratonic terranes in the Sylvester allochthon. The stops are along the access roads to the Cusac (formerly the Erickson) gold mines. The roads are on the Cusac mining property; *permission to access these mining roads should be obtained from the Cusac Gold Mines office at the start of the road (250-239-3337)*. This road network provides easy access to alpine exposures on Table Mountain, where we will do two short hikes: one along the top of Table Mountain where Paleozoic and Triassic strata of Slide Mountain Terrane are exposed (Division II of Nelson, 1993); and another to the Huntergroup Range, where we will examine some of the structurally highest thrust sheets of the Sylvester allochthon, composed of late Paleozoic rocks of Quesnellia (Nelson and Friedman, 2004).

Sylvester allochthon

The Sylvester allochthon comprises some of the most inboard of the allochthonous Cordilleran thrust sheets, resting directly above strata of the western Laurentian margin near Cassiar in far northern British Columbia (Fig. 2-1). It is actually a stack of separate, internally imbricated allochthons that represent three major terranes. From base to top, these are:

- the Slide Mountain Terrane, a late Paleozoic marginal oceanic assemblage overlain by Triassic clastic strata;
- the Harper Ranch subterrane of Quesnellia, a late Paleozoic island arc assemblage;
- the Mississippian and older Dorsey Complex, part of the Yukon-Tanana Terrane (Figs. 2-2 and 2-3).

The Slide Mountain Terrane comprises two divisions: a lower assemblage that is dominated by deep-water sedimentary strata, and an upper assemblage that contains abundant basalt, gabbro and ultramafic rocks as well as sedimentary rocks (Nelson, 1993). Each forms an internally imbricated thrust duplex. This structural order is similar to the architecture of the Slide Mountain Terrane in central and southern British Columbia (Schiarizza and Preto, 1987; Ferri, 1997). The lower Slide Mountain assemblage consists of thrust-imbricated Early Mississippian to mid-Permian deep-water chert/argillite/siliciclastic strata with minor gabbro-diabase sills. It is structurally overlain by an imbricated ophiolitic assemblage, which consists of 1) Early Mississippian (possibly uppermost Devonian) to mid-Permian MORB basalts interbedded with deep-water sedimentary strata identical to those of the lower assemblage, including abundant chert-quartz sandstones; and 2) ultramafic-gabbro panels, one of which has been dated as mid-Permian by U-Pb methods on zircon (Gabrielse *et al.*, 1993; Nelson, 1993).



Continuous stratigraphic sections in both assemblages grade upwards from dark grey and green Early Mississippian deep-water sedimentary strata, through Late Mississippian and Pennsylvanian chert-dominated units, to Early Permian red, maroon and green chert and argillite (Fig. 2-4). In the ophiolitic assemblage, these are accompanied by abundant basalt flows and basalt-diabase sills. The occurrence of long-lived stratigraphic sections suggest very slow spreading rates in the Slide Mountain ocean, at least in parts of the basin. Another indicator of slow spreading rates is that there are no sheeted dykes. Instead, feeder zones consist of sill complexes developed in pre-existing sedimentary(/basalt) intervals (Fig. 2-5).

Chert-quartz grit layers, ranging from centimetre-scale laminations to beds hundreds of metres thick, are particularily abundant in the oldest, Late Devonian(?)-Early Mississippian, units in both upper and lower assemblages (Fig. 2-6). The age, clast content and mode of occurrence (poorly sorted, immature, massive, grit-argillite alternation without significant siltstone) of these siliciclastic beds are very similar to sandstone in the parautochthonous Earn Group situated beneath the allochthon.

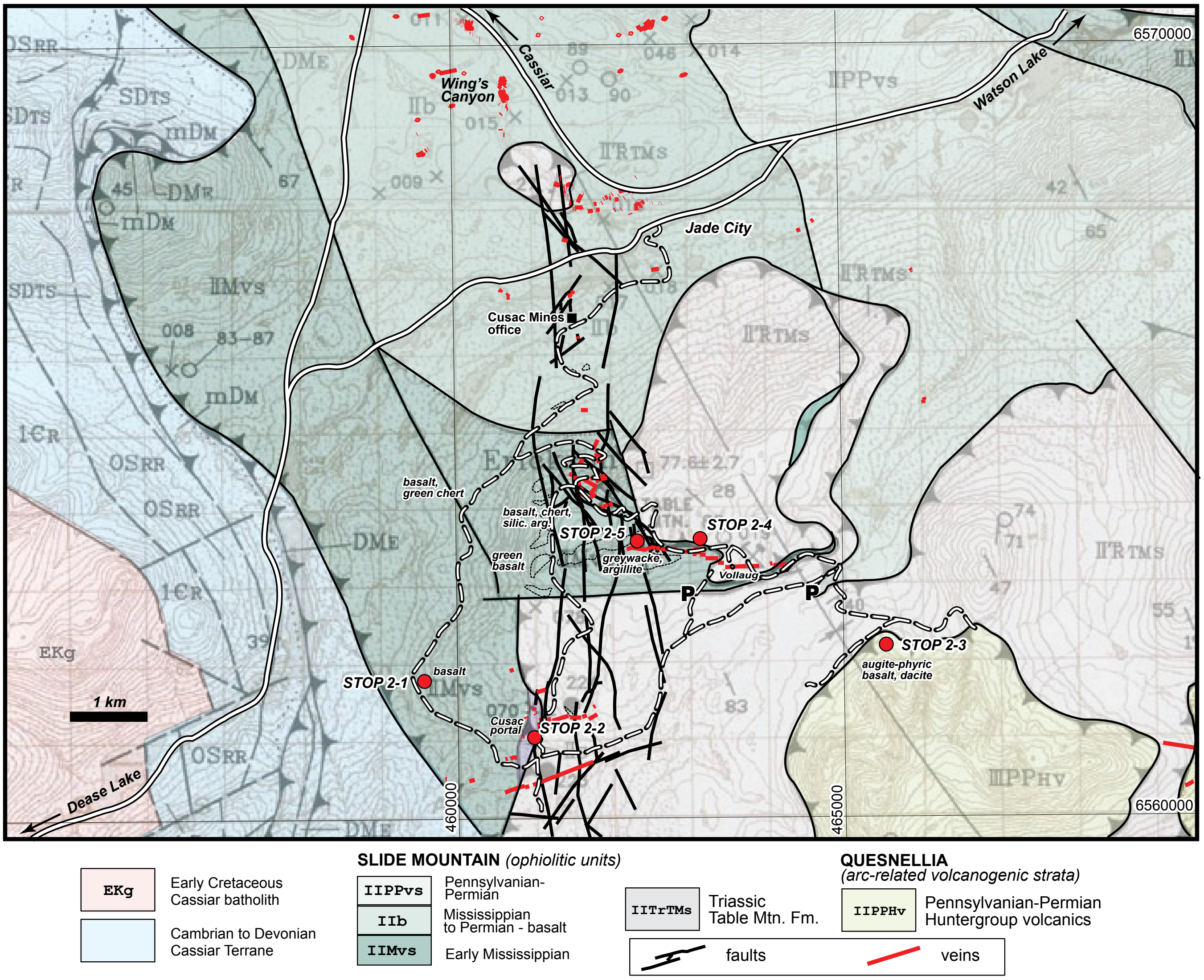


Figure 2-1. *Detailed geological map of the Table Mountain area (after Nelson and Bradford, 1993). Details of faults and veins of the Cusac mining camp are also shown. "P" indicates parking location at the start of the two short traverses to Stops 2-3, 2-4 and 2-5 on top of Table Mountain.*

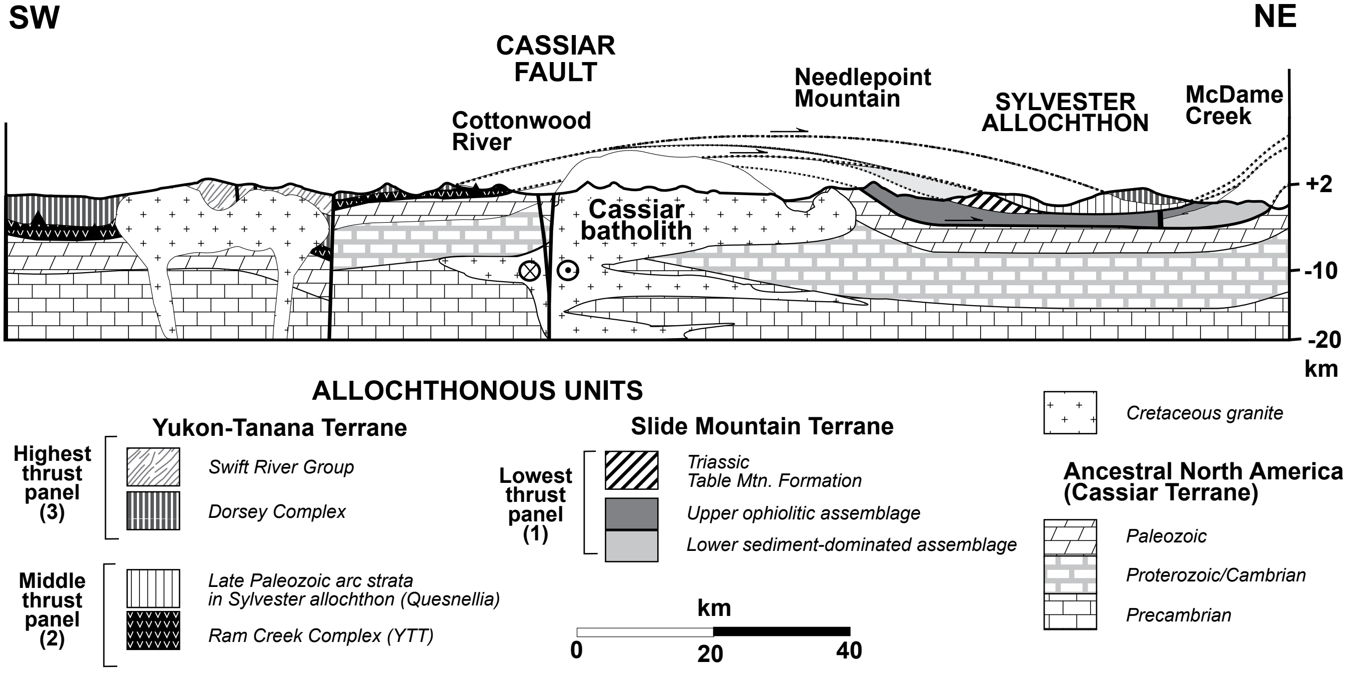


Figure 2-2. *Composite cross-section of allochthonous assemblages in the northern Cassiar Mountains (after Nelson and Friedman, 2004). YTT = Yukon-Tanana Terrane.*

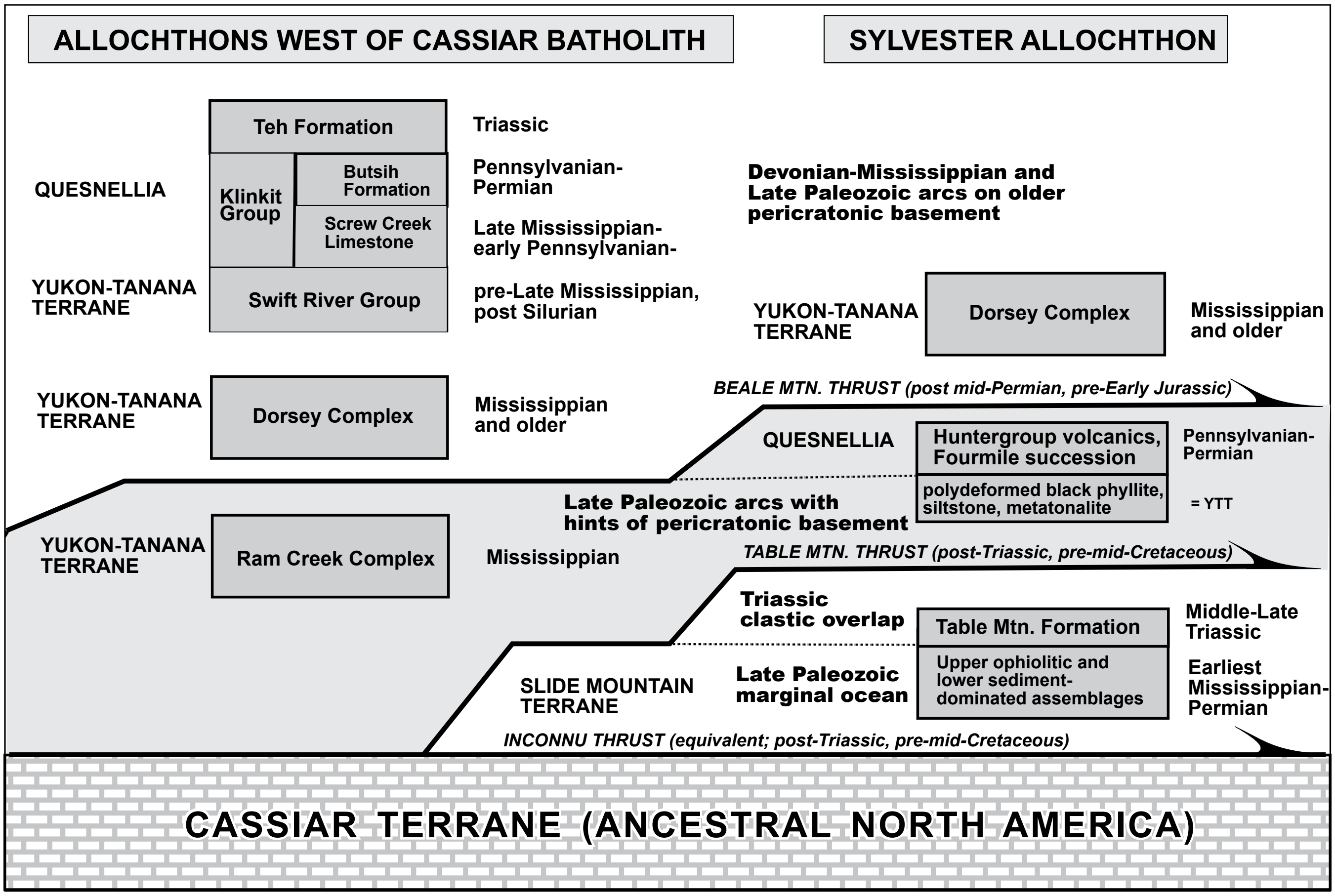


Figure 2-3. *Schematic structural stacking of allochthonous assemblages in the northern Cassiar Mountains (after Nelson and Friedman, 2004). YTT = Yukon-Tanana Terrane.*

The Blue Dome fault, a steep structure with a strike length over 80 km, cuts across the Slide Mountain assemblages and runs nearly the length of the Sylvester allochthon (Plate 1). It contains lenses of serpentinite and also extensive sedimentary breccias and ophicalcites, one of which yielded Kungurian to Middle Permian conodonts (Fig. 2-7; M. Orchard in Nelson and Bradford, 1993; revised age assignment in Orchard, 2006). It was probably a transform fault in Permian time, although evidence for sense of displacement is equivocal.

Figure 2-4. *Typical red and green chert from the Pennsylvanian to Permian units of Slide Mountain Terrane.*

Figure 2-5. *Most diabase-basalt intrusions in the Slide Mountain Terrane are sills (rather than dykes) intruding the sedimentary strata.*

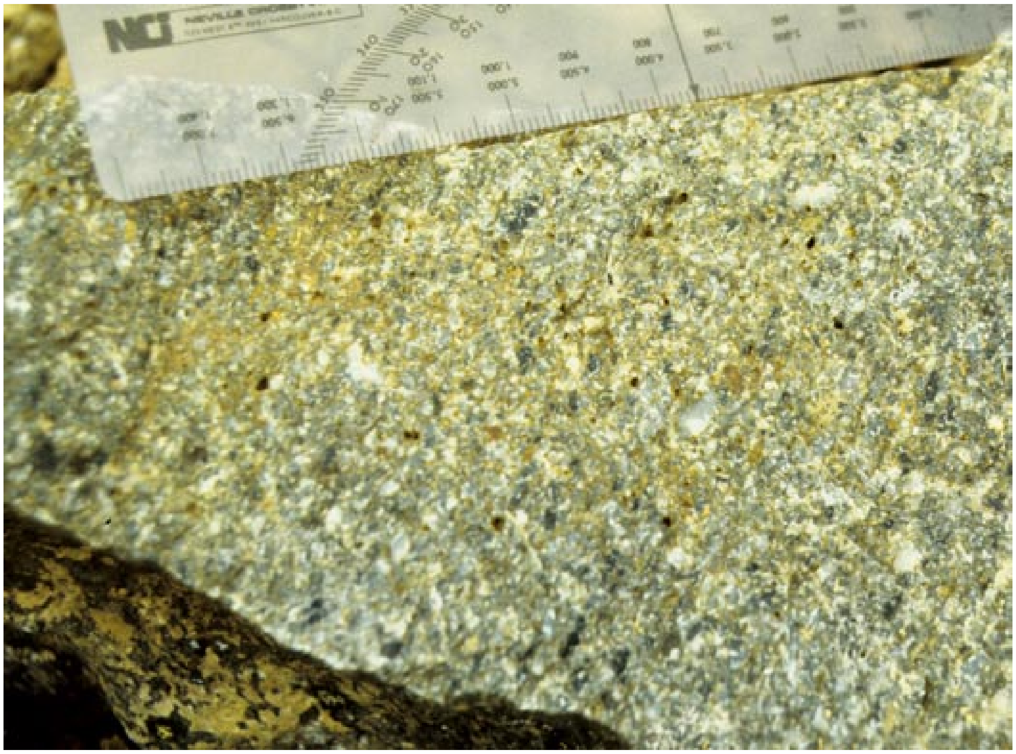


Figure 2-6. *A relatively coarse-grained example of chert-quartz grit interbedded with the Early Mississippian basalt, chert and argillite sequence of the Slide Mountain Terrane.*

Figure 2-7. *The Blue Dome fault zone is a zone of ultramafic rocks, shearing and coarse talus breccia that extends almost the length of the Sylvester allochthon, within the Slide Mountain Terrane. This breccia contains basalt and gabbro clasts in a calcareous matrix that has yielded Middle Permian conodonts. The Blue Dome fault is interpreted as a late Paleozoic, syndepositional transform fault.*

Discontinuous Triassic siliciclastic and carbonate strata of the Table Mountain Formation overlie the ophiolitic assemblage, forming the structurally (and probably stratigraphically) highest Slide Mountain Terrane unit within the allochthon. The Table Mountain Formation is part of a widespread Triassic clastic sequence that was deposited on both the western Laurentian continent margin and on the allochthonous Yukon-Tanana, Quesnel and Slide Mountain terranes, from southern B.C. to central Yukon.

Late Paleozoic Quesnellia is represented by a set of imbricated late Paleozoic units of volcanic arc affinity (Division III of Nelson, 1993) that structurally overlie the Slide Mountain Terrane and the Triassic strata on Table Mountain. It includes the Pennsylvanian Huntergroup volcanics

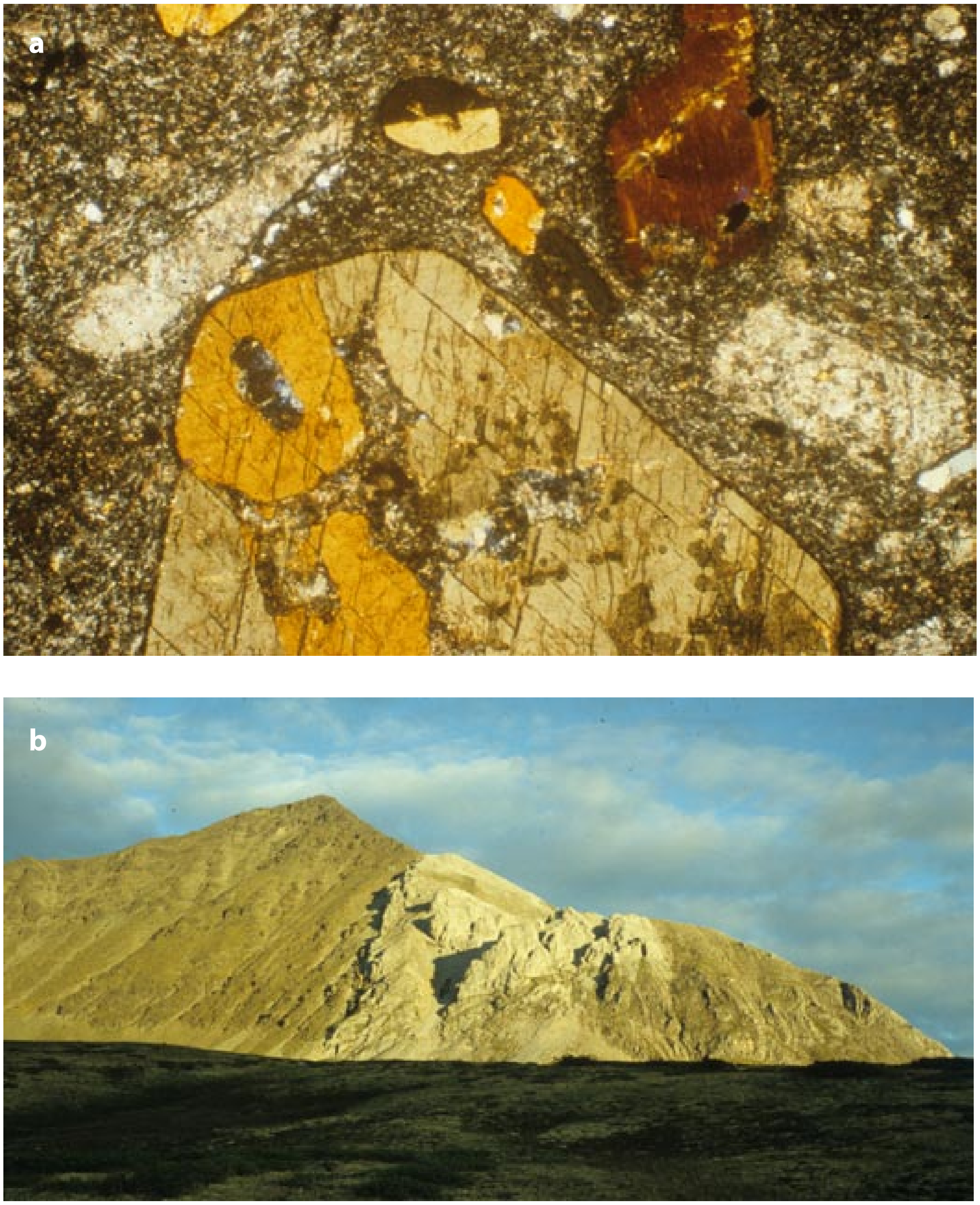


Figure 2-8. ***(a)*** *Coarse-grained hornblende-plagioclase porphyrytic andesite of Huntergroup volcanics. Field of view is approximately 4 mm.* ***(b)*** *Limestone interbedded with arc volcanic rocks of the Huntergroup volcanics ranges in age from Early Pennsylvanian to Middle Permian. Some limestone occurrences contain faunas of McCloud affinity.*

(Nelson, 1993) and the Pennsylvanian-Permian Four Mile volcanics (Nelson and Friedman, 2004). Porphyritic andesite, basalt, dacite, rhyolite and volcaniclastic strata are accompanied by varicoloured chert and macrofossil-bearing limestone (Fig. 2-8a, b). Giant *Parafusulina*, similar to those found in the McCloud belt terranes of the eastern Klamaths and northern Sierras (Miller, 1987) occur in one of the limestones (Nelson, 1993; Nelson and Bradford, 1993). Package II of Harms (1986), which lies structurally above Slide Mountain rocks in the southern part of the allochthon (her packages I and III), is composed of volcanic units and thick late Paleozoic limestones such as the macrofossil-rich, Late Mississippian Nizi limestone. It is included in the Quesnellia arc assemblage as well. These rocks are correlative with the Klinkit assemblage of Yukon-Tanana Terrane that we will examine on Day 3 of this trip.

Yukon-Tanana Terrane rocks of the Dorsey Complex occur in the structurally highest sheet in the Sylvester allochthon, resting on top of the late Paleozoic arc units (Figs. 2-2, 2-3). The Dorsey Complex is a highly deformed, metamorphosed pericratonic unit intruded by strained Early Mississippian plutons. It continues west of the Cassiar batholith, where it is part of the southern Yukon-Tanana Terrane (Snowcap assemblage of Colpron, 2006; Colpron *et al.*, 2006a). In the Sylvester allochthon, its basal thrust fault, termed the Beale Mountain thrust after spectacular cliff exposures near the Four Mile River, places polydeformed metamorphic rocks on top of an undeformed, weakly metamorphosed Pennsylvanian-Early Permian volcanic and plutonic footwall. Foliations in the Dorsey Complex and bedding in the underlying strata parallel the basal thrust contact. Sense of displacement in the Dorsey Complex, associated with quartz stretching lineations and also with streaking and shear bands near its base, is top-to-the-east, congruent with that shown in the Dorsey Complex west of the Cassiar batholith. Mid-Permian plutons are late kinematic with respect to this fabric, and one of them plugs a thrust fault in the underlying imbricated Quesnellia strata. The thrust fault at the base of the Quesnellia arc assemblage, however, must be post-Triassic because it overlies the Table Mountain Formation as well as late Paleozoic Slide Mountain Terrane rocks. Therefore the structural development of the superimposed allochthons must have been multi-episodic.

A master thrust fault (Figs. 2-2, 2-3), at the base of the combined allochthonous assemblages (Sylvester allochthon), carries successively higher (and more outboard) panels in its immediate hanging wall from northeast to southwest. In the eastern Sylvester allochthon, Slide Mountain rocks occupy this position. In southern Yukon, and at one locality west of Cassiar batholith in northern B.C., the Ram Creek Complex of the Yukon-Tanana Terrane directly overlies the fault (Plate 1). In the southern Sylvester allochthon between the Cassiar batholith and the Major Hart pluton, the Dorsey Complex is the highest allochthonous unit. The master fault is equivalent to the Inconnu fault in the Finlayson Lake area, which places Yukon-Tanana and Slide Mountain rocks on top of continental margin strata (Murphy *et al.*, 2006).

TRIP LOG

From the Cassiar mining camp, drive back towards the junction with Highway 37.

Approximately 9.9 km from the camp, a cat trail on right-hand side of the road leads to Quartzrock Creek and the old Wings Canyon placer operation (UTM 9v, 460636E, 6569687N, elev. 1030 m). This canyon exposure shows the mesothermal vein and accompanying alteration styles that are typical of the Table Mountain – Taurus gold camp (Fig. 2-9). Most veins are hosted by Slide Mountain basalts. The veins themselves are composed of white bull quartz that contains concentrations of free gold in association with sulphide minerals: pyrite, chalcopyrite, sphalerite, galena, arsenopyrite and tetrahedrite. Gold/silver ratios are typically >1, and mined gold grades average 10-15 g/t. Vein selvages show strong, orange-weathering Fe-Mg carbonate alteration: ankerite, siderite, kaolinite, dolomite, pyrite, carbon, Ti-oxide, arsenopyrite and sericite. Listwanite occurs locally in association with ultramafic rocks. K-Ar ages from sericite average 120 Ma, which is about 10 Ma older than the Cassiar batholith.

The fractures and minor faults that host the veins form a roughly north-northeast-trending swarm (Fig. 2-1); individual veins strike northeast to east-northeast, with steep dips that cut across the gently dipping thrust faults of the allochthon. Granite clasts in lamprophyre dykes associated with the veins, along with the broad greenschist-grade contact aureole and a strong positive magnetic anomaly around the camp, suggest that the mineralization was related to a large subjacent intrusive body.

Continue driving to the junction with Highway 37, approximately 14.4 km from the Cassiar camp. Turn right on highway (*km 604.5*).

km 602.7 Jade City.

km 602.3 Turn left on road to Cusac Gold mines - reset odometre; distances along the Cusac mine roads are measured from the junction with Highway 37. Drive along the main road to the office (approx. 1.7 km; keep right after the creek). Report in to the office before proceeding up the road.

Figure 2-9. *Northeast-trending vein system and carbonate alteration typical of the Cusac-Taurus camp, exposed in Wings Canyon along Quartzrock Creek.*

Stop 2-1 – Late Paleozoic basalt and the Jill vein

UTM 9v, 459643E, 6561643N, elev. 1195 m

Approximately 9.1 km up the Cusac road, park on the side of the road near outcrop.

Basalts are the most common lithology in the upper, ophiolitic panel of the Slide Mountain Terrane. Here we see a typical example. The basalts are generally aphanitic to finely holocrystalline, equigranular to very finely augite-phyric, with common hyaloclastite breccia (Fig. 2-10), but rare pillows, and sporadic concentrations of spherulites. They are interbedded with chert, argillite and in some cases siliciclastic rocks. Simple geochemical indicators from this area define them as MORBs. No modern (post-1990) geochemical work has been done on basalts within the Sylvester allochthon, so the presence of BABB or enriched MORBs cannot be assessed.

At this locality we also see an east-northeast-striking, steeply-dipping quartz vein with wide orange-weathering carbonate-altered selvages. Although similar in style and orientation to the mined Cusac veins, the Jill vein exposed here does not have mineable gold grades.

Continue driving up the road, keeping straight at ~10.2 km.

Figure 2-10. *Hyaloclastite breccia in Mississippian basalt of the Slide Mountain Terrane.*

Stop 2-2 – Cusac portal

UTM 9v, 460978E, 6561170N, elev. 1295 m.

At approximately 10.7 km, we arrive at some mining buildings. Continue past the buildings and park vehicle near entrance portal on the left.

The veins in the Cusac mine (formerly Erickson mine) were among the earliest discoveries in the Cassiar gold camp, in 1932 by Hans Erickson and Jim Vollaug. Overall this mine produced more than 489,780 ounces (14 million grams) of gold averaging 15.6 g/t Au and 11.31 g/t Ag (BC MINFILE, 104P 029, July 2007). Although it was finally mined out and this portal closed in 1988, activity continues nearby, with present active mining on the Bain vein 500 m to the southwest. Approximately 50 m beyond the portal, there is an ore pile worth investigating. These rocks include listwanite, various quartz vein textures, fresh basalt and small black outcrops that are the first exposures of Triassic rocks along this transect.

The eastern wall of the portal exposes thin-bedded green and locally red, chert and siliceous argillite, which are part of Pennsylvanian-Permian sections of the Slide Mountain Terrane. In the west wall, the sedimentary strata overlie a basalt or diabase flow or sill. Original relationships are obscured by strong shearing and alteration.

Resume driving up the Cusac road. Leaving Cusac portal, the road now climbs onto the flat top of Table Mountain, which is underlain by recessive Triassic strata that overlie the late Paleozoic Slide Mountain Terrane. We will visit these later; now our mission is to bolt cross country and structurally higher. The imposing mountains that lie to the south, the Huntergroup Range, are underlain by resistant Pennsylvanian and Permian arc-related volcanogenic strata (Fig. 2-11). Their base is a thrust fault above the Table Mountain Formation (Harms *et al.*, 1989).

Spur road to the left at 13.5 km. We will return to this point to access Stops 2-4 and 2-5. Continue driving eastward.

Stop 2-3 – Huntergroup Range: Klinkit assemblage rocks

UTM 9v, 465410E, 6562227N, elev. 1560 m.

At ~15.9 km, park vehicle near junction with a decommissioned road on the right (UTM 9v, 464751E, 6563347N, elev. 1425 m; road is hard to see coming from the west). Walk along this road to the base of the Huntergroup Range, approximately 1.5 km (Fig. 2-11).

The Huntergroup volcanics are an extensive volcanic/volcaniclastic edifice that is exposed over 40 km^2, from this range south to the Dease River. They consist of augite porphyry basalt, augite-hornblende-plagioclase porphyry andesite, lapilli tuff, tuffaceous sandstone, and rare rhyolite, limestone, chert and argillite. Three conodont collections from this unit (# 70, 71 and 81) returned Early Pennsylvanian ages (Nelson and Bradford, 1993); a fourth (72), collected near its base, is Late? Permian (*ibid.*), suggesting local thrust imbrication. Geochemically, the Huntergroup volcanics show suprasubduction zone signatures on Ti vs. V, Ti vs. Zr, and Ti vs. Cr plots, along with LREE enrichment and Nb depletion (*ibid.*).

Approximately 10 km southeast of this locality, the Huntergroup volcanics are overlain by a unit of limestone, bedded chert/limestone-matrix epiclastic breccia, brightly coloured chert and argillite. The limestones contain Early Permian macrofaunas, including productid and spiriferid brachiopods, and *Parafusulina* and *Schwagerina* (fusulinids), including large forms. The brachiopods are considered of North American/Uralian affinity (W. Bamber, *in:* Nelson, 1993). The large fusulinids may be *Parafusulina macdamensis*, which occurs in an equivalent unit in a klippe near the Blue River. Ross (1969) compares this giant form to other occurrences within the McCloud faunal belt in western U.S., and the autochthonous Word Formation of west Texas.

In age and character, the volcanic and sedimentary strata of this thrust panel resemble the late Paleozoic, arc-related Klinkit Group west of the Cassiar batholith, which in turn correlates with rocks of the Lay Range of central British Columbia, which represent the late Paleozoic of Quesnellia.

Return to your vehicle, and turn around driving back toward the Cusac portal, approximately 2.4 km to a spur road (13.5 km from start of the road). Turn right onto the spur road and drive 0.4 km to a washout. Park vehicle and walk up to the end of the road and onto the upper road (~500 m). An old mining car standing upright and plugging an abandonned raise provides a good landmark. From this point we will walk west and examine outcrops along the road on top of Table Mountain.

Figure 2-11. *Looking south at the Huntergroup Range, underlain by Pennsylvanian-Permian arc volcanic strata of Quesnellia.*

Stop 2-4 – Triassic sandstone, siltstone and shale

UTM 9v, 463177E, 6563669N, elev. 1600 m.

Outcrops along this road expose the main siliciclastic facies of the Table Mountain Formation. It consists of organic-rich, calcareous quartzose siltstone, thicker sandstone, and shale (Fig. 2-12). Detrital mica is common in the coarser grained rocks. A late middle Norian conodont assemblage from this area (collection # 88, Nelson and Bradford, 1993) consists of *Epigondolella serrulata* Orchard and *Neogondolella* sp.

Triassic siliciclastic strata of the Table Mountain Formation are typical of Triassic exposures throughout the northern Cordillera, which overlie Paleozoic rocks of ancestral North America, and Slide Mountain and Yukon-Tanana terranes. Preliminary provenance studies clearly indicate a common source region to the west, in the metamorphic highlands of the Yukon-Tanana Terrane, providing strong evidence that the Slide Mountain ocean was closed by Triassic time (Beranek and Mortensen, 2007; L.P. Beranek, pers. comm., 2007).

In this area, the Table Mountain Formation contains restricted carbonate bank deposits - a thin, dark grey limestone unit with *Halobia* or *Daonella* imprints. In the best example, northwest of the Blue River, limestone contains *Halobia*, ammonites, belemnites, and a single reported ichthyosaur vertebrae.

Extensive workings to the south are open pits on the Vollaug vein. These workings follow the base of the Table Mountain Formation, which served as a cap rock to the Table Mountain-Taurus vein system. The vein varies from 0.5 to 3.0 m wide and has been traced, semi-continuously, for almost 2 km. It is a typical mesothermal gold-quartz vein, with gold grades averaging 10-15 grams per tonne. Sooty carbon folia are prominent in the quartz. Up to 1998, Erickson Gold Mining Corporation produced 489 780 tonnes of ore grading 15.6 g/t Au and 11.31 g/t Ag (this figure includes production from the Vollaug (104P 019), Wildcat (104P 057) and Table Mountain (104P 070) veins (BC MINFILE).

Figure 2-12. *Triassic sandstone and shale of the Table Mountain Formation.*

Stop 2-5 – Lithic wacke, argillite in Mississippian ophiolitic supracrustal sequence

UTM 9v, 462247E, 6563616N, elev. 1655 m.

This exposure shows some of the sedimentary strata that are typical of Mississippian units of the Slide Mountain Terrane. Here we see drab grey chert-quartz sandstone and argillite. Microscopically, the sandstones also contain detrital muscovite, zircon and tourmaline, requiring a continental sediment source. These form part of a stratigraphic sequence that includes basalt like those at Stop 2-1 (these are exposed approximately 100 m to the south). Unlike those in the Cache Creek Terrane, the ophiolitic sequence in the Slide Mountain Terrane did not develop in mid-oceanic settings. Stratigraphic evidence in the Goat Range of southern B.C. ties the Slide Mountain Terrane to the ancestral western Laurentian margin, whereas in the Finlayson Lake belt of Yukon, the Slide Mountain is linked to the Yukon-Tanana continental arc fragment (Colpron *et al.*, 2007).

To date, limited detrital zircon data is available from siliciclastic rocks of the Sylvester allochthon. A few ID-TIMS (Isotope Dilution and Thermal Ionisation Mass Spectroscopy) analyses of single detrital zircons from a sample collected on McDame Mountain have yielded individual zircon ages of *ca*. 1910, 1820, 427 and 355 Ma (R. Friedman and J. Nelson, unpublished data, 1989). The Paleoproterozoic ages are consistent with Alberta basement; Silurian zircons are common in the autochthonous Earn Group, and the 355 Ma age best fits arc activity within the Yukon-Tanana Terrane.

Return to vehicle and drive back down the Cusac road to the junction with Highway 37. This marks the end of Day 2. We will now drive to Watson Lake, a distance of ~140 km (2 hours).

DAY 3 – WATSON LAKE TO TESLIN

The third day of the geological transect will travel along the Alaska Highway from Watson Lake to Teslin and focus primarily on the Yukon-Tanana Terrane. Its relationships to Paleozoic and early Mesozoic Quesnellia will also be discussed. The field trip will end in Mesozoic rocks of Quesnellia near Teslin and offer a prelude to Day 4.

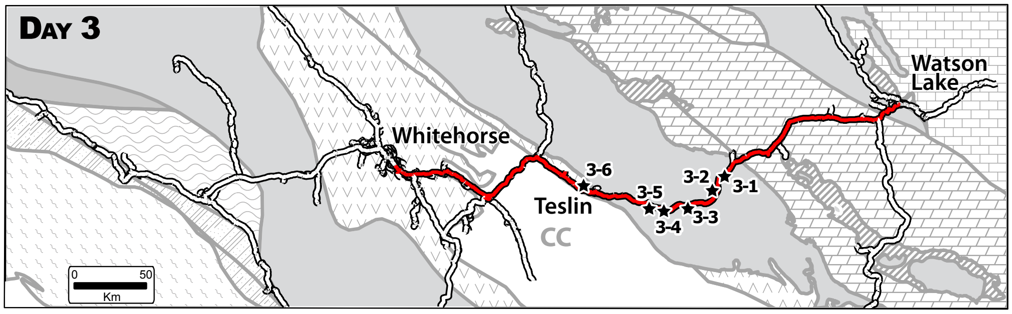
Tintina fault

The town of Watson Lake (pop. 1500) is located near the eastern edge of the Liard Plain, a vast area (~7500 km^2) of few rock exposures at the junction of the Northern Rocky Mountain and Tintina trenches (Fig. A2). These two major topographic lineaments are underlain by one of the most prominent transcurrent fault systems in the Canadian Cordillera; the Tintina-Northern Rocky Mountain Trench (NRMT) fault (Figs. A1 and A6). This dextral strike-slip fault system has a well-constrained displacement of 400-430 km in Eocene time. An additional 60 km of Cretaceous dextral offset is postulated for the Tintina fault and additional earlier displacement is possible on the NRMT (Gabrielse *et al.*, 2006). In seismic reflection profiles, the Tintina fault appears as a 10-30 km -wide, structurally complex, crust-penetrating subvertical zone where gently-dipping reflectors are abruptly truncated (Fig. A3; Cook *et al.*, 2004; Snyder *et al.*, 2005). The fault zone comprises at least four steeply-dipping fault panels (Snyder *et al.*, 2005), some of which are expressed at surface by grabens containing Upper Cretaceous to Eocene non-marine sedimentary strata, including coal, and minor Eocene volcanic and intrusive rocks (Jackson *et al.*, 1986). The profound change in the geochemistry of Quaternary volcanic rocks across the Tintina fault indicates different sub-lithospheric mantle sources on either side and suggests that the fault extends into the upper mantle (Abraham *et al.*, 2001).

A number of recent low-magnitude (5 or less, Richter scale) earthquakes have been recorded along the Tintina fault zone (Fig. A8). One of the most recent was a magnitude 4.6 earthquake with an epicentre near Faro, occurring in the aftermath of the magnitude 7.9 earthquake along the Denali fault, in east-central Alaska, in November, 2002. Only limited displacement has apparently occurred since Eocene time, as major rivers cross the Tintina Trench without significant deflection (Fig. A2). Earthquake statistics suggests that modern displacement along the Tintina fault is much less than 1 mm/yr (Hyndman *et al.*, 2005).

Terranes west of the Cassiar batholith

West of the Cassiar batholith, between the Cassiar fault and Teslin, the Alaska Highway traverses some of the peri-Laurentian terranes that are structurally higher and/or more outboard than the Slide Mountain Terrane: Yukon-Tanana Terrane and Quesnellia. Along this transect, Yukon-



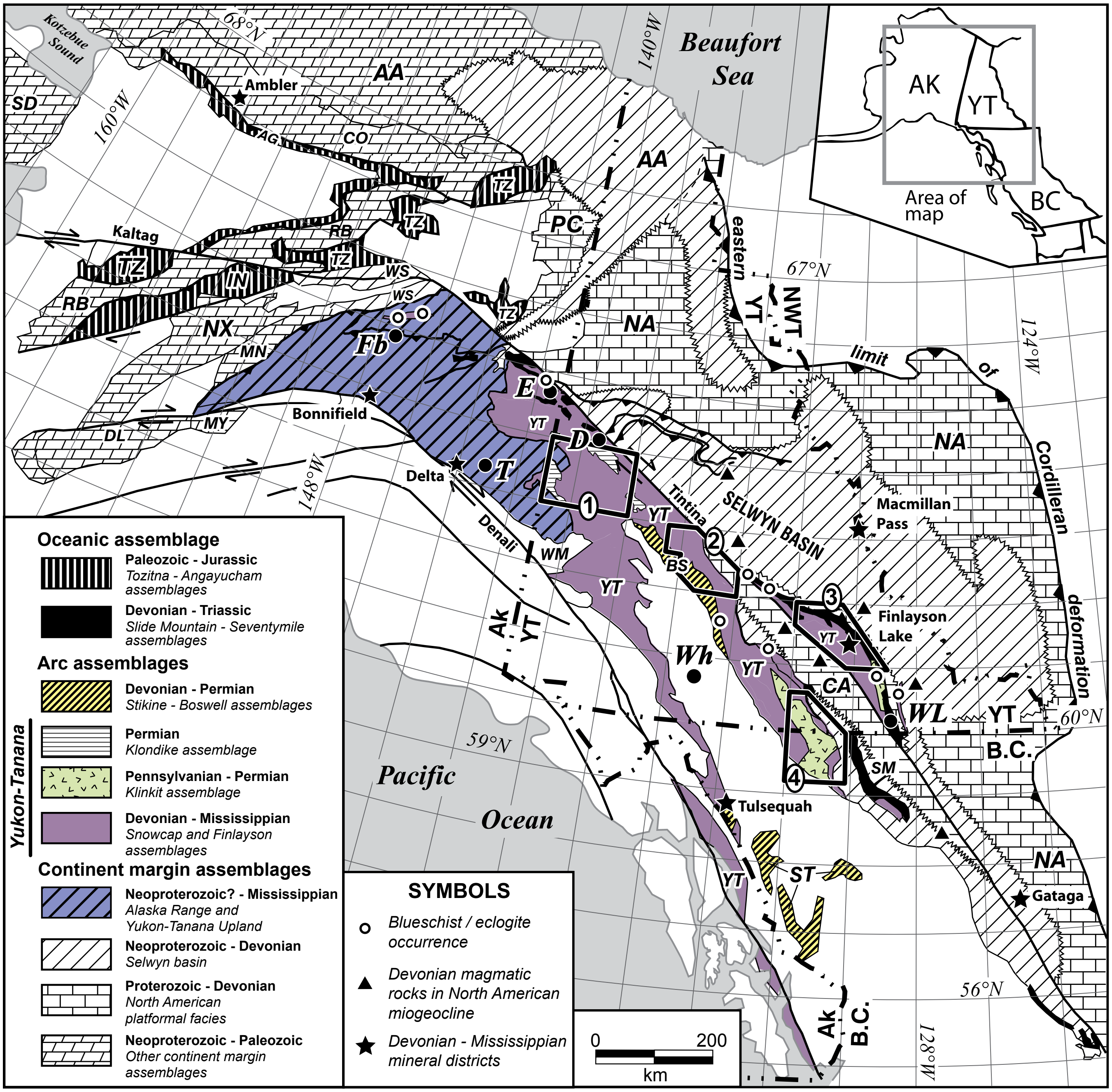


Figure 3-1. *Paleozoic tectonic assemblages of the northern Cordillera (modified after Wheeler et al., 1991; Silberling et al., 1992; Foster et al., 1994). Lithotectonic terranes and assemblages: AA – Arctic Alaska (includes Endicott Mountains, North Slope and Skajit allochthon); AG – Angayucham; CA – Cassiar; CO – Coldfoot (schist belt of southern Brooks Range); DL – Dillinger; IN – Innoko; MN – Minchumina; MY – Mystic; NA – North American miogeocline; NX – Nixon Fork; PC – Porcupine; RB – Ruby; SD – Seward; SM – Slide Mountain – Seventymile; ST – Stikine (Asitka); TZ – Tozitna; WM – Windy-McKinley; WS – Wickersham;* YT_A *– Yukon-Tanana Upland and Alaska Range; YT – Yukon-Tanana in Yukon and B.C.*
Other abbreviations: Ak – Alaska; B.C. – British Columbia; D – Dawson; E – Eagle; Fb – Fairbanks; NWT – Northwest Territories; Wh – Whitehorse; WL – Watson Lake; T – Tok; YT – Yukon Territory.
New bedrock mapping conducted under the auspices of the Ancient Pacific Margin NATMAP project is indicated by boxes: 1 – Stewart River area (Gordey and Ryan, 2005); 2 – Glenlyon area (Colpron et al., 2006b); 3 – Finlayson Lake (Murphy et al., 2006); and 4 – Wolf Lake-Jennings River area (Mihalynuk et al., 2006; Roots et al., 2006).

Tanana Terrane rests directly above North American marginal rocks, in the immediate hanging wall of the master thrust fault (the Inconnu fault) at the base of the combined allochthons (Slide Mountain + Yukon-Tanana + Quesnellia; Fig. 2-3).

The Yukon-Tanana Terrane is a vast terrane of pericratonic affinity that extends from east-central Alaska across southern Yukon and into north-central British Columbia (Fig. 3-1). It lies outboard of parautochthonous distal ancestral North American strata and remnants of the oceanic Slide Mountain Terrane, but generally inboard of arc and oceanic terranes that were accreted in Mesozoic time (Stikinia, Quesnellia and Cache Creek). Over the past decade, regional bedrock mapping programs in selected areas of Yukon-Tanana and related terranes under the Ancient Pacific Margin NATMAP project (Fig. 3-1) involved detailed structural and stratigraphic analysis, complemented by extensive new U-Pb geochronology and conodont biostratigraphy (Fig. 3-2). These data have provided the basis for unravelling the complex stratigraphic and intrusive relationships in the various parts of the terrane. The details of these relationships are presented in the series of papers edited by Colpron and Nelson (2006). From these detailed studies, a regional tectonostratigraphic framework was developed for the Yukon-Tanana Terrane (Fig. 3-3; Colpron *et al.*, 2006a).

The Yukon-Tanana Terrane of Yukon and northern B.C. is a stratigraphic succession of four ***tectonic assemblages***. The basal siliciclastic assemblage, the ***Snowcap assemblage*** (Fig. 3-3), is overlain by up to three unconformity-bounded volcanic and volcaniclastic successions of predominantly continental arc character (Piercey *et al.*, 2006, and references therein). These are the Late Devonian to Early Mississippian ***Finlayson assemblage***, the mid-Mississippian to Early

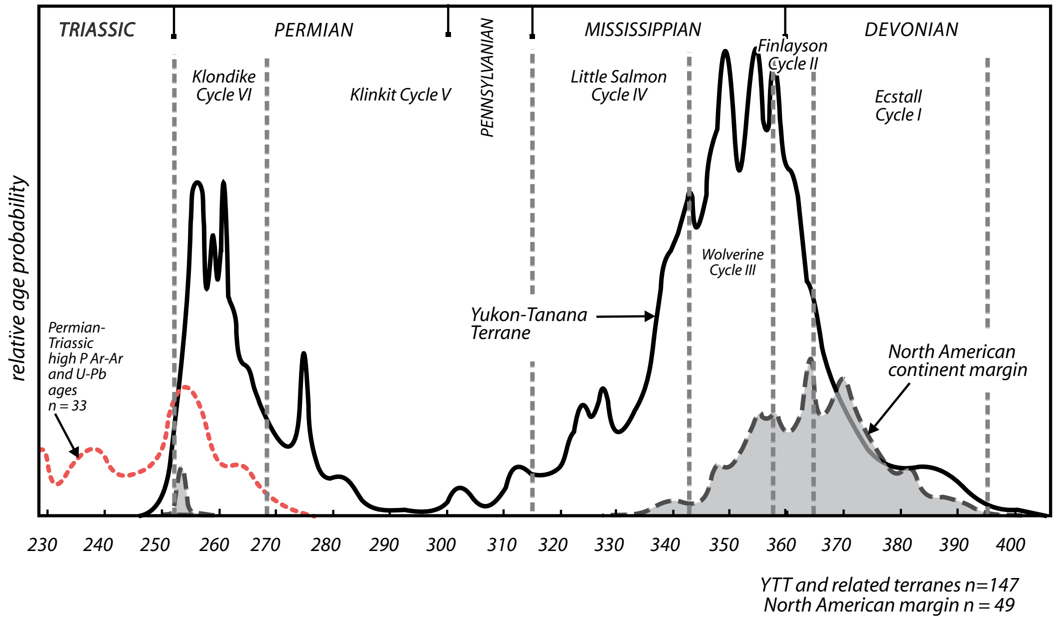


Figure 3-2. *Probability density diagram for Devonian-Permian magmatism (solid line) and high-pressure metamorphism (dotted line) in Yukon-Tanana and related terranes, and autochthonous and parautochthonous North America (dashed line and grey shaded areas; after Nelson et al., 2006). The peaks in probability density of U-Pb ages outline the two main pulses of felsic magmatism in Yukon-Tanana Terrane, corresponding to the Finlayson and Klondike assemblages. The Pennsylvanian to Permian lull in felsic magmatism corresponds to the predominantly mafic volcanic rocks and carbonate of the Klinkit assemblage, which are dated primarily by conodonts (Orchard, 2006). Magmatic cycles (I-VI) for Yukon-Tanana Terrane are labelled at top of the diagram (cf., Nelson et al., 2006; Piercey et al., 2006).*

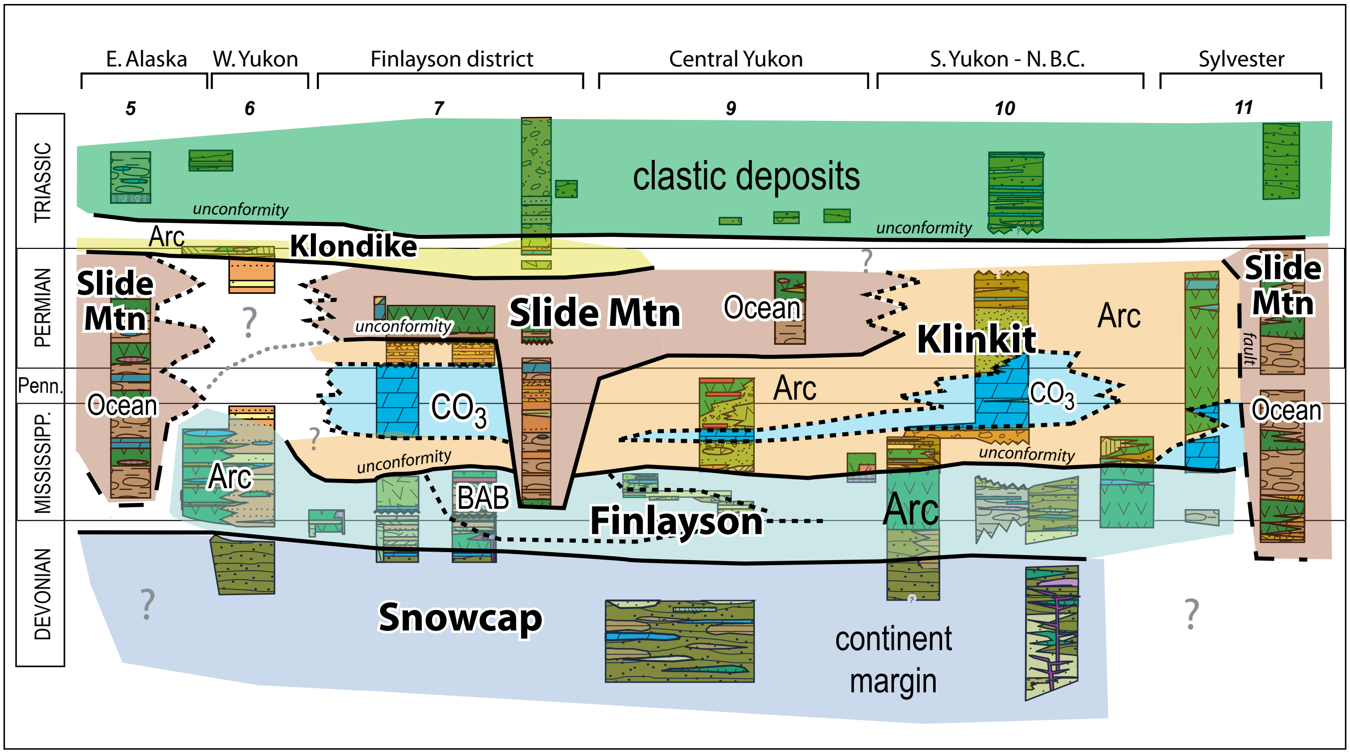


Figure 3-3. Tectonic assemblages for the pericratonic terranes of northern B.C. and Yukon (after Colpron et al., 2006a). 'CO$_3$' highlights large carbonate accumulations in parts of Klinkit assemblage.

Permian ***Klinkit assemblage*** and the Middle to Late Permian ***Klondike assemblage*** (Fig. 3-3). These Yukon-Tanana assemblages are coeval with the oceanic assemblage of chert, argillite and mafic volcanic rocks of the Slide Mountain Terrane (Fig. 3-3), which forms a discontinuous belt along the eastern edge of Yukon-Tanana Terrane. Immature, fine-grained clastic rocks and polymictic conglomerate of Permian to Triassic age overlie tectonic assemblages of Yukon-Tanana and Slide Mountain terranes, as well as miogeoclinal rocks of Selwyn basin and Cassiar Terrane in Yukon and northern B.C. (Fig. 3-3).

The Snowcap assemblage is pre-Late Devonian in age and comprises varying amounts of quartzite, pelite, psammite, marble and calc-silicate, and minor mafic metavolcanic and meta-intrusive rocks (Colpron *et al.*, 2006a). Its lithological, geochemical and isotopic compositions, as well as its detrital zircon ages, suggest that the Snowcap complex represents a distal portion of the ancestral North American continental margin that was rifted off western Laurentia in mid-Paleozoic time (Nelson *et al.*, 2006; Piercey and Colpron, 2006) and subsequently formed the nucleus upon which magmatic arcs of the Finlayson, Klinkit and Klondike assemblages were deposited. Rocks of the Snowcap assemblage appear to have been deformed and metamorphosed prior to deposition of the overlying Upper Devonian to Permian strata. Along the field trip transect, the Snowcap assemblage is represented by rocks of the Dorsey Complex (Figs. 2-3, 3-4, 3-5; Roots *et al.*, 2006) which are not easily accessible from the Alaska Highway. Therefore, we will not see these rocks on this trip.

Magmatism in the Yukon-Tanana Terrane occurred in six distinct magmatic pulses, or cycles, that are punctuated (at least locally) by unconformities and/or deformational events (Fig. 3-2; Nelson *et al.*, 2006; Piercey *et al.*, 2006):

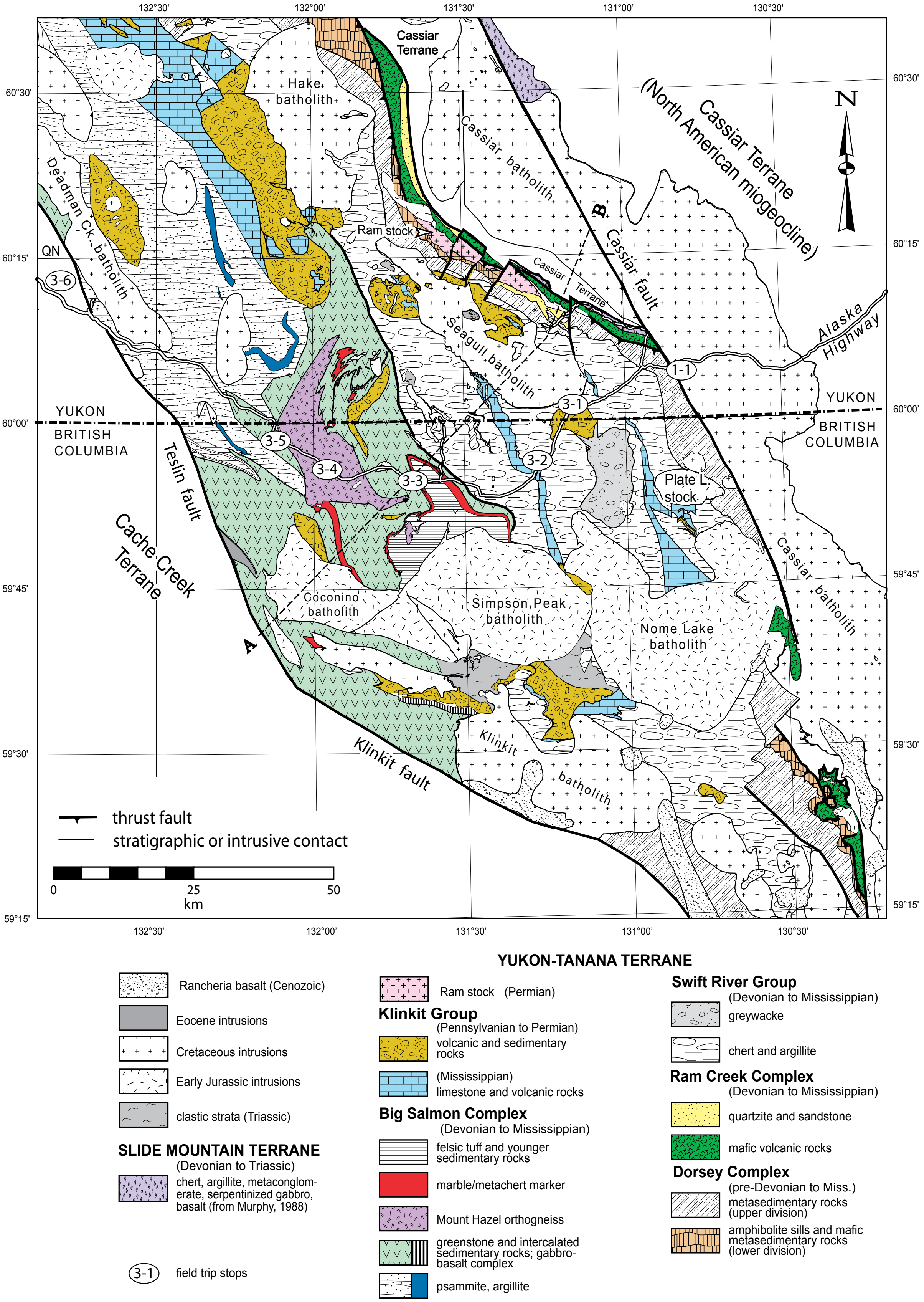


Figure 3-4. *Geological map of the Yukon-Tanana Terrane near the British Columbia - Yukon boundary (after Roots et al., 2006). Cross section line A-B is detailed in Figure 3-5. QN – Quesnellia.*

Cycle I	390-365 Ma	mid- to Late Devonian
Cycle II	365-357 Ma	latest Devonian to Early Mississippian
Cycle III	357-342 Ma	Early Mississippian
Cycle IV	342-314 Ma	Late Mississippian
Cycle V	314-269 Ma	Pennsylvanian-Early Permian
Cycle VI	269-253 Ma	Middle-Late Permian

Igneous rocks of the Devonian Cycle I have been recorded only in the Coast Mountains (Gehrels *et al.*, 1992; Gareau and Woodsworth, 2000; Alldrick, 2001) and in the parautochthonous terrane of east-central Alaska (Dusel-Bacon *et al.*, 2006). The Finlayson assemblage includes rocks with ages spanning the Late Devonian-Early Mississippian Cycles II and III of arc system development. In the Finlayson Lake district (Fig. 3-1), volcanic rocks of Cycles II and III are separated by a prominent unconformity, and weakly deformed intrusive rocks of Cycle III intrude more highly deformed rocks of Cycle II (Murphy *et al.*, 2006). Magmatism of Cycles II and III is the most widespread in Yukon-Tanana Terrane. The combination of detailed geological mapping, and geochemical and isotopic studies has allowed delineation of arc and backarc facies within the Finlayson assemblage (Fig. 3-6). Syngenetic sulphide mineral deposits occur in the

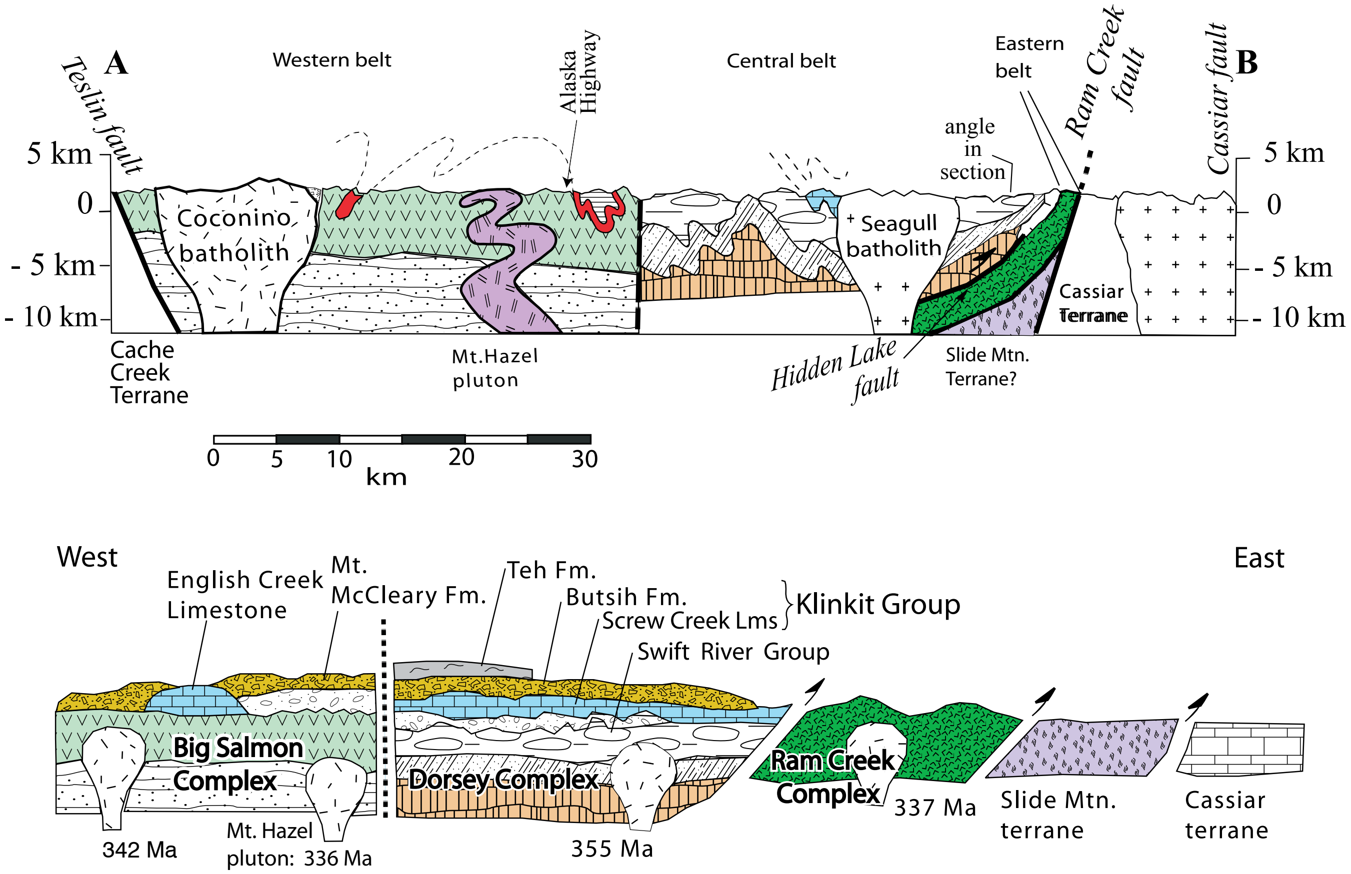


Figure 3-5. (a) *Schematic cross-section of southeastern Yukon-Tanana Terrane (line of section and legend are shown on Fig. 3-4);* ***(b)*** *Conceptual placement of the main stratigraphic units prior to deformation. The contact between Big Salmon Complex and Swift River Group is interpreted as a steeply-dipping fault. Both these units are structurally underlain by the dominantly silicilastic Snowcap assemblage (Dorsey Complex; after Roots et al., 2006).*

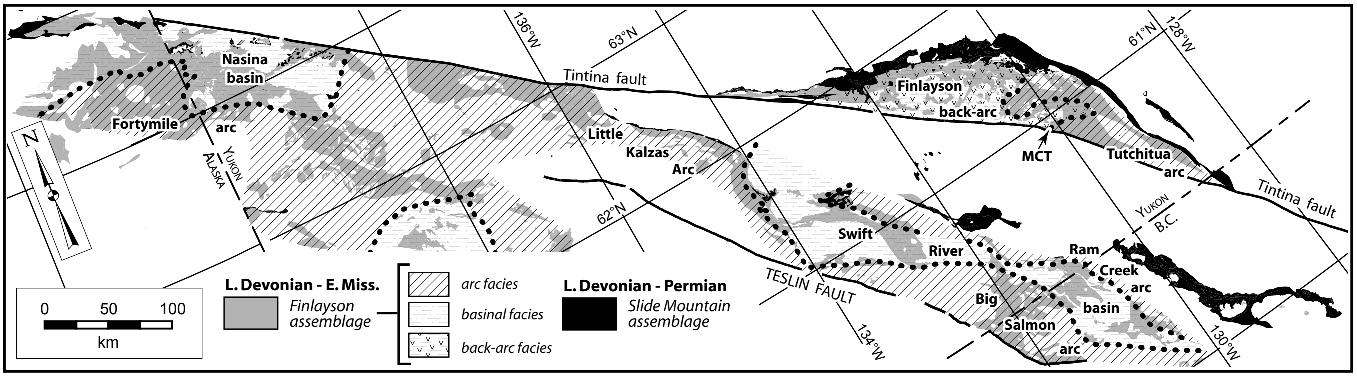


Figure 3-6. *Distribution of arc, backarc and basinal rocks of the Late Devonian – Early Mississippian Finlayson assemblage (after Colpron et al., 2006a).*

backarc facies rocks of Cycles II and III in the Finlayson Lake district (e.g., Kudz Ze Kayah, GP4F and Wolverine; Hunt, 2002; Piercey *et al.*, 2001, 2002, 2006; Murphy *et al.*, 2006). Along this transect, the Finlayson assemblage is represented by greenstone of the Ram Creek Complex, part of the Big Salmon Complex, and basinal metasedimentary strata of the Swift River Group (Figs. 2-3, 3-4, 3-5; Mihalynuk *et al.*, 2006; Roots *et al.*, 2006). Basinal rocks of the Swift River Group likely represent an amagmatic extension of the backarc southwest of Tintina fault (Fig. 3-6).

The Klinkit assemblage includes rocks with ages spanning the Late Mississippian-Early Permian (arc cycles IV and V). It is represented by the Klinkit Group along this transect, which unconformably overlies older units of the Finlayson assemblage (Swift River Group and Big Salmon Complex; Fig. 3-4) and comprises a basal conglomerate overlain by Upper Mississippian to Pennsylvanian limestone and Pennsylvanian to Permian volcaniclastic and siliciclastic strata. The sub-Klinkit unconformity has regional extent within Yukon-Tanana Terrane, postdating a Mississippian event of intra-arc(?) deformation that affected strata of the Finlayson and Snowcap assemblages (Colpron *et al.*, 2006a). Simard *et al.* (2003) define the Klinkit Group in this region and correlate it with late Paleozoic arc sequences in Quesnellia (Lay Range, Harper Ranch). Thus, it forms a stratigraphic tie between these two terranes, which were formerly considered discrete tectonic units (Colpron *et al.*, 2007). Further genetic ties between Yukon-Tanana and Quesnellia are indicated by intrusion of Early Jurassic plutons of Quesnellia, such as the Simpson Peak batholith (Fig. 3-4), into the Yukon-Tanana Terrane. The geochemical and isotopic compositions of the Klinkit Group indicate that it represents development of a mature magmatic arc with limited interaction with evolved crustal material (Simard *et al.*, 2003).

Finally, the Klondike assemblage corresponds to Cycle VI, the latest phase of arc development in Yukon-Tanana Terrane (Figs. 3-2, 3-3). Rocks of the Klondike assemblage are almost exclusively exposed in the Klondike district, south of Dawson City, site of the famous Gold Rush of 1898. Near this transect, quartz monzonite of the Permian Ram stock is inferred to be part of the Klondike magmatic cycle (Piercey *et al.*, 2006; Roots *et al.*, 2006). Rocks of the Ram stock are not exposed along the Alaska Highway. Magmatism of Cycle VI is paired with high-pressure metamorphism (eclogite U-Pb zircon ages of 267-269 Ma) along the eastern edge of Yukon-Tanana Terrane (Fig. 3-1). Arc magmatism of the Klondike cycle is interpreted to record subduction of the Slide Mountain lithosphere beneath the Yukon-Tanana Terrane in mid- to Late Permian.

The oceanic Slide Mountain assemblage that we examined on Day 2 in the Sylvester allochthon spans all of the Yukon-Tanana magmatic cycles, except the first, as its component units reflect the evolution of a marginal ocean contemporaneous with most of the arc history of Yukon-Tanana Terrane (Fig. 3-3; Nelson *et al.*, 2006; Piercey *et al.*, 2006; Colpron *et al.*, 2007).

Although we will not see these rocks along this part of the transect, Triassic siliciclastic strata similar to the Table Mountain Formation in the Sylvester allochthon unconformably overlie the Yukon-Tanana Terrane in this region (Teh Formation of Roots *et al.*, 2006). One distinction of Triassic rocks overlying Yukon-Tanana Terrane is the local occurrence of polymicitic conglomerates (Fig. 3-7). Conglomerate occurs north of the Alaska Highway in Teslin map area (Gordey and Stevens, 1994; reinterpreted as Triassic by Colpron, 2006). A similar conglomerate in Glenlyon map-area, approximately 310 km to the northwest, comprises clasts the are locally derived and detrital zircons that yielded mostly late Paleozoic ages, pointing to local sources in Yukon-Tanana and Slide Mountain terranes, and the upper Paleozoic Boswell assemblage of Quesnellia to the west (Colpron *et al.*, 2005).

We will end Day 3 in Upper Triassic volcanic, volcaniclastic and sedimentary rocks of Quesnellia near Teslin (Fig. 3-4). The characteristics of Quesnellia are reviewed in the introduction to Day 4, below.

Figure 3-7. *Triassic conglomerate in the Englishman Range, Teslin map area.*

TRIP LOG

From Watson Lake (km 980.3 – junction with Robert Campbell Highway), drive west along Alaska Highway to Rancheria Falls (km 1112.5, Stop 1-1). The first 84 km travels through the rolling hills of Liard Plain. As we enter the northern Cassiar Mountains, the following 40 km offers some localized exposures of primarily carbonate rocks of Cassiar Terrane (early Paleozoic).

km 1096.7-1102.0 Quaternary columnar-jointed basalts are exposed on the valley walls to the north on either side of the hamlet of Rancheria. Dozens of isolated valley lava occurrences and several larger cinder cones and tuyas occur throughout the area (Rancheria flows or Tuya Formation; Gabrielse, 1969). Tuya Lake, some 50 km south of this point, is the type area for these sub-glacial volcanoes.

km 1104.5 Granite of the Cassiar batholith is exposed in this road-cut.

km 1112.5 Rancheria Falls, where we stopped on Day 1 (Stop 1-1). After a brief rest, continue westward along the Alaska Highway.

km 1115.2 Crossing the Cassiar fault; entering Yukon-Tanana Terrane here.

km 1119.1 The low, green outcrops on either sides of the road are greenstone of the Ram Creek Complex, Yukon-Tanana Terrane (Roots *et al.*, 2006).

km 1119.8 Continental Divide (rest area). The continental divide along this transect is one of the most gentle gradients in the North American Cordillera.

km 1124 Bridge over the Swift River, which flows west to Teslin Lake and the Yukon River basin.

Stop 3-1 – Klinkit Group volcaniclastic rocks

UTM 9v – 380659E, 6655272N, elev. 935 m

km 1133.1: Isolated outcrop on south side of the road. Park well off the road on grassy shoulder (eastbound traffic has limited visibility).

This is one of the few highway-accessible exposures of volcaniclastic rocks of the Klinkit Group, an Upper Mississippian to Lower Permian volcanic arc sequence that unconformably overlies Lower Mississippian and older parts of the Yukon-Tanana Terrane (Simard *et al.*, 2003; Roots *et al.*, 2006). Here, the rock consists of strongly deformed chlorite schist (probable epiclastic protolith), pebble to boulder conglomerate and local crystal meta-tuff. Clasts in the conglomerate include limestone, andesite (see west end of outcrop, at head level) and dark argillite, and are supported by a matrix of epiclastic chlorite schist. The layering is deformed by an east-verging, tight synform. Ductile strain is evident in the conglomerate clasts and in the epiclastic granules.

km 1136.9 Hamlet of Swift River - highway maintenance camp.

km 1137.3 Yukon-B.C. border.

km 1145 Black outcrops along the north side of the road are of graded black cherty argillite, siltstone and fine-grained lithic wacke of the Swift River Group.

km 1147.8 White-weathering outcrops along the north side of the road (UTM 9v, 372281E, 6644993N) are of overturned Screw Creek Limestone (Klinkit Group) near a synclinal hinge. The rock is medium- to thick-bedded limestone with minor grit and chert-granule conglomerate. Poorly preserved crinoids, brachiopods and coral fragments are locally present.

km 1148.2 Road to Swan Lake communication tower (UTM 9v, 371971E, 6644727N). Turn right and drive to junction, ~0.4 km. Turn right and drive up to communication tower, ~3.2 km.

Stop 3-2 – Basal Klinkit conglomerate, Screw Creek Limestone and Swift River Group

UTM 9v, 371945E, 6646430N, elev. 1260 m

The purpose of this stop is to show the character of the basal Klinkit Group. The structure here is a regional, north-trending, westerly-overturned recumbent syncline cored by the Upper Mississippian to Lower Pennsylvanian Screw Creek Limestone (Fig. 3-5). The limestone forms prominent bluffs on the ridge to the west of this vantage point and we passed outcrops of limestone approximately half-way up the access road. Pebble to boulder conglomerate exposed below the tower dips steeply to the southwest, beneath the Screw Creek Limestone, and marks the base of the Klinkit Group (Fig. 3-8; Simard *et al.*, 2003; Roots *et al.*, 2006). Unconformably below the Klinkit Group are bedded chert, quartzite and argillite of the Swift River Group (we will examine these rocks on the return trip to the highway). These Swift River lithologies make up the clasts in the basal Klinkit conglomerate exposed here. The chert clasts are grey, black and green; quartzite clasts are green and grey. Most clasts are well rounded.

A detrital zircon sample from this locality shows a dominant peak in age probability at *ca.* 1800-2100 Ma, with lesser Archean peaks and three Late Devonian grains probably derived from igneous bodies within Yukon-Tanana Terrane (Fig. 3-9; Nelson and Gehrels, 2007). The Precambrian population is very similar to a sample of grit from the underlying Swift River Group (Fig. 3-9). Both, in turn, show a strong similarity with the reference data from northern B.C. and Alaska (Fig. 3-10), which are derived from the Paleoproterozoic basement terranes in the subsurface of Alberta. An equivalent conglomerate at the base of the Little Salmon formation, near Little Salmon Lake (~310 km to the northwest), yielded detrital zircons with a prominent Early Mississippian peak in age probability (~356 Ma) with few grains of early Paleozoic (434 Ma), Neoproterozoic (727 Ma), Paleoproterozoic (1.8-2.0 Ga) and Archean (2.5 Ga) ages (Colpron *et al.*, 2006b).

On the west side of the parking area (below the boulders) are lichen-covered outcrops containing a 2 m-wide, dark green, hornblende-biotite porphyry dyke (^{40}Ar/^{39}Ar biotite plateau age of 177.0 ± 1.8 Ma; R. Stevens, pers. comm., 2000). The dyke intrudes a mottled light grey quartzite which may belong to the Swift River Group, or represent a quartzite horizon within the basal Klinkit conglomerate.

Vista (compass direction – declination 23° 28'E)

- 020°: valley of Partridge Creek, where Swift River and Klinkit groups are in contact.
- 037°: valley of Seagull Creek; slope beyond is eastern limit of Seagull batholith; and lower hills are Swift River argillite with thinner band of Screw Creek Limestone.
- 043°: hamlet of Swift River beside the Alaska Highway, beyond is the low continental divide, where highway curves right (east) into the Rancheria River drainage (Arctic watershed via the Liard River).
- 080-090°: forested hills of folded strata. Squarish ridge crest is Screw Creek Limestone, dipping northeast.
- 120°: valley of McNaughton Creek. Looking down structural trend to high-grade Dorsey Complex intruded by Jurassic Nome Lake batholith at head.
- 140°: forested slopes and grassy ridge of subdued ridges are dark chert/argillite of Swift River Group. Rubble covered mountains and cirques beyond are Jurassic Simpson Peak batholith (*ca.* 180 Ma) from 165 to 240°.
- 180°: Redfish Creek. Grey outcrop visible in trees is Screw Creek Limestone, southern extension of the outcropping Screw Creek Limestone here.
- 190°: Pyramidal hill ('Saddle Mountain'). Black chert and argillite of the Swift River Group.
- 206°: Simpson Peak (elev. 2173 m/7130') - a batholith of medium-grained granite.
- 216-226°: Swan Lake (elev. 749 m/2460').
- 238°: Mount Francis (1704 m/5592'). Felsic tuff horizon and Arsenault skarn property on west side. This is part of the Big Salmon Complex.
- 255°: foreground knobs are white-weathering Screw Creek Limestone. Distant peaks are Snowdon Range, across Teslin Lake, ~70 km distant (underlain by Cache Creek Terrane).
- 280°: on low ridge in middle distance (~35 km) is next communication tower, on south spur of Mount Hazel. Underlain by a Mississippian pluton.

Returning down the access road, at ~0.8 km stop by heap of chert gravel on the left, before a right hand turn. Outcrops on the right side of the road comprise the highest strata of the overturned Swift River Group. They include grey chert and siliceous argillite. Trace fossils (*Planolites* sp.) are preserved on bedding surfaces (Fig. 3-11). The brown, resistant rock is a mafic dyke. Return to Alaska Highway (km 1148.2) and resume travel to the west.

Figure 3-8. *Basal conglomerate of the Klinkit Group near Swan Lake.*

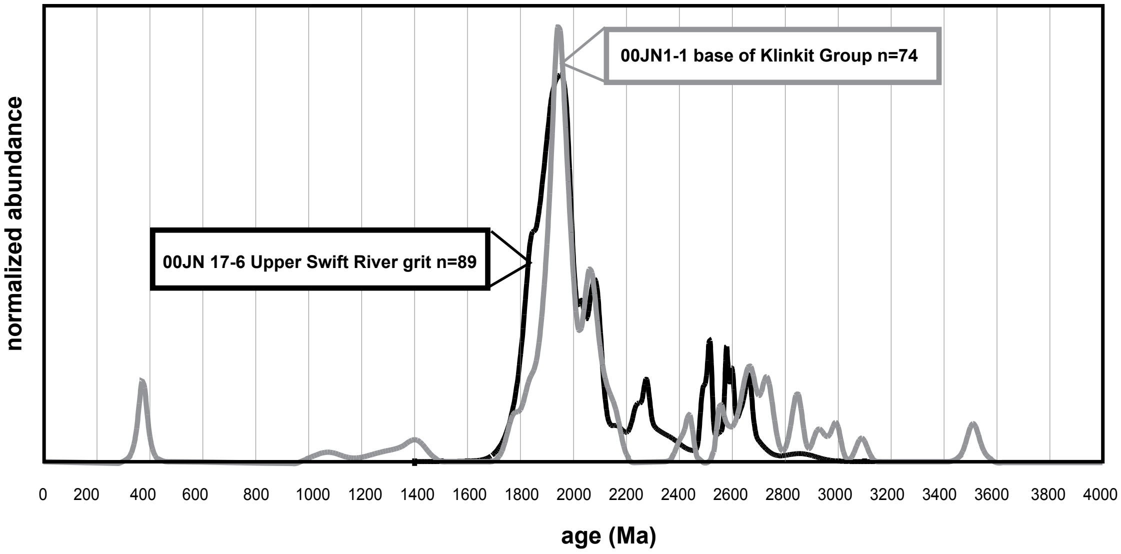


Figure 3-9. *Age probability density plot of single detrital zircon grains from the basal Klinkit conglomerate and a grit unit of the underlying Swift River Group (after Nelson and Gehrels, 2007).*

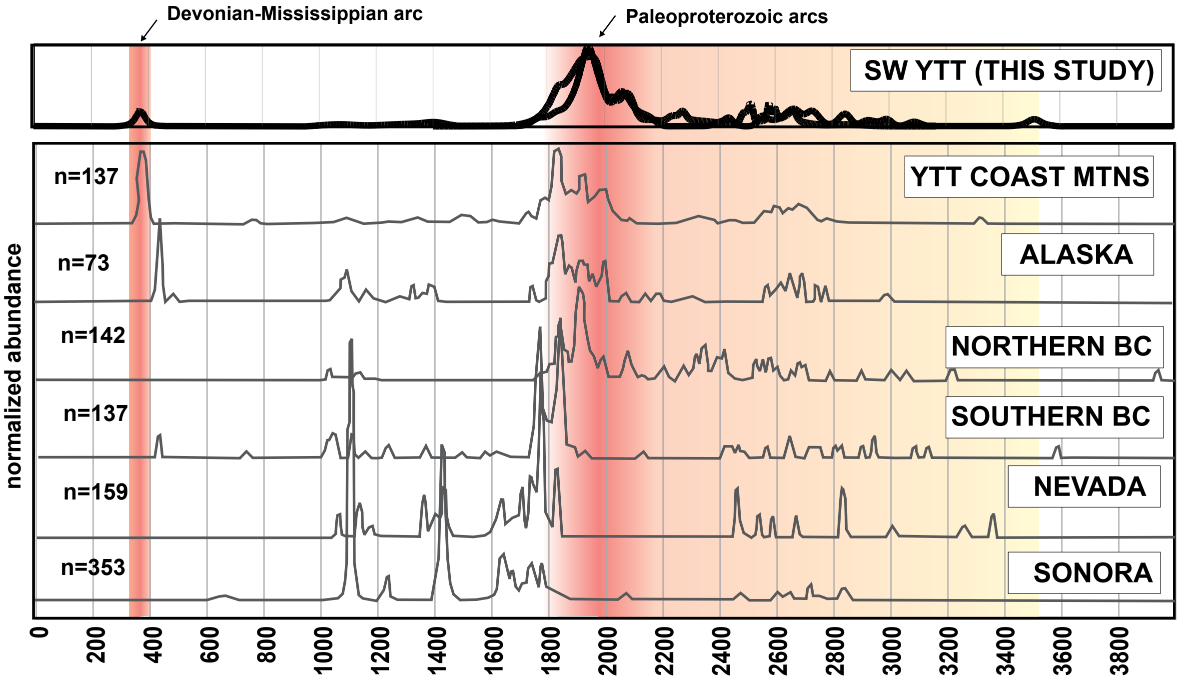


Figure 3-10. *Age probability density plot of single detrital zircon grains for southern Yukon-Tanana Terrane (YTT; see Fig. 3-8; Nelson and Gehrels, 2007) compared with Yukon-Tanana in southeast Alaska and coastal British Columbia (Gehrels, 2002), and the North American reference data of Gehrels et al. (1995).*

Figure 3-11. *Trace fossils (Planolites sp.) in the Swift River Group near Swan Lake. Photo by Charlie Roots.*

km 1149.7 At right-hand curve are low outcrops of Pleistocene to recent basalt.

km 1153 Roadside pullout on south side (with refuse bin and pit toilets). Here is an excellent view southward across the east end of Swan Lake, where the sluggish Swift River enters, to sharp ridges of chert and argillite (Swift River Group) and Simpson Peak, the highest triangular peak at N196°, ~20 km distant (Fig. 3-12). This peak is underlain by rocks of the eponymous Simpson Peak batholith of late Early Jurassic age (186 Ma). Simpson Peak, Nome Lake and Plate Creek intrusions are part of an Early Jurassic suite that intrudes the length of Quesnellia, Stikinia, and Yukon-Tanana Terrane.

km 1163.3 Glacially polished outcrops of Smart River greenstone (Big Salmon Complex; UTM 9v, 359055E, 6643710N; see also Stop 3-3 below). Here the rock is metamorphosed epiclastic sandstone.

km 1166.1 Outcrops of Smart River greenstone.

km 1166.3 Large white outcrops on the north side of the highway are of chloritic metatuff interlayered with buff-weathering marble (equivalent to Screw Creek Limestone). Crinoids, and solitary and branching corals are preserved at the top of this outcrop (UTM 9v, 356209E, 6644281N).

km 1167.9 Gravel road north of the highway leads to the Logtung property, a W-Mo-Bi-Be (beryl, aquamarine) deposit associated with a mid-Cretaceous (110 Ma) monzogranite (Mortensen *et al.*, 2007).

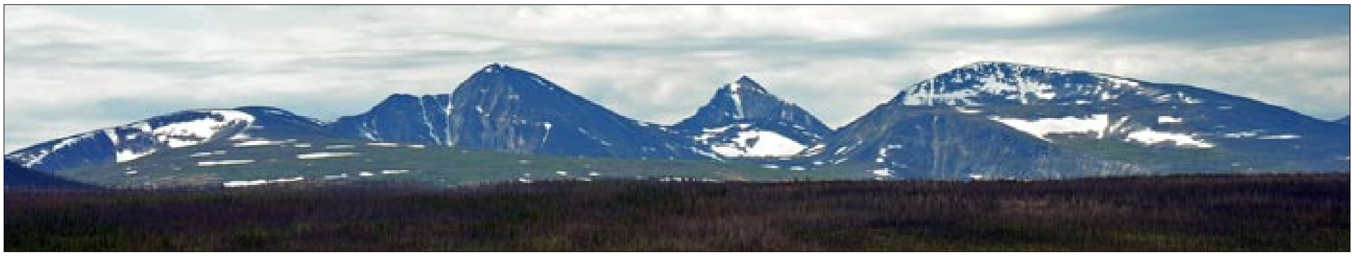


Figure 3-12. *Looking southwest at Simpson Peak (triangular peak in the middle), underlain by Early Jurassic granite that forms the roots of Quesnellia in the northern Cordillera.*

Stop 3-3 – Big Salmon Complex

UTM 9v, 350079E, 6644980N, elev. 880 m.

km 1172.4: The low-lying outcrops in the grassy cutbanks along the highway are strongly foliated Smart River greenstone of the Big Salmon Complex.

The overall composition of the greenstone at this locality, and some of its textural aspects (stretched lapilli?), suggest a volcaniclastic (tuffaceous?) origin for this rock. More mafic and massive greenstone elsewhere in this region has the geochemical character of island-arc tholeiite (Piercey *et al.*, 2006). Mississippian arc-related to continental backarc- and rift-related volcanic and plutonic rocks are one of the hallmarks of the Yukon-Tanana Terrane. A minor felsic unit within the Smart River greenstone has yielded a comparatively young U-Pb age of *ca.* 336 Ma (Fig. 3-2; Mihalynuk *et al.*, 2006). This age suggests that volcanism in the Big Salmon Complex occurred during magmatic cycle IV of Yukon-Tanana Terrane (Nelson *et al.*, 2006; Piercey *et al.*, 2006).

The Big Salmon Complex lies within a separate, fault-bounded panel from the Yukon-Tanana Terrane rocks that are exposed between Cassiar fault and Swan Lake (Figs. 3-4, 3-5). Nevertheless, it is clearly of Yukon-Tanana affinity (previous terrane maps show it as part of Slide Mountain Terrane; Wheeler *et al.*, 1991). It consists of Mississippian arc-related volcanic rocks (Smart River greenstone), siliciclastic rocks, marble, and metamorphosed manganiferous exhalite (Old Highway metachert), all intruded by the Mississippian Hazel pluton (Mihalynuk *et al.*, 2006; Roots *et al.*, 2006).

In this outcrop, the foliation is defined by fine-grained actinolite. Biotite porphyroblasts are randomly oriented and cut across the dominant foliation. Intrafolial folds are locally present. Late euhedral pyrite is well developed in places.

An excellent exposure of Old Highway metachert (a Mn-exhalite, Fig. 3-13; see also Stop 3-4 below) occurs in the bush approximately 1 km to the north of this locality (UTM 9v, 350800E, 6644575N), and continues from there northwesterly for several kilometres (Mihalynuk *et al.*, 2000a).

Figure 3-13. *Pink manganese chert of the Old Highway metachert unit on Hazel Ridge, southern Yukon.*

km 1177.3	Crossing the Smart River.
km 1186.8	Gravel access road on north side of highway leads to the Mount Hazel communication tower (~2.2 km) on a low knob, with exposures of the Mississippian Mount Hazel pluton.

Stop 3-4 – Mount Hazel pluton

UTM 9v, 334798E, 6647717N, elev. 875 m

km 1189.5: Outcrops on the south side of the highway are metaplutonic rocks of the Mount Hazel pluton. Park along the shoulder, on flat stretch of the road, just west of the outcrop.

The Mount Hazel pluton is one of the numerous Mississippian calc-alkaline intrusive bodies that characterize the Yukon-Tanana Terrane. It varies in composition from diorite to granite. Strongly foliated, medium-grained hornblende diorite to fine-grained, grey tonalite are prominent phases in this area. A sample of granodiorite collected a few kilometres west of this locality yielded a concordant U-Pb zircon age of 336.6 ± 0.8 Ma (Mihalynuk *et al.*, 2006), suggesting that this intrusion is part of the regional Tatlmain plutonic suite (Colpron, 2006; Colpron *et al.*, 2006a) and magmatic cycle IV of Yukon-Tanana Terrane (Nelson *et al.*, 2006; Piercey *et al.*, 2006). The older, 350-345 Ma Simpson Range plutonic suite (Mortensen, 1992) is more widespread in Yukon-Tanana Terrane and characterized by similar hornblende- and biotite-bearing granitoid rocks (magmatic cycle III; Piercey *et al.*, 2006). In western Yukon, a granitoid pluton of the Simpson Range plutonic suite is associated with dissiminated copper-gold mineralization at the Lucky Joe property (Yukon MINFILE 115O 051, Deklerk and Traynor, 2005), a possible Mississippian porphyry occurrence. In this outcrop the penetrative foliation in the metaplutonic rock is folded by a series of open folds with nearly horizontal axial planes and shallow, southeast-plunging fold axes.

km 1194 Rest area and Helen Lake (behind trees) on north side of the highway.

km 1198.8 Turn left (south) onto gravel road, approximately 0.1 km before Andrew Creek. This is a segment of the old Alaska Highway. Drive approximately 1.4 km to a white gravel slope and reddish outcrop on the left (north), just before a grassy mound that partially blocks the road ahead.

Stop 3-5 – Old Highway metachert

UTM 8v, 662667E, 6651698N, elev. 870 m

This is the type exposure of the Old Highway metachert, part of the 'Jennings marker' succession that overlies the Smart River metabasalt (Mihalynuk *et al.*, 2006). Here it is sericitic to manganiferous, with abundant pink piedmontite (Mn-epidote; Fig. 3-13). The Old Highway metachert is a thin but laterally very continuous marker, with a strike length over 40 km. In addition to piedmontite, it locally contains manganiferous garnet, staurolite and hematite. Copper concentrations are locally associated with it. The Old Highway metachert is interpreted as a hydrothermal sedimentary rock (exhalite) possibly related to VMS systems in the region (e.g., MOR prospect, north of Morley Lake; Yukon MINFILE 105C 061; Mihalynuk and Peter, 2001).

The metachert is folded by outcrop-scale isoclinal folds that are themselves refolded by shallow, east-plunging open folds. The well-developed crenulation lineation parallels the open fold axes. In recent years, a small volume of rock has been extracted from this outcrop for use as an ornamental stone.

Retrace the route back to the Alaska Highway. Turn left and drive north along the highway.

km 1202.3 B.C. – Yukon border.

km 1204 Morley River bridge.

km 1231.7 Dawson Peaks resort.

km 1243 The longest bridge on the Alaska Highway; it crosses Nisutlin Bay of Teslin Lake. Entering the village of Teslin (pop. 411). Continue northwestward travel along Alaska Highway.

km 1254.1 Turn right onto gravel access road and drive to the Teslin communication tower, approximately 3.1 km.

Stop 3-6 – Quesnellia

UTM 8v, 621030E, 6676841N, elev. 1085 m

Rocks exposed around the communication tower and for 50 m down the access road are Triassic arc-related rocks typical of Mesozoic Quesnellia. Similar augite-phyric, basaltic to andesitic volcaniclastic rocks and flows dominate stratigraphic sequences of Quesnellia from here southward to Quesnel and Kamloops in southern B.C. Notably, although late Paleozoic strata overlying southern Yukon-Tanana Terrane (Klinkit Group) are correlative with units of Quesnellia (Lay Range succession), the Triassic strata there are very thin and non-volcanogenic. It is possible that a major fault with thrust and/or transcurrent motion separates the Triassic arc from coeval backarc, basinal facies of Quesnellia. Its location would coincide with the present eastern strand of the Teslin fault, northeast of this locality (Plate 1), and with the Klinkit fault farther south (see further discussion of the Teslin fault below).

At the communication tower are little metamorphosed, buff-weathering, tan to dark green, augite-phyric and augite-feldspar-phyric tuffs, autoclastic breccia and flows. Flow horizons are locally evident. These rocks are interbedded with, and overlie, a sequence of argillaceous sandstone and bioturbated mudstone, which define a well-developed set of turbidites (exposed along the access road). These rocks are steeply dipping to slightly overturned in the west limb of an asymmetric, west-verging antiform. Parasitic folds of bedding are rare.

Carnian and Norian fossils are present in these rocks, which are included in Quesnellia based on: 1) the presence of Upper Triassic augite-phyric volcanic rocks; 2) the lack of penetrative deformation and metamorphism; and 3) their structural position east of the Cache Creek Terrane and Teslin fault (Plate 1 and Fig. A9). These rocks are assigned to the Shonektaw Formation (Gordey and Stevens, 1994).

Teslin fault

To the west is Teslin Lake, underlain by the Teslin fault, the northern extension of the Thibert-Kutcho fault system of northern B.C. (Fig. A7). Along much of its length, the Teslin-Thibert fault system juxtaposes Mesozoic Quesnellia, on the east, from Cache Creek Terrane, on the west. Along southern Teslin Lake, the Big Salmon Complex (Yukon-Tanana Terrane) occurs east of Teslin fault. North of Teslin, the Teslin fault once again separates Quesnellia and Cache Creek terranes. An eastern strand of the fault juxtaposes the Yukon-Tanana Terrane with Quesnellia and the Jurassic Laberge Group; this strand is intruded by the Early Cretaceous Deadman Creek batholith (Gordey and Stevens, 1994). To the north, the Teslin fault follows Teslin River for ~150 km; it extends northwesterly beyond that for another 100 km, to east of Carmacks, where it apparently loses stratigraphic separation, as Lower to Middle Jurassic strata of the Laberge Group (Whitehorse trough) occur on both sides of the fault.

In seismic-reflection surveys, the Teslin fault is the surface expression of a series of east-dipping reflectors that extend to mid-crustal level (Fig. A4; Cook *et al.*, 2004; Snyder *et al.*, 2005). (Similar reflectors are also observed in a seismic survey along Robert Campbell Highway, east of Carmacks, ~250 km to the northwest; D. White and M. Colpron, unpublished data, 2004). The dip of this structure is congruent with southwest-verging thrust faults imbricating Cache Creek and Stikinia to the west (*cf.* Stop 4-4), and thus may suggest in part a history of southwest-verging thrusting along the Teslin fault, possibly in Early to Middle Jurassic time (Mihalynuk *et al.*, 2004). A lone exposure of the fault to the south, along the Jennings River, records early sinistral ductile transpression overprinted by younger, dextral brittle-ductile transpression (de Keijzer *et al.*, 2000). A dextral offset of up to 130 km is estimated along the Thibert fault in northern B.C. (Gabrielse *et al.*, 2006). The progressive northward decrease in apparent dextral displacement along Teslin fault may in part be the result of transferring its displacement to a series of north-striking splays, including the d'Abbadie (~30 km ?) and Big Salmon faults (~56 km; Colpron *et al.*, 2003). Dextral strike-slip displacement is in part coeval with mid-Cretaceous magmatism (95-110 Ma; e.g., Cassiar batholith; Gabrielse *et al.*, 2006), but likely persisted until early Cenozoic time, as indicated by development of dextral C/S fabrics in the Paleocene Charlie Cole pluton (Mihalynuk *et al.*, 2006).

Vista to the south at Stop 3-6

To the south across the lake are the Dawson Peaks. These mountains lie just to the south of the British Columbia - Yukon border and are underlain by Upper Cretaceous volcanic rocks of the Carmacks Group and by Late Cretaceous granitic rocks included in the Surprise Lake plutonic suite. To the west-southwest is Mount Bryde, a large granitic intrusion (*ca.* 172 Ma) included in the Fourth of July plutonic suite. Plutonic rocks of the Surprise Lake and Fourth of July suites are isotopically primitive, suggesting that the crust beneath the Cache Creek Terrane lacked evolved crystalline rocks at the time of intrusion.

Stop 3-6 marks the end of Day 3 of our geological transect. From here, we drive to Whitehorse, approximately 170 km distant (~2 hours). The following log highlights a few of the features between this point (km 1254.1) and Jakes Corner (km 1341.1).

km 1289.2 Outcrop of volcaniclastic rocks of Quesnellia. Looking to the west, across Teslin Lake, is Hayes Peak. The peak is underlain by an ultramafic intrusion that crystallized at *ca.* 245 Ma (U-Pb zircon; Gordey *et al.*, 1998).

km 1295 Junction of the Canol road (Yukon Highway 6).

The Canol (short for ‘Canadian Oil’) road and pipeline were built in 1942-43 to connect the high-grade oil fields at Norman Wells, in the NWT, with Whitehorse, Yukon, where a refinery was built to supply fuel for maintenance of the Alaska Highway and to U.S. military bases in Alaska during World War II. Oil began to flow along the four-inch pipe in 1944, but was shut down in 1945 when the project was reviewed in Washington. The road was abandoned by 1946-47 and most of the pipe salvaged. In 1958, the southern part of the road was reopened to connect the community of Ross River to the Alaska Highway here at Johnson’s Crossing. The northern portion of the Canol road in Yukon, to the NWT border, was reopened in 1972 to assist mineral exploration near Macmillan Pass (sedimentary-exhalative district at the edge of Selwyn basin). The road is now maintained for summer use only. It is one of the few original wartime road-beds in Yukon, and winds through the scenic Pelly and Selwyn mountains. The northern two-thirds of Line 3 of the SNORCLE seismic transect was acquired along the Canol road in 1999 (Cook *et al.*, 2004).

km 1296.3 Teslin River bridge at Johnson’s Crossing. We cross the Teslin fault which here juxtaposes Jurassic sedimentary strata of the Laberge Group (Whitehorse trough), to the east, against Late Triassic volcanic strata of the Cache Creek Terrane, to the west.

km 1315.5 Squanga Lake, famous for northern pike, arctic grayling, lake trout and pygmy whitefish.

km 1316 Mountains to the north are underlain by Mississippian to Triassic (?) tholeiitic volcanic rocks and chert of the Cache Creek Terrane. The volcanic rocks host a series of Permian ultramafic bodies. These rocks are bound by steeply-dipping contacts; it is not clear if they intrude the volcanic rocks or if they represent fault-bounded bodies. To the south and ahead to the west are reefal carbonate buildups of Pennsylvanian-Permian age, underlying Mount White. Permian fusulinid and coral faunas of exotic, Tethyan (Asian) affinity are preserved in these strata suggesting that the Cache Creek Terrane is far-travelled (Ross and Ross, 1983). The significance of Tethyan faunas in the Intermontane terranes will be discussed at length on Day 4 of the field trip.

km 1341.1 Jakes Corner: road departs to the west to Tagish (pop. 200) and Carcross (pop. 450),Yukon, and Atlin, B.C. (pop. 450).

The geology along the Alaska Highway between Jakes Corner and Whitehorse is described on Day 4 of the field trip.

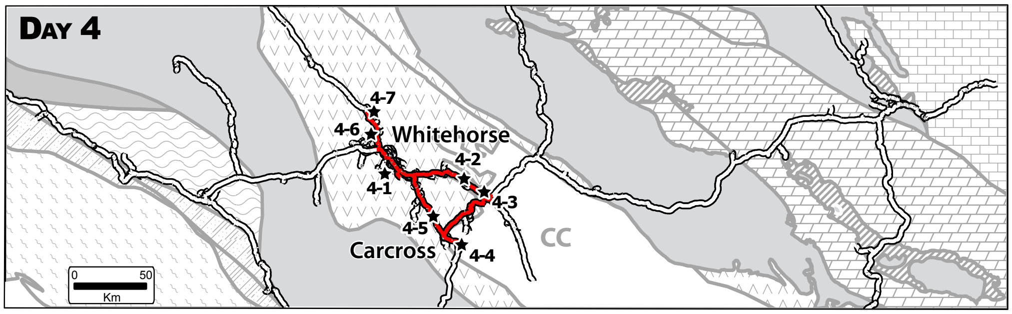
km 1419.4 Robert Service Way – access road to Whitehorse (pop. 24 000).

DAY 4 – CACHE CREEK, STIKINIA AND WHITEHORSE TROUGH; WHITEHORSE COPPER BELT

Day 4 of the transect will examine the geology of the Whitehorse region, focusing primarily on rocks of the Cache Creek Terrane, Stikinia and the Whitehorse trough. The day will begin with an overview of the Whitehorse area and a visit to a copper skarn deposit in the Whitehorse Copper Belt. The trip log for the day consists of two loops: a morning loop south of Whitehorse (Marsh Lake-Tagish-Carcross) and an afternoon loop north of the city to Lake Laberge.

Stikinia and Quesnellia

Stikinia and Quesnellia (also commonly referred to as the Quesnel and Stikine terranes) are two large terranes in which surface exposures consist primarily of Mesozoic volcanic and plutonic arc rocks (Fig. A1). Both terranes also include sporadically exposed Paleozoic arc 'basement' rocks. In Stikinia these correspond to the Stikine assemblage of northwestern British Columbia, a volcanic-sedimentary sequence of Devonian to Lower Permian age. It has Late Devonian to Early Mississippian calc-alkaline plutons intruding its base and limestone with McCloud faunal affinity at its top (Logan *et al.*, 2000; Gunning *et al.*, 2006). Correlative rocks in Yukon are the metamorphosed volcanic, volcaniclastic and minor carbonate rocks of the upper Paleozoic Takhini assemblage, exposed west of Whitehorse (see Stop 5-3; Hart, 1997). In Quesnellia upper Paleozoic arc and backarc assemblages are found in the Lay Range of central British Columbia (Ferri, 1997) and the Harper Ranch Group of southern British Columbia (Beatty *et al.*, 2006), which are correlated with the Klinkit assemblage of Yukon-Tanana Terrane (see Stops 3-1, 3-2; Simard *et al.*, 2003) and the Huntergroup volcanics in the Sylvester allochthon (see Stop 2-3; Nelson and Friedman, 2004). The Boswell assemblage of south-central Yukon is another upper Paleozoic volcanic-sedimentary sequence tentatively assigned to Quesnellia (M. Colpron, unpublished data). It consists of basalt (MORB, EMORB) and limestone of the Upper Devonian to Lower Mississippian Moose formation and Upper Mississippian to Lower Permian arc volcanic, volcaniclastic and sedimentary rocks (including Pennsylvanian-Permian fossiliferous limestone) of the Boswell formation (Simard, 2003; Simard and Devine, 2003; M. Colpron, unpublished data). A Pennsylvanian tonalite pluton intrudes rocks of the Moose formation at the northern end of the belt (Colpron, 2006, and unpublished data). These rocks are unconformably overlain by Upper Triassic volcanic and volcaniclastic strata of the Semenof formation (R.-L. Simard and M. Colpron, unpublished data). The Boswell assemblage and Semenof formation are assigned to Quesnellia based on their age, composition and position east (in the hanging wall) of the Teslin fault (Plate 1; Figs. A4, A9; Cook *et al.*, 2004; and D. White and M. Colpron, unpublished data, 2004). The relations between Boswell assemblage and other late Paleozoic sequences of Quesnellia and Yukon-Tanana Terrane are uncertain. Pennsylvanian detrital zircons in a Triassic



conglomerate overlying Yukon-Tanana Terrane, and imbricated with Slide Mountain Terrane, suggest proximity of the Boswell assemblage at that time (Colpron *et al.*, 2005).

The oldest Mesozoic volcanic and intrusive rocks in Quesnellia and Stikinia are Middle Triassic, but voluminous arc-related build-ups with coeval, cogenetic plutonism began in the Late Triassic (Anderson, 1991). In B.C. they include the Takla and Nicola groups northeast of the Cache Creek Terrane and the Takla and Stuhini groups to the southwest (the oceanic, accretionary Cache Creek assemblage is used to demarcate between similar Mesozoic strata assigned to Quesnellia and Stikinia; see Wheeler *et al.*, 1991). Upper Triassic, dominantly augite-(plagioclase-) phyric volcanogenic units on both sides of the Cache Creek assemblage are strongly similar in field characteristics, arc geochemistry and primitive isotopic signatures (Dostal *et al.*, 1999). The main Triassic volcanic accumulations of Quesnellia lie west of the belt of Paleozoic pericratonic exposures, which are onlapped by thinner, volcanic-poor siliciclastic units with continentally-influenced isotopic signatures (Unterschutz *et al.*, 2002) that also overlie Yukon-Tanana Terrane and the western continental margin (Beranek and Mortensen, 2007). Following the Permo-Triassic accretion of the innermost pericratonic terranes (Slide Mountain, Quesnellia and Yukon-Tanana), it is likely that the axis of the new west-facing arc migrated outboard from the collision zone. In Stikinia there is no evidence for a shift in the arc axis: the Stuhini and Takla groups are developed in a broad region on top of variably-deformed Paleozoic arc units.

In Yukon Mesozoic Stikinia is represented by volcanic and sedimentary strata of the Middle Triassic Joe Mountain Formation and the Upper Triassic Lewes River Group (Fig. 4-1), which underlie large parts of the Whitehorse map area (Hart, 1997). The Joe Mountain Formation consists of a mafic-ultramafic intrusive complex, basalt and volcaniclastic rocks of Ladinian (Middle Triassic) age and of MORB to BABB geochemical affinity (Hart, 1997; Piercey, 2005). The Upper Triassic Lewes River Group includes a lower formation of Carnian augite-phyric basalt, basaltic andesite and volcaniclastic rocks (Povoas formation; informal nomenclature of Tempelman-Kluit, 1984) and an upper formation of Carnian to Rhaetian epiclastic, volcanogenic sedimentary rocks and limestone (Aksala formation; Fig. 4-1). Volcanic rocks of the Povoas formation have the general character of island arc tholeiite with minor MORB (S.J. Piercey, personal communication, 2005). The Aksala formation includes three mappable members (Fig. 4-1): 1) the Casca member, a Carnian-Norian heterogeneous sequence of lithic sandstone, argillite and conglomerate; 2) the Hancock member, a Norian-Rhaetian reef limestone, including Grey Mountain in Whitehorse and Lime Peak near Lake Laberge; and 3) the Mandanna member, a Rhaetian maroon lithic sandstone, siltstone, mudstone and minor conglomerate of fluvial to tidal origin (Long, 2005; see Stop 5-1). These rocks record the waning stage of the Lewes River arc.

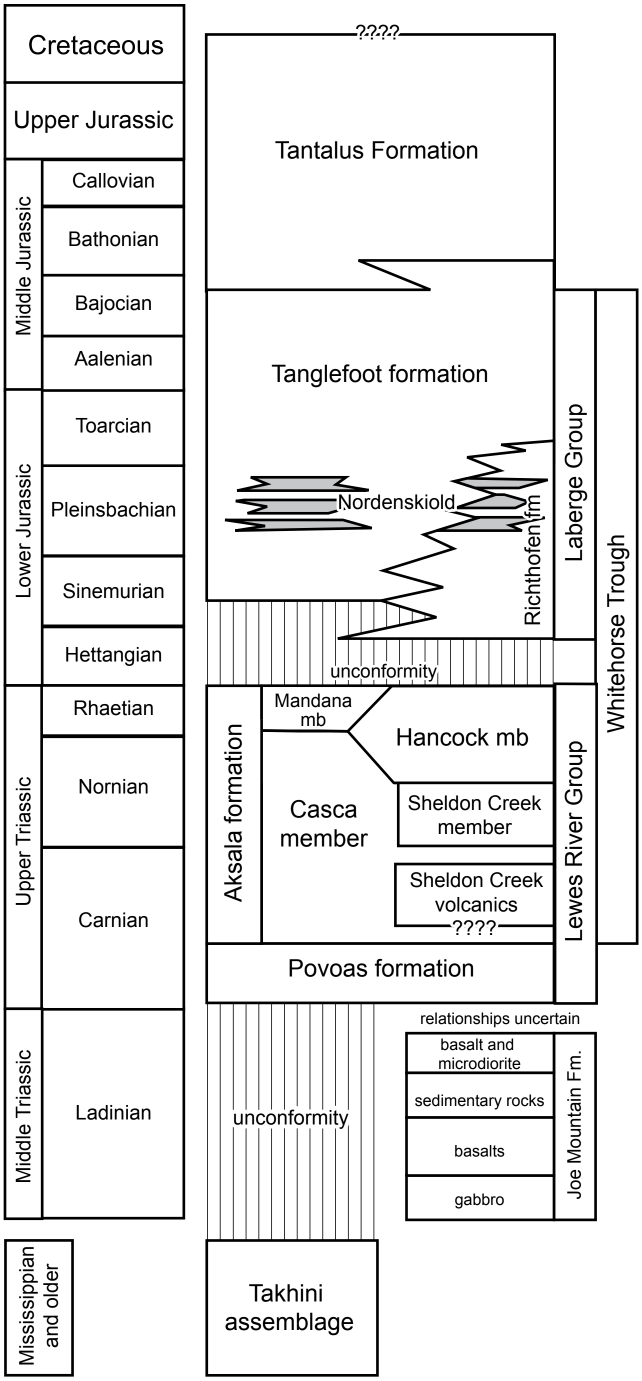


Figure 4-1. *Composite stratigraphic chart for Stikinia and Whitehorse trough in southern Yukon (modified after Hart, 1997; Lowey, 2004; and unpublished data).*

Lime Peak north of Whitehorse is the site of the thickest and best-developed Upper Triassic reef complex in the North American Cordillera (see Stop 4-6). Norian in age, it contains corals, sponges, brachiopods, bivalves, disjectoporids, and spongiomorphs, including a number of coral species that are also found in central Quesnellia, the Wallowa Terrane of Oregon, and the Antimonio Terrane of western Mexico, as well as in the parautochthonous Luning Formation of Nevada (Yarnell *et al.*, 1999). Similar reef faunas occur in the western part of the Tethyan seaway, an equatorial belt that extended along the southern margin of Pangea, from Asia through southern Europe. The similarity of Triassic Cordilleran and European species lends support to the early-opening stages of the "Hispanic corridor", a shallow, westward continuation of the Tethyan seaway that was fully established by Early Jurassic time (Stanley, 1994). The more northerly terranes Quesnellia and Stikinia contain equatorial faunas, hence they may have undergone considerable northward displacement since the Late Triassic.

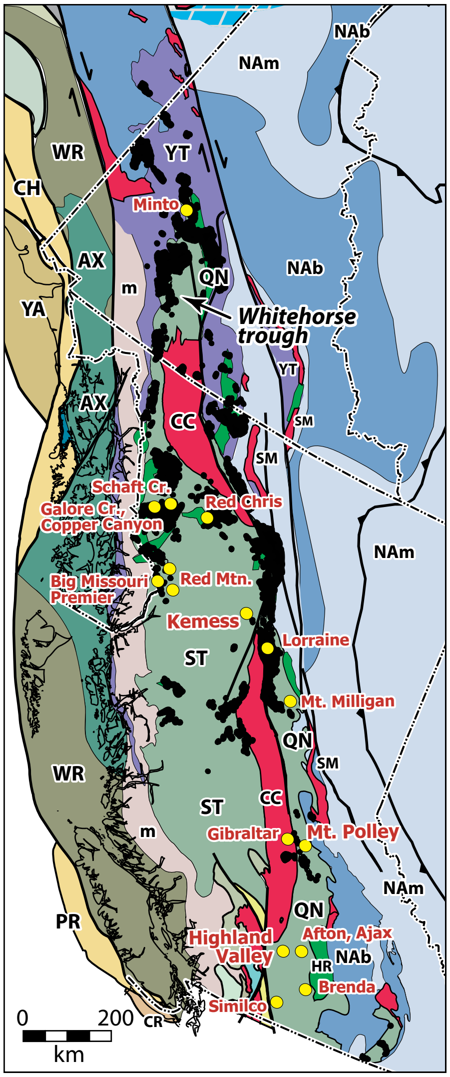


Figure 4-2. *Triassic to Middle Jurassic magmatic belts and associated deposits of the Intermontane terranes. Black areas are distibution of Late Triassic-Early Jurassic plutons in Yukon-Tanana, Stikinia and Quesnellia. Porphyry deposit locations (yellow circles) are from McMillan et al. (1995). Terrane legend is as in Figure A1.*

Basinal Triassic sedimentary rocks, which have been modelled as backarc basins to the Triassic arc of Quesnellia, show evidence of pre-Triassic ties to the northern part of the continental margin (Colpron *et al.*, 2006a; Beranek and Mortensen, 2007). None of these contain Tethyan coralline faunas. This contrast may argue for considerable tectonic lateral mobility of the frontal arcs with respect to their backarc regions in early Mesozoic time.

Mesozoic volcanogenic exposures of Quesnellia in Yukon are restricted to a narrow and discontinuous belt northeast of Teslin fault (Gordey and Stevens, 1994; Gordey and Makepeace, 2000; Simard, 2003; Simard and Devine, 2003; and M. Colpron, unpublished data). These rocks have been variously assigned to the Shonektaw Formation in Teslin area (see Stop 3-6; Gordey and Stevens, 1994), the Semenof formation in Laberge area (Tempelman-Kluit, 1984; Simard, 2003; Simard and Devine, 2003) and the Lewes River Group (Povoas formation) in Glenlyon (Colpron *et al.*, 2002).

By the Early Jurassic newly-configured arcs were superimposed on the Triassic architecture on both sides of the Cache Creek Terrane. Contact relationships range regionally from disconformable to deeply unconformable on folded and thrust-faulted older strata. In Quesnellia and Yukon-Tanana Terrane, the Early Jurassic magmatic zone migrated eastwards towards the continent, as shown by abundant 200-185 Ma plutons in the Yukon-Tanana Terrane. These are equivalent to the volcanic strata of the Lower Jurassic Rossland Group, which lie well east of the Triassic Nicola Group in southern B.C. (Wheeler and McFeely, 1991). In Stikinia, Lower Jurassic volcanogenic strata of the Hazelton Group are widespread and voluminous. The preferred tectonic model for this terrane in Early Jurassic time is a microplate with subduction under both east and west sides (present coordinates), which generated two arcs separated by a marine trough (Marsden and Thorkelson, 1992).

In northern B.C. and southern Yukon the Early Jurassic plutonic suite of Quesnellia and Stikinia intrudes pericratonic basement rocks of Yukon-Tanana Terrane in a horseshoe-shaped belt around the northern end of Whitehorse trough (Fig. 4-2), which is an Early to Middle Jurassic forearc basin (see below). The Early Jurassic suite was emplaced during rapid exhumation of the metamorphic host rocks of the Yukon-Tanana Terrane. Early phases are variably foliated (locally mylonitic), epidote-bearing granodiorite; younger phases are undeformed granite and pegmatite, locally with miarolitic cavities (Johnston and Erdmer, 1995; Johnston *et al.*, 1996a; Colpron *et al.*, 2003). Mica cooling ages from the Yukon-Tanana Terrane indicate that most of it had cooled below ~300°C by late Early Jurassic time (Fig. A5; Breitsprecher and

Mortensen, 2004). The Late Triassic to Early Jurassic plutonic suite of Quesnellia and Stikinia is famous for its copper-gold and copper-molybdenum porphyry deposits, including the Highland Valley, Gibraltar, Kemess, and Mt. Polley mines in British Columbia (to name a few), and the newly opened Minto mine in Yukon (Fig. 4-2; Nelson and Colpron, 2007). At Minto, the high-grade copper-gold ore is hosted in strongly deformed early phases of the Granite Mountain batholith.

Cache Creek Terrane

The Cache Creek Terrane consists predominantly of oceanic rocks (basalt, chert, argillite, gabbro and ultramafic rocks) of Early Mississippian to Middle Jurassic age, and upper Paleozoic limestone with exotic Tethyan faunas (Monger and Ross, 1971; Monger, 1975; Gabrielse, 1998; Mihalynuk, 1999). Also present locally are abundant Upper Permian arc volcanic rocks (Kutcho assemblage; English and Johnston, 2005). The highly disrupted nature of the Cache Creek Terrane and occurrences of Triassic and Middle Jurassic blueschist indicate that it represents an accretionary complex, possibly recording more than 6000 km of subduction of Panthalassa lithosphere beneath the Quesnellia-Stikinia arcs (Monger, 1969; Cordey *et al.*, 1991; Struik *et al.*, 2001). Early Permian faunas of the Cache Creek Terrane are more closely related to Eurasia than North America (Ross and Ross, 1983; Stevens, 2007). The position of the very exotic Cache Creek Terrane between the less exotic Quesnel and Stikine terranes is best explained by oroclinal entrapment during the Jurassic amalgamation of the Intermontane terranes (Mihalynuk *et al.*, 1994). By the Middle Jurassic, the Cache Creek complex was rapidly exhumed and thrust westward onto Lower to Middle Jurassic strata of the Laberge Group (Whitehorse trough; see below) along the Nahlin fault (Mihalynuk *et al.*, 2004; English and Johnston, 2005). Major units of the Cache Creek Terrane (Cache Creek Group) in northern B.C. and southern Yukon include the Mississippian to Pennsylvanian Nakina Formation (basalt, minor chert), the Pennsylvanian-Permian Horsefeed Formation (limestone), and the Permian-Jurassic Kedahda Formation (chert, clastic rocks; Gabrielse, 1998; Mihalynuk, 1999).

Whitehorse trough

The Whitehorse trough is an elongated, northwest-trending sedimentary basin which extends some 650 km from just north of Carmacks, Yukon, to near Dease Lake, British Columbia (Fig. 4-3). It includes the upper sedimentary strata of the Upper Triassic Lewes River Group (Aksala formation) and the clastic sedimentary rocks and reworked tuff of the Lower to Middle Jurassic Laberge Group (Fig. 4-1). In southern Yukon, the Laberge Group comprises a southern unit of deep-water turbidite (sandstone-siltstone-argillite) and mass-flow conglomerate, the late Hettangian to Pliensbachian Richthofen formation (equivalent to the Inklin Formation of northern B.C.; Johannson *et al.*, 1997; Mihalynuk, 1999), and a northern, in part coeval unit of shallow marine to fluvial sandstone, conglomerate and minor shale with coal seams, the Sinemurian to Bathonian Tanglefoot formation (Fig. 4-1; Hart, 1997; Lowey, 2004). A reworked, crystal lithic tuff unit, the Pliensbachian Nordenskiold formation, occurs at multiple stratigraphic levels and is common to both the Richthofen and Tanglefoot formations (Fig. 4-1).

Deposition of the Laberge Group began as the plutonic roots of Stikinia and Quesnellia (and their Yukon-Tanana basement) were rapidly exhumed in Early Jurassic (Fig. A5). Provenance studies indicate local derivations from terranes immediately adjacent to the Whitehorse trough (Dickie and Hein, 1995; Hart *et al.*, 1995; Johannson *et al.*, 1997; see Stops 4-7 and 5-2 for further discussion). In northern B.C., Pliensbachian strata of the Inklin Formation contains ultrahigh-pressure detritus (Canil *et al.*, 2006). The Whitehorse trough is interpreted as a forearc basin that developed between the Cache Creek trench and the Early Jurassic Stikinia arc. It provides the geodynamic link between Stikinia and Cache Creek Terrane (Johannson *et al.*, 1997). In southern Yukon, strata of the Laberge Group (Tanglefoot formation) also overlie volcanogenic rocks of Quesnellia northeast of Teslin fault (Colpron *et al.*, 2002; Colpron, 2006), and thus overlap Stikinia and Quesnellia.

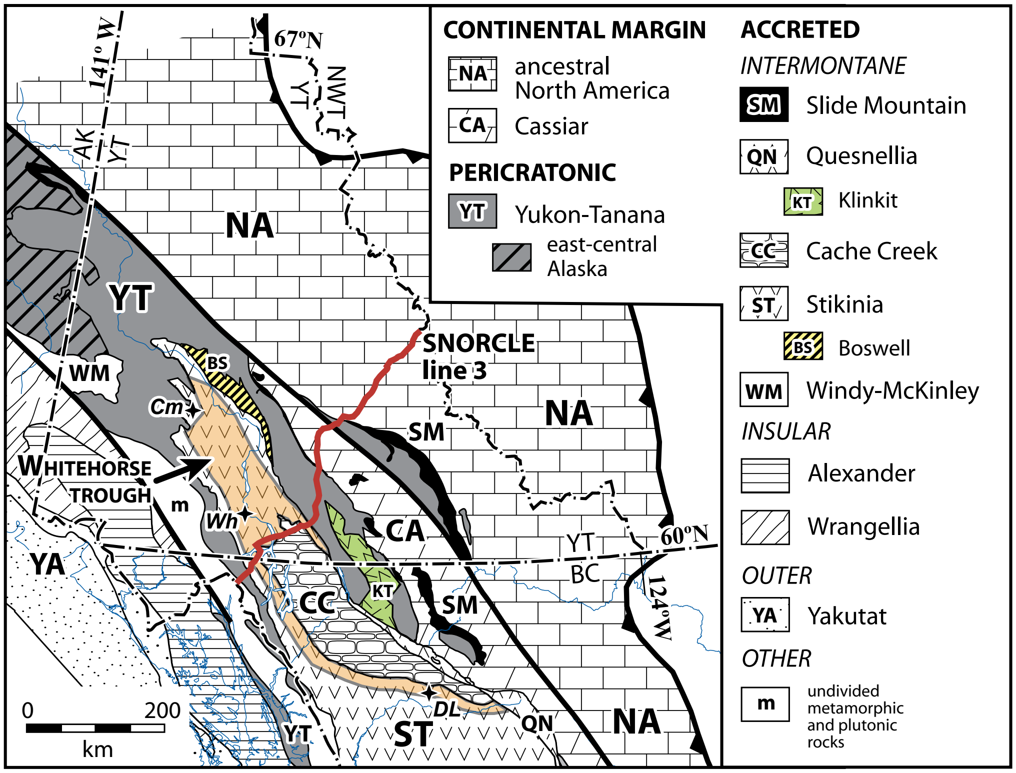


Figure 4-3. *Location of Whitehorse trough (grey-shaded area) with respect to terranes of the northern Canadian Cordillera. The location of the SNORCLE line 3 seismic transect is also shown (the southern part of which is reproduced in Figure A4).*

The Laberge Group is unconformably overlain by the Upper Jurassic to Cretaceous Tantalus Formation, a coal-bearing sequence of fluvial chert-pebble conglomerate and sandstone (Long, 2005). The chert is likely derived from the Cache Creek Terrane, and detrital zircons indicate similar sources as for the underlying Laberge Group, with a contribution from a Middle to Late Jurassic magmatic source (M. Colpron and D.G.F. Long, unpublished data, 2005).

The Whitehorse trough is a southwest-verging fold-and-thrust belt of Jura-Cretaceous age (Fig. A4; Cook *et al.*, 2004; White *et al.*, 2006; and unpublished data). It is bounded to the east by the Nahlin fault, near the B.C.-Yukon border, and the Tadru fault at the north end of the trough (Fig. 4-3). Near Whitehorse the trough is bounded to the west by the Tally-Ho shear zone, of probable Jurassic sinistral displacement (Hart and Radloff, 1990), and the southwest-verging Ibex thrust (Hart, 1997). To the north, near Carmacks, the western boundary of the Whitehorse trough is the cryptic Braeburn fault (Tempelman-Kluit, 1984).

From 1904 to 1922 small tonnages of coal were mined from the Tantalus mine at Carmacks and used to fuel riverboats plying the Yukon River from Whitehorse to Dawson and for domestic heating in Dawson. In 1923 a new mine was opened at Tantalus Butte, and up until 1938 a few hundred tonnes were mined each year for domestic heating in Dawson. From 1947 to 1968 coal was mined for use in the mines at Elsa and Cassiar, and from 1972 to 1981 up to 25 000 tonnes per year were mined by Cyprus Anvil Mining Corp. for plant heating and concentrate drying at the Faro lead-zinc mine (sedimentary-exhalative deposits in Selwyn basin).

The Whitehorse trough has been identified as an immature, gas-prone basin in which potential source rocks, reservoirs and seals occur (National Energy Board, 2001). Potential for some 7.3 trillion cubic feet (Tcf) of gas, and possibly some oil, is estimated for the basin, with 2.6 to 4.8 Tcf in Yukon (K. Ozadetz, pers. comm., 2004), with the best potential being at the north end of the trough near Carmacks (Lowey and Long, 2006).

TRIP LOG

From downtown Whitehorse, drive south to the Alaska Highway via Robert Campbell Way (south access; km 1419.4). Turn left onto the Alaska Highway and drive south approximately 0.5 km to first road on the right.

km 1418.9 Lobird road (reset odometre) – turn right (south) onto Lobird road. Take the first left onto haul road (~0.2 km). Watch for truck traffic. Continue past the gravel pit to junction with Copper Haul road (~3 km); turn left, then right onto rough road. Park vehicle on the large shoulder of the road, below the pit (~0.6 km; just before hill; Fig. 4-4). Walk the remaining 0.2 km to open pit.

Figure 4-4. Detailed map of the route to the Arctic Chief west pit (Stop 4-1). Extracted from Google™ Earth, June, 2007.

Stop 4-1 – Whitehorse Copper Belt – Arctic Chief West pit

UTM 8v, 493605E, 6725078N, elev. 910 m

Private property. Call 867-633-3677 for permission to access this site.

The copper skarn occurrences of the 30 km -long Whitehorse Copper Belt were important in the development and growth of Whitehorse as a stable community. Copper was discovered near Whitehorse in 1897 by prospectors on their way to the Klondike Goldfields. High-grade ore was extracted intermittently by hand-mining, depending upon world copper prices, from the turn of the century until 1920. Mining resumed in the early 1960s and continued until 1982. During this latter period six deposits were mined, mostly by underground mining. The copper belt was then one of the mainstays of the Whitehorse economy. In 1970 road infrastructure was developed to transport the ore to a central mill facility near McCrae. Today, part of this road system has been adopted for the Trans-Canada Trail. Currently undeveloped resources of almost 3 million tonnes are distributed between five deposits. The mines of the Whitehorse Copper Belt are presently fully decommissioned. The tailings remain a potential source of magnetite for use in coal preparation plants, and also contain significant gold.

The copper skarn deposits occur along the contact between granodiorite of the mid-Cretaceous Whitehorse batholith and Upper Triassic limestone of the Lewes River Group (Hancock member of the Aksala formation). At Arctic Chief two separate pods of dark magnetite-serpentine skarn with brown and green garnet-diopside skarn occur on the west flank of a pendant of sedimentary rocks enclosed in the granodiorite (Fig. 4-5; Tenney, 1981). The ore consists of chalcopyrite and minor bornite; malachite staining is locally visible on the pit walls (Fig. 4-6).
The Arctic Chief deposit was amongst the richest with ~1.5% copper and the highest grades in gold (~1 g/t) and silver (~17 g/t) of the copper belt (Tenney, 1981; Watson, 1984). The west pit contains a lens of magnetite skarn at the contact between limestone and granodiorite. The dark and rusty skarn lens stands in contrast with the light grey marble. Folding of the layering in the marble is evident on the pit wall (Fig. 4-6). This area is popular for mineral collecting; garnet, diopside, pink calcite and yellow serpentine are abundant on the pit floor (Héon, 2004).

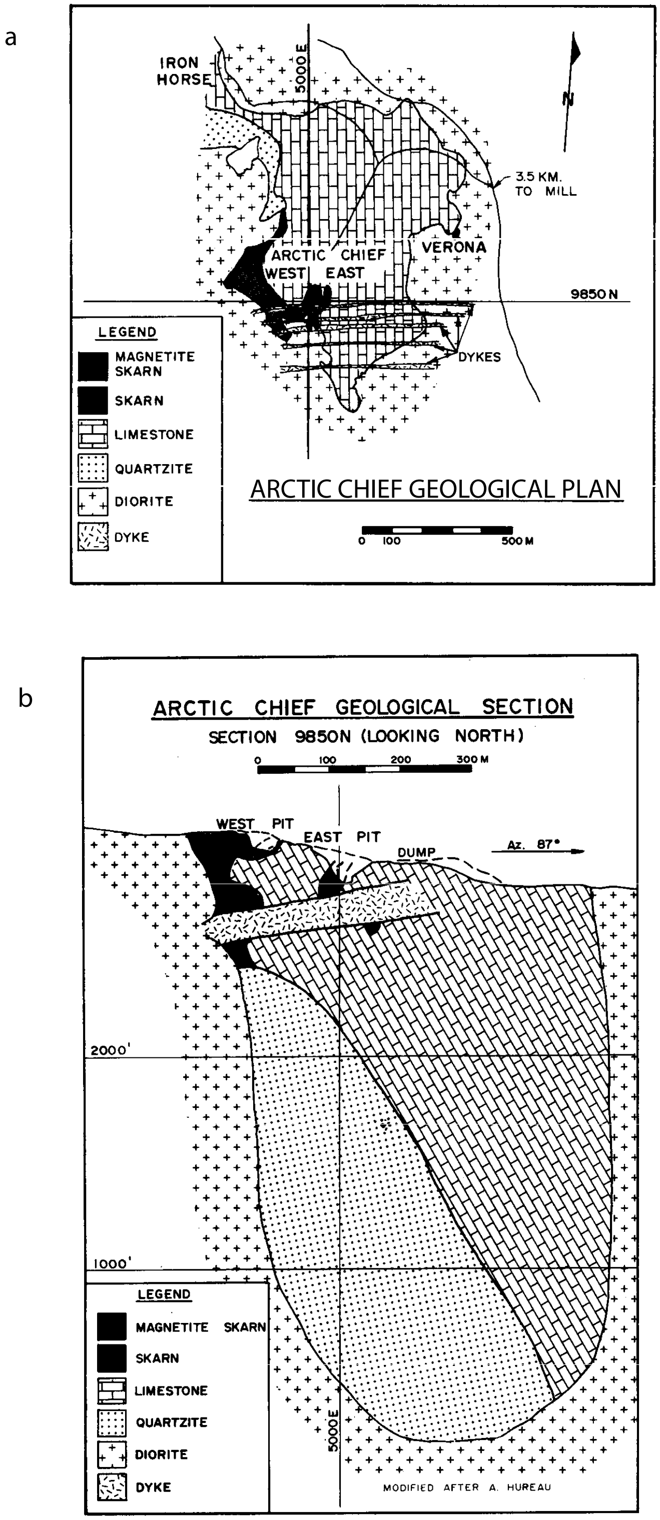


Figure 4-5. *Geological map **(a)** and cross section **(b)** of the Arctic Chief deposit in the Whitehorse Copper belt. After Tenney (1981).*

Figure 4-6. *Folding, faulting and malachite staining in the west wall of the Arctic Chief west pit.*

Vista at Stop 4-1

The edge of the Arctic Chief West pit provides a good overview of Whitehorse and the Yukon River valley. The City of Whitehorse lies north of this point and the southern shore of Lake Laberge marks the horizon. Across the valley to the northeast Canyon Mountain (locally known as Grey Mountain; Fig. 4-7) is underlain by Upper Norian limestone and immature clastic sedimentary rocks of the Aksala formation of the Lewes River Group. A band of Upper Cretaceous (?) mafic volcanic rocks locally overlies the Triassic rocks. Cap Mountain, the high ridge beyond Grey Mountain, is predominantly underlain by the mid-Cretaceous Mount Billings batholith. The mountains to the southeast are those surrounding Marsh Lake; they are underlain by rocks of the Cache Creek Terrane and the Jurassic Laberge Group.

Retrace the route to the Alaska Highway, via Lobird road. Turn right and drive south onto the Alaska Highway.

km 1402 Outcrops of resistant blocky, light grey weathering, medium to coarse-grained, hornblende-biotite granodiorite of the mid-Cretaceous Whitehorse batholith. The following description is from Johnston *et al.* (1993): "This northwest-trending batholith is 26 km long, covers approximately 100 km^2 and is zoned from dioritic xenolith margins to a quartz monzonite core. Marginal phases are rich in xenocrystic augite scavenged from the Lewes River Group country rocks, and hornblende commonly has pyroxene cores. Accessory minerals include magnetite, sphene, apatite and zircon. This location yielded concordant hornblende-biotite K-Ar ages of 109 Ma although a hornblende from the northern part of the batholith gave a 116 Ma age".

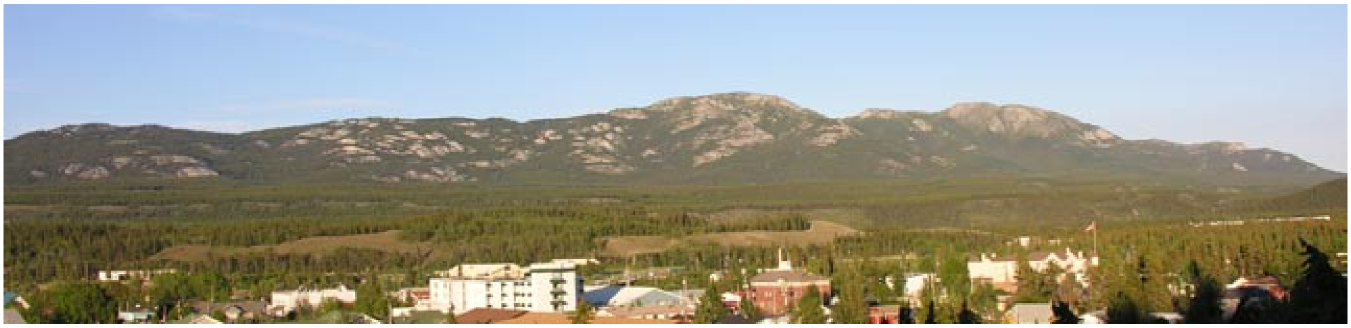


Figure 4-7. *Grey Mountain (also known as Canyon Mountain) in Whitehorse is primarily underlain by Norian limestone interbedded with volcaniclastic strata of the Aksala formation (Lewes River Group).*

km 1401.5	Carcross Corner – junction with South Klondike Highway to Carcross (pop. 437) and Skagway, Alaska (pop. 832). Continue south on Alaska Highway.
km 1393	Yukon River bridge.
km 1385.4	Outcrop of olivine basalt; Upper Cretaceous? (UTM Zone 8v, 525364E, 6714491N, elev. 665 m).
km 1382	Road cuts of Upper Cretaceous volcanic rocks, in slight curve (UTM Zone 8v, 527085E, 6713453N, elev. 678 m).
km 1375.4	Outcrop of Cretaceous diorite (UTM Zone 8v, 532951E, 6711928N, elev. 659 m).
km 1366	Scout Bay road, gravel road on the right (southwest side of highway) and sign for Lakeview Marina. Park on shoulder well off the road, approximately 200 m past Scout Bay road, across from outcrop on northeast side of the highway.

Stop 4-2 – Cache Creek ribbon chert, Marsh Lake

UTM 8v, 539355E, 6705661N, elev. 668 m

km 1365.8: This outcrop is composed of thin- to medium-bedded, dark grey chert of the Cache Creek Terrane (Nakina Formation?; Fig. 4-8).

The chert beds are generally 1-5 cm thick but can be as thick as 15 cm locally. The chert is interbedded with dark-grey to black argillite beds 0.5-3 cm thick. On weathered surfaces (top of the outcrop) both chert and argillite are whitish in colour. These rocks record hemipelagic sedimentation on the Cache Creek ocean floor.

This sequence is affected by tight southwest-verging folds and a weak axial-planar cleavage is developed in the chert beds. A metre-scale synform can be seen at the northwest end of the outcrop and smaller, decimetre-scale parasitic folds are present on top of the outcrop. A series of late brittle faults, with at least one down-to-the-west normal fault, cuts across all ductile structures.

Figure 4-8. *Ribbon chert of the Cache Creek Terrane near Marsh Lake (Stop 4-2).*

Stop 4-3 – Cache Creek basalt near Jakes Corner

UTM 8v, 551296E, 6691395N, elev. 780

km 1346.8: Outcrop of brown-weathering, dark green to black, medium-grained greenstone of the Cache Creek Terrane (Nakina Formation).

The rocks here are strongly altered and fractured (sheared), a common occurrence in the imbricated Cache Creek Terrane. On a regional scale these rocks are associated with fine-grained gabbro and serpentinite. The geochemical character of the Cache Creek Terrane includes a mixture of MORB, island arc tholeiite (IAT), calc-alkaline basalt (CAB), backarc basin basalt (BABB) and ocean-island basalt (OIB; English and Johnston, 2005; Tardy *et al.*, 2001; S.J. Piercey, pers. comm., 2006).

Approaching Jakes Corner the majestic white peak to the southeast is Mount White, made up of massive carbonate of the Pennsylvanian to Permian Horsefeed Formation (Cache Creek Terrane).

km 1341.3 Jakes Corner – turn right onto Tagish road. Continue west along this road to the junction with the South Klondike Highway at Carcross, ~54.6 km. The drive along the Tagish road is very scenic but is devoid of outcrops, at least until nearing the town of Carcross, where exposures of Laberge Group are present. The Tagish valley follows the trace of the Crag Lake fault, a south-side-down normal fault juxtaposing oceanic rocks of the Cache Creek Terrane, to the south, against forearc sedimentary rocks of the Whitehorse trough, to the north.

Turn left at the junction with South Klondike Highway. Drive south through village of Carcross, approximately 11.6 km to Bove Island lookout on left-hand side of the road. (Distances from this point on are measured along the South Klondike Highway and shown in italics (*km*), starting at km 95 at Bove Island). Field trip log resumes from this stop. The trip log between Bove Island and Carcross Corner is reproduced with little modifications from Johnston *et al.* (1993).

Stop 4-4 – Bove Island Lookout (km 95)

UTM 8v, 524601E, 6664145N, elev. 772 m

To the southeast across the Windy Arm of Tagish Lake are spectacularly displayed, nearly vertical, southwesterly-directed, imbricate-thrust-faulted panels of upper Paleozoic Cache Creek (Horsefeed Formation) limestone, dolostone, marble and altered basic volcanic rocks (Nakina Formation; Fig. 4-9). Abundant fusulinid collections suggest that they are dominantly Middle Pennsylvanian to Early Permian and 'young' to the northeast. This structural style is typical of the Cache Creek Terrane, although younger normal and strike-slip faulting typically disrupts and further complicates the geology.

Bove Island is composed of Middle Pennsylvanian carbonates intercalated with numerous thick sills/flows of altered mafic volcanic rocks. The carbonates contain an unusual Tethyan ammonite which is also found in west Texas and in the Canadian high Arctic.

The road cut at this stop is composed of a white, slightly silicified marble which is cut by networks of fractures which are seen as black lines. This carbonate is cut by several near vertical faults and is locally intensely brecciated; it also contains evidence of ductile deformation.

Outcrops between Bove Island and Carcross comprise various Cache Creek lithologies – greenstone, chert and carbonate.

km 101.6 Cache Creek basalt and cherty tuff? (UTM 8v, 519762E, 6667685N, elev. 746 m)

km 105.2 The bridge crossing Nares River, a short river between Tagish (north) and Bennett (south) lakes, is essentially the boundary between the Cache Creek and Stikine terranes. This contact typically corresponds to the Nahlin fault, but at this location is intruded by a Late Cretaceous granite.

km 105.3 Carcross Information Kiosk – The Nahlin thrust fault is cut by the Crag Lake fault at approximately this location.

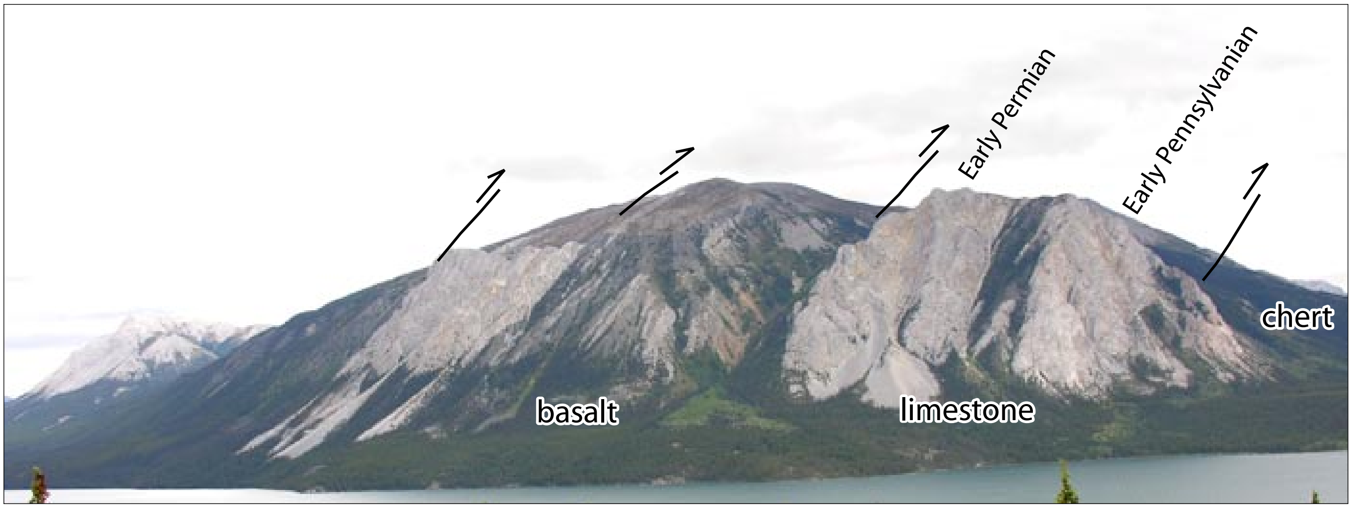


Figure 4-9. *Looking southeast, from Bove Island lookout, at southwest-verging thrust imbricate of Cache Creek limestone, chert and basalt.*

km 105.5 Carcross (pop. 437, elev. 655 m), known for its scenic and quaint beauty, was originally called Caribou Crossing. It was named for the large herds of migrating caribou that used to cross the Nares River. The site was originally a Tagish/ Tlingit hunting ground; they called this area Todeza'ane', meaning water going through narrows. More than 7000 boats, rafts, scows and other floating objects of dubious integrity floated past this point in a mad dash to the Klondike.

Carcross is also the site of the driving of the last spike of the White Pass and Yukon Route railway. Construction of this 110-mile-long (177 km), narrow gauge railway began on May 28, 1898. More than 3500 men worked for over 26 months to complete the line. Carcross was then established as a transportation hub during the early part of the 20th century, as the railway brought people and goods from Skagway and Whitehorse and exchanged them with the riverboats at the south ends of Tagish and Bennett lakes. The swing bridge allowed boat traffic to migrate between Tagish and Bennett lakes and the various mines, lumber mills and fish camps located on their shores.

km 106.5 Junction with Tagish road.

km 107.7 We drive by the 'Carcross Desert'. Affectionately known as the world's smallest desert, it is actually the windblown remains of a large proglacial lake which covered most of this region during the last ice retreat. The melting of the ice dam to the north lowered the lake level and exposed the glacial and lacustrine sands. Strong prevailing winds, generated in the ice-capped mountainous region to the south, whip along much of the 40 km length of Bennett Lake. They work the sands into large parabolic dunes that are still developing today and prevent the establishment of vegetation. Lodgepole pine (*Pinus contortus*) and a waxy leave ground cover called knikknik have had some success growing in this region.

Northwest of this location is Caribou Mountain (elev. 1950 m) which is composed of hornfelsed Lower and Middle Jurassic Laberge Group sedimentary rocks around two small (<1 km^2) stocks of Late Cretaceous biotite granite. East of this location is Nares Mountain (elev. 1780 m) which is composed of Cache Creek Group greenstone and microdiorite.

The highway between Carcross and Whitehorse parallels the axis of the Whitehorse trough, adjacent to its western margin. For most of the drive Upper Triassic Lewes River Group volcanic, volcaniclastic and carbonate rocks are exposed on the west side of the highway and basal conglomerate overlain by greywacke, sandstone and argillite of the Lower and Middle Jurassic Laberge Group outcrop on the east side of the road.

km 115.4 Spirit Lake Lodge – Outcrops of Upper Triassic Lewes River Group carbonate are present in this area.

Stop 4-5 – Emerald Lake: Laberge Group conglomerate

UTM 8v, 514091E, 6681287N, elev. 750 m

km 117.5: Pull over to the left in parking area overlooking Emerald Lake.

The wide range of colours which characterize Emerald Lake, and to a lesser extent Spirit Lake to the south, is the result of blue-green light waves reflecting off of the white lake bottom. The lake bottom sediments are post glacial lacustrine silts deposited as part of a much larger lake which covered this region for most of the period after the glacial maximum.

Since this lake has no drainages entering or exiting it, it has no incoming sediments or organics which typically cover lake bottoms. Despite its brilliant colouration, the low oxygen levels in the water prevent typical freshwater organisms from flourishing in the lake. Numerous lakes such as these occur to the west where large glacial remnants formed ice dams during the last glacial recession *ca.* 8000 years ago.

This location marks the contact between the upper Norian (Upper Triassic) Lewes River Group limestone, seen to the southwest of the lake, and the Lower Jurassic (Pliensbachian?) Laberge Group conglomerate, greywacke and arkosic sandstone which are exposed in a road cut on the east side of the highway (Fig. 4-10). The conglomerate is composed of approximately equal proportions of angular sedimentary clasts and well-rounded volcanic and granitic clasts. This road cut is cut by a north-trending, east-side -down normal fault with a small sinistral component. The hills above this exposure are composed of a >600 m thick sequence of openly-folded, north-striking, upper Lower and Middle Jurassic Laberge Group argillaceous rocks.

Vista to the west

The north-trending chain of mountains to the west of this location is known as Grey Ridge. The craggy ridges in the southern portion of this feature are composed of the Late Cretaceous biotite granodiorite of the Carcross pluton (68 Ma K-Ar biotite). The rest of the ridge is composed of folded Mesozoic Whitehorse trough strata (note the prominent upper Norian Lewes River Group limestone to the northwest) unconformably overlain by nearly flat-laying Upper Cretaceous (78-80 Ma) volcanic rocks of the Carmacks Group.

Vista to the south

Directly to the south in the distance is the Montana Mountain massif. This feature is composed of four rock assemblages. The westernmost part consists of the folded and hornfelsed Mesozoic Whitehorse trough sedimentary rocks. The craggy peaks in the centre are the mid-Cretaceous (95 Ma U-Pb zircon) andesites and breccias of the Montana Mountain volcanic complex (part of the Mount Nansen Group). The highest peak in the middle is Montana Mountain at 2200 m. The gentle slopes on the eastern portion are the upper Paleozoic sea-floor volcanic rocks and tectonized harzburgite of the Cache Creek Group. These rocks are in thrust contact (Nahlin fault) against the Whitehorse trough rocks underlying the Montana Mountain volcanics. The fourth package of rocks form the gentle plateau in the foreground of the massif. They are the mid- and Late Cretaceous granitic rocks of the Montana (107 Ma) and Carcross (*ca.* 70 Ma) plutons.

Figure 4-10. *Laberge Group conglomerate at Emerald Lake.*

km 124.8	Road cut into permafrost – this road cut has been a persistent problem since it was first cut in 1987. The thawing of permafrost in the loess causes the material to slump into the ditch and disrupt drainage. At this latitude permafrost is discontinuous and is typically found on north-facing slopes.
km 127.1	To Lewes Creek, deglaciation features. Looking ahead to the north from these points on the highway are good examples of hummocky kame and pothole lake terrane. Retreating glaciers deposited extensive sands and gravels which provide excellent sources of aggregate. Many road cuts in this region are through finely laminated periglacial lacustrine silts.

km 130.5-131.5 Carmacks Group – dark grey, massive, aphyric to plagioclase-pyroxene-phyric andesite and basaltic andesite flows form several roadside exposures belonging to the Wheaton River volcanics on the east side of the highway.

km 135.7-136.8 Laberge Group conglomerate – outcrops in this region are composed of Lower and Middle Jurassic Laberge Group, polymictic, cobble conglomerate. The best exposures are in the outcrops on either side of Rat Lake.

km 140 Annie Lake road. This turnoff to the west leads into the Wheaton and Watson rivers area. This region is historically and economically important for its large numbers of gold-bearing quartz veins. The Mount Skukum Gold mine operated there between 1986-1988. Exploration has resumed in recent years and is identifying new reserves. This road also gives access to the Tally Ho shear-Llewellyn fault zones, which define the western margin of Stikinia at this latitude.

km 1401.5 Carcross Corner, junction with the Alaska Highway. Turn left and drive towards Whitehorse. From this point kilometre postings are those along the Alaska Highway.

km 1416.1 Seasonal road to Miles Canyon (~1.2 km) and Schwatka Lake (~2.5 km).

Outcrops of columnar-jointed, Miocene-Pliocene Miles Canyon basalt are spectacularly exposed at Miles Canyon (UTM 8v, 498439E, 6725115N). These rocks once formed treacherous rapids which destroyed numerous boats and killed several stampeders who ventured on the Yukon River in crudely-built boats in an attempt to reach the Klondike gold fields in 1897 and 1898 (Fig. 4-11). These cataracts, Whitehorse Rapids and Miles Canyon, have since been tamed by the Whitehorse hydroelectric dam and the flooding of Schwatka Lake in 1954. During the Gold Rush era they prevented steam powered riverboats from ascending the Yukon River any further, thus requiring transfer of supplies destined for Dawson City from trains of the White Pass & Yukon route to steamboats, such as the S.S. Klondike preserved in downtown Whitehorse. The city of Whitehorse originated from this Gold Rush transportation hub.

Figure 4-11. *Columnar-jointed basalt at Miles Canyon ca. 1900. Photograph from the Anton Vogee collection, Yukon Archives, #146.*

The Miles Canyon basalt is part of a large province of late Tertiary to recent alkaline olivine basalts which forms isolated occurrences in the northwestern Canadian Cordillera; the northern Cordilleran volcanic province (Edwards and Russell, 1999). Exposures at Miles Canyon are part of a series of north-trending flows with a surface area of approximately 30 km^2 (Hart and Villeneuve, 1999). Other good exposures are also found nearby, approximately 1 km up the road to Mount Sima ski area, south of the Alaska Highway (McCrae area). At Miles Canyon the exposed succession consists of at least one ~20 m thick and two or three moderately thick (2–5 m) vesiculated flows that form the walls of the canyon constraining the Yukon River (Fig. 4-11). At the north end of the canyon the basal flows lie directly upon deeply weathered granite of the Whitehorse batholith. A sample of Miles Canyon basalt collected at the foot of the Whitehorse Dam yielded a whole rock ^{40}Ar/^{39}Ar date of 8.38 ± 0.12 Ma (Hart and Villeneuve, 1999).

km 1419.4 Junction with Robert Service way, south access to downtown Whitehorse. Continue west along the Alaska Highway.

km 1422.8 Beringia Centre, Transportation Museum and Whitehorse International Airport.

km 1425.3 Junction with Two-Mile Hill, north access to downtown Whitehorse. Outcrops between this point and the Kopper King commercial complex (km 1426.8) are hornblende granodiorite of the mid-Cretaceous Whitehorse batholith. The contact between the batholith and Upper Triassic carbonates of the Lewes River Group is crossed at McIntyre Creek (km 1428.0). Copper and gold-bearing skarn deposits of the Whitehorse Copper Belt (Yukon MINFILE 105D 053, Deklerk and Traynor, 2005) occur along this contact. The first discovery of these deposits was made 500 m west of this crossing by Jack McIntyre in 1898 while he was out hunting. The Kopper King deposit is accessible by a short road south of McIntyre Creek.

km 1428.2 Junction with Fish Lake road, leading to the Whitehorse Copper Belt and the first hydro-electric operations in the Whitehorse area. Electricity is still generated from two locations on this creek.

km 1429 Entering Rabbitsfoot Canyon. Exposures on either side of this natural canyon are of well-bedded carbonate of the Upper Triassic Lewes River Group (Hancock member of the Aksala formation). Rocks at the south end of the canyon are marble developed in the contact aureole of the Whitehorse batholith. Malachite staining is present in these rocks to the left (south) as we enter the canyon. The strata form a northwest-striking, moderately to steeply northeast-dipping sequence with some complex tight folds and southwest-verging thrust faults. Although generally northwest-trending, most Whitehorse trough strata typically form low amplitude open folds. Here the well-bedded carbonate likely acted as a detachment horizon.

km 1434.4 Outcrops from here to the North Klondike Highway junction are maroon and green lithic sandstone of the upper Lewes River Group (Aksala formation, Casca member). These rocks occur both above and below the carbonate unit (Hancock member). Strata along this section are dipping gently to the north.

km 1437.1 Junction with North Klondike Highway (Mayo road). Turn right on Mayo road. Distances from this point are along the Mayo road and shown in italics, starting at *km 191.8*.

km 195.6 Takhini River bridge. Leaving City of Whitehorse.

km 197.8 Junction with Takhini Hotspring road.

km 201.0 Exposure of Lewes River Group on east side of the road.

km 202.2 Turn left on Vista road. Drive up Vista road. Take the right fork approximately 3.8 km from the highway and continue all the way to the communication tower, another 2.5 km.

Stop 4-6 – Nordenskiold 'dacite' – Upper Laberge (Vista road)

UTM 8v, 487871E, 6753552N, elev. 1075 m

Exposures at the base of the communication tower are of the Nordenskiold 'dacite', a crystal-lithic tuff unit of dacitic composition interbedded with the clastic sedimentary rocks of the Laberge Group (Figs. 4-1, 4-12 (next page)). Here the Nordenskiold is dark blue grey in colour, resistant and generally massive, and weathers a mottled grey. Finer grained tuff horizons have rusty weathering. The Nordenskiold consists of a high density of medium- to coarse-grained (up to 2 mm) plagioclase and quartz crystals, with finer and fewer hornblende and biotite crystals, and locally abundant angular to subangular mudstone clasts (up to 10 cm; Fig. 4-13a; Hart, 1997; Fillmore, 2006). Bedding is locally defined by faint laminations in the tuff. To the south and across the access road rusty weathering, fine- to medium-grained crystal-lithic tuff is interbedded with argillite and lithic sandstone (Richthofen formation). Patches of brecciated tuff (< 2 cm) in a matrix of brown-weathering, recessive carbonate are likely gas escape structures (Fig. 4-13b). The Nordenskiold was likely emplaced as a series of subaqueous pyroclastic flows (Fillmore, 2006).

A sample of crystal-lithic tuff collected near this locality yielded a U-Pb zircon date of 184.1 ± 4.2 Ma (Hart, 1997), similar to ages of *ca.* 186 Ma reported from the Nordenskiold in northern B.C. (Johannson *et al.*, 1997). Ammonite collections from both stratigraphically below and above the horizon sampled for U-Pb dating also indicate an upper Pliensbachian (Lower Jurassic) age for this section (Hart, 1997). A comparative geochemical study of the Nordenskiold 'dacite' and nearby Early Jurassic plutonic suites to the west (Aishihik and Long Lake) suggests that granodiorite of the *ca.* 186 Ma Aishihik batholith (Johnston *et al.*, 1996a) is the most likely magmatic parent of the tuffaceous rocks of the Laberge Group (Fillmore, 2006).

Figure 4-13. (a) *Crystal lithic tuff of the Nordenskiold formation;* ***(b)*** *gas escape structure in tuff of the Nordenskiold formation.*

Vista

From this vantage point there is a clear view of Whitehorse, most notably the airport approximately 20 km to the south. Ridges to the east and northeast, across the Yukon River valley and Lake Laberge, are underlain primarily by volcanic and sedimentary rocks of the Upper Triassic Lewes River Group. The two high peaks east of Lake Laberge are Lime Peak (north peak – underlain by upper Norian limestone of the Hancock member, Lewes River Group) and Mt. Laurier (to the south – underlain by conglomerate of the Laberge Group). Lime Peak is the site of the study by Yarnell *et al.* (1999). The high ridge to the west is the Miners Range which is underlain by Eocene granite of the Flat Creek pluton.

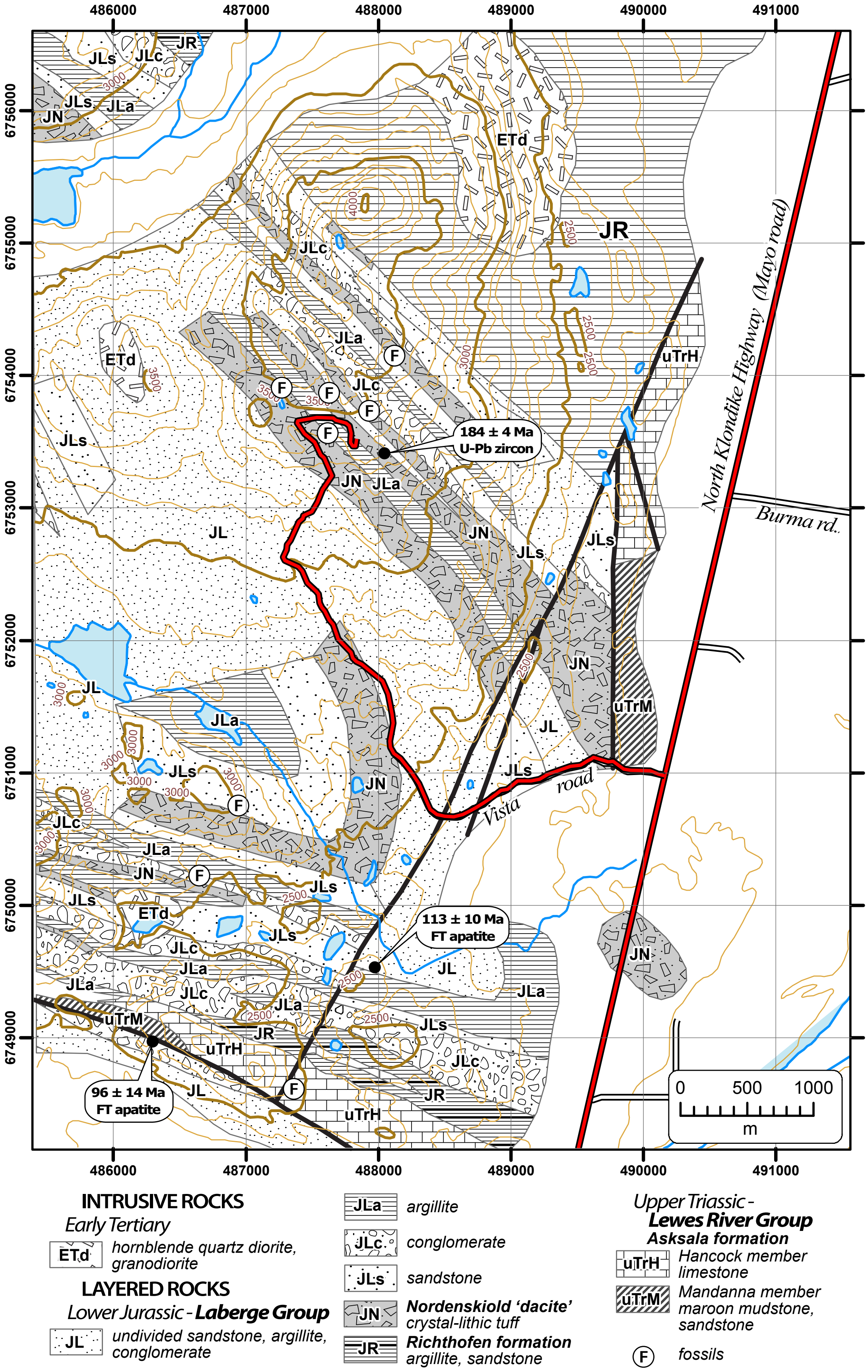


Figure 4-12. *Detailed geological map of the Vista road area (after Hart, 1997). FT – Fission track.*

Return to North Klondike Highway via Vista road. Turn left and drive north towards Lake Laberge.

km 204.4	Burma road.
km 212.0	Horse Creek. Exposures on the right are of sandstone of the Laberge Group (Richthofen formation) and contain an enigmatic ultramafic body that may be related to the Cache Creek Terrane (Hart, 1997).
km 224.6	Deep Creek; prepare to turn right in 400 m.
km 225.0	Turn right on Deep Creek road. Follow signs to Lake Laberge campground, going straight on main road at ~2.0 km, and veer left at 3.0 km. Park vehicles in large open area near covered picnic shelter approx. 200 m from entrance. Walk down the boat launch to exposures on the beach to the right.

Stop 4-7 – Richthofen formation – Lake Laberge campground

UTM 8v, 489370E, 6771381N, elev. 635 m

Exposures along the shore of Lake Laberge near the boat launch are thin-bedded (<10 cm), graded siltstone-sandstone and mudstone couplets of the Richthofen formation (Richthofen Island is approximately 1.6 km offshore from this point). These rocks have the characteristics of thin-bedded turbidites, with graded bedding and Bouma Tcde subdivisions (Lowey, 2004, 2005), as well as localized load and slump structures (Fig. 4-14a). Exposures to the south, between the campground and Deep Creek (~250 m), are of thick-bedded (~1 m) lithic sandstone. The sandstone is immature both compositionally and texturally, and is comprised of medium-grained, angular to sub-rounded feldspar, quartz, volcanic (and plutonic?) lithic clasts, as well as grains of augite and epidote. Concretions are abundant within the sandstone at this locality. Graded siltstone-mudstone beds ~10 cm-thick occur between the thick sandstone beds. Mudstone rip-up clasts up to 10 cm-long are present locally at the base of sandstone beds (Fig. 4-14b). Lenses of reworked crystal-lithic tuff similar to the Nordenskiold occur on top of the southernmost exposure.

A sample of lithic sandstone from the Richthofen formation at this locality was analysed for detrital zircons (M. Colpron and G.E. Gehrels, unpublished data, 2005). The majority of zircon grains yielded ages between 180 and 220 Ma, with a peak in the age distribution at *ca.* 197 Ma (78 of 100 grains), and a subordinate population of Paleozoic (Mississippian) grains with ages between 320 and 350 Ma (Fig. 4-15a). The Late Triassic to Early Jurassic ages match well those of plutons intruding Stikinia, Quesnellia and Yukon-Tanana Terrane around Whitehorse trough (Fig. 4-15c). These plutons likely represent the roots of the arc contributing sediments that filled the Whitehorse trough. Mississippian sources are also known in Stikinia (Takhini assemblage), Quesnellia (Boswell assemblage) and Yukon-Tanana Terrane (Simpson Range and Tatlmain plutonic suites; Piercey *et al.*, 2006). This detrital zircon signature clearly indicates local derivation for sandstone of the Richthofen formation.

The Richthofen formation ranges in age from Hettangian to Toarcian (Lower Jurassic; Fig. 4-1; Lowey, 2004). The correlative Inklin Formation in northern B.C. ranges from Sinemurian to Toarcian in age (Mihalynuk, 1999).

From Lake Laberge campground retrace the route to Whitehorse, first traveling south along Mayo road, then east (south according to highway signs) onto the Alaska Highway.

Figure 4-14. (a) *Graded sandstone-mudstone couplet of the Richthofen formation;* ***(b)*** *Mudstone intraclast at the base of a sandstone bed, Richthofen formation.*

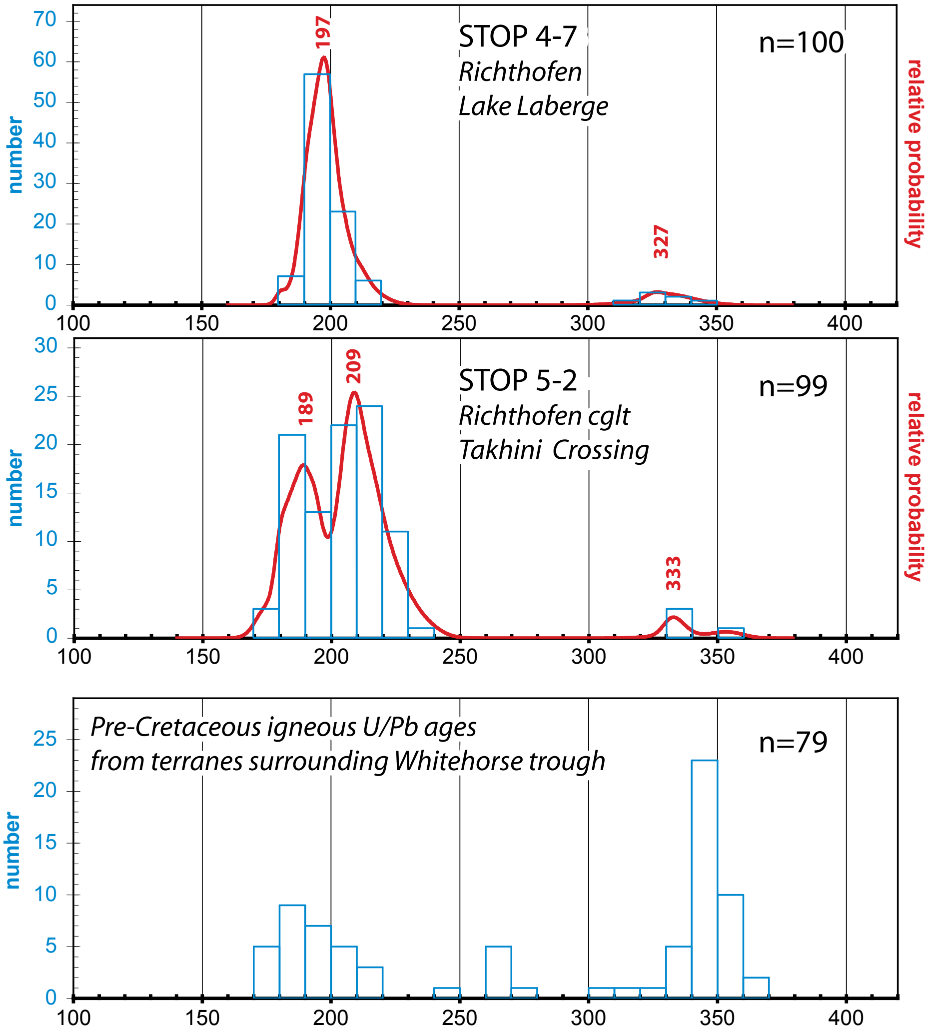


Figure 4-15. *Age probability plots for detrital zircons of the Laberge Group near Whitehorse (M. Colpron and G.E. Gehrels, unpublished data, 2005). A) Sandstone of the Richthofen formation (Stop 4-7); B) matrix from conglomerate of the Richthofen formation near Takhini Crossing (Stop 5-2); C) histogram of pre-Cretaceous U-Pb zircon crystallization ages from terranes surrounding the Whitehorse trough. The large number number of Mississippian grains is a sampling bias resulting from recent intensive studies of the Yukon-Tanana Terrane.*

DAY 5 – WHITEHORSE TO KLUANE LAKE

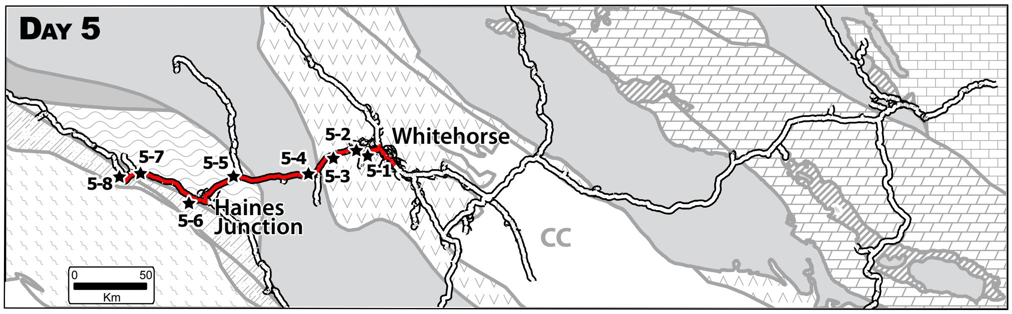
The last day of this geological transect of the northern Canadian Cordillera will take us from the rolling hills of the Intermontane terranes near Whitehorse, through progressively more rugged mountains underlain by the Coast Plutonic Complex, and finally to the foot of the majestic Kluane Ranges, underlain by the Insular terranes, between Haines Junction and Kluane Lake.

Coast Plutonic Complex

The Coast Plutonic Complex is a long, narrow and continuous zone of plutonic and lesser metamorphic rocks that extends the length of the Canadian Cordillera, from southern B.C. to Yukon (Woodsworth *et al.*, 1991). It straddles the boundary between the peri-Laurentian and Arctic realms (Fig. A1 inset), although most plutons lie near the western edge of the Intermontane terranes. The calc-akaline batholiths of the Coast Plutonic Complex vary in ages from Middle Jurassic to Eocene, with predominance of older plutons in southern B.C. and progressively younger ones in the northern Cordillera (Wheeler and McFeely, 1991). These rocks apparently become younger eastward across the belt from southeast Alaska to southern British Columbia, and may represent migration of the magmatic arc from west to east (van der Heyden, 1992).

The development of the Coast Plutonic Complex is attributed to accretion of the Insular terranes to the western margin of the Intermontane terranes, beginning in Middle Jurassic (or before) and continuing for at least 150 m.y. (Monger *et al.*, 1982; McClelland *et al.*, 1992; van der Heyden, 1992; Gehrels, 2001). Protracted deformation accompanied intrusion of the plutonic rocks, and several phases of deformation linked to orogen development have been tied to crustal thickening, extension and exhumation of middle and lower crustal rocks (Andronicos *et al.*, 1999; Crawford *et al.*, 1999; Rusmore *et al.*, 2005; Hollister and Andronicos, 2006). In southern Yukon, the large granitic batholiths east of Denali fault are mainly Eocene in age (Nisling Range suite; including the Ruby Range and Annie Ned batholiths; Plate 1). They form a nearly continuous belt that passes eastwards into smaller and older plutons, including the mid-Cretaceous Whitehorse plutonic suite.

Metamorphic septas within the Coast Plutonic Complex are generally of metasedimentary rocks assigned to the Yukon-Tanana Terrane (Nisling Terrane of Wheeler *et al.*, 1991; likely equivalent to the Snowcap assemblage of Colpron, 2006; Plate 1). Along its eastern edge, Eocene and older granitic plutons intrude the upper Paleozoic Takhini assemblage of Stikinia (see Stop 5-3; Hart, 1997). To the west, the Eocene Ruby Range batholith intrudes the enigmatic Kluane Schist, a belt of predominantly pelitic schist of unknown age and probably related to some degree to the Insular terranes (e.g., Eisbacher, 1976; Mezger *et al.*, 2001b; see Stop 5-5), and the Windy-McKinley Terrane of western Yukon, a composite terrane with elements of Yukon-Tanana, Chulitna and possibly parts of McKinley, Aurora Peak and Pingstone terranes of Alaska (Murphy, 2007).



The Insular terranes – Wrangellia, Alexander

The Insular terranes include Wrangellia and Alexander Terrane in the Canadian Cordillera, and the Peninsular Terrane of Alaska (Fig. A1). Amalgamation of the Insular terranes began in Pennsylvanian time, as indicated by a pluton intruding both Wrangellia and Alexander Terrane in southern Alaska (Gardner *et al.*, 1988). However, the Mesozoic histories of these terranes are quite different, particularly in Late Triassic time, and this dissimilarity remains one of the great enigmas of Cordilleran geology. Accretion of the Insular terranes to the Intermontane terranes likely began in Early to Middle Jurassic time (McClelland *et al.*, 1992; van der Heyden, 1992; Gehrels, 2001).

Wrangellia

Wrangellia is one of the most extensive terranes in the Canadian Cordillera (Fig. A1). It extends from Alaska to the northwest United States and includes sedimentary and volcanic rocks of middle Paleozoic to middle Mesozoic age. The hallmark of Wrangellia is a thick sequence of Upper Triassic flood basalts. However, the Paleozoic basement to these flood basalts differs along the length of the terrane, from Vancouver Island to southern Alaska. On Vancouver Island, Devonian arc rocks of the Sicker Group are overlain by Pennsylvanian to Permian deep-marine sedimentary and carbonate rocks of the Buttle Lake Group. Middle Triassic siliceous and calcareous shale unconformably overlie the Paleozoic rocks and underlie as much as 6000 m of dominantly subaqueous flood basalts of the Karmutsen Formation (Carlisle and Suzuki, 1974; Nixon and Orr, 2006). The sequence is capped by thick carbonates of the Late Triassic Quatsino Limestone and Lower Jurassic arc volcanic rocks of the Bonanza Group.

In southern Yukon, the oldest rocks in Wrangellia are Pennsylvanian to Permian volcanic and sedimentary rocks of the Skolai Group (Read and Monger, 1976). The Station Creek Formation is characterized by arc basalt and andesite intercalated with thick units of pyroclastic breccia and tuff. It is assigned a probable Pennsylvanian age based on scattered fossil occurrences in southern Alaska (Smith and MacKevett, 1970). The volcanic rocks grade into overlying turbidites, carbonates and conglomerates of the Hasen Creek Formation. Abundant fossils indicate a Permian age for the Hasen Creek Formation. Locally, a thin sequence of Middle Triassic mudstone, identified by *Daonella*-rich beds, unconformably overlies the Paleozoic rocks. In Yukon, the Wrangellia flood basalt is represented by the Upper Triassic Nikolai formation, which consists of highly vesicular and amygdaloidal, maroon and olive green basalts. The Nikolai basalts have been interpreted as dominantly subaerial based on the ubiquitous presence of amygdules, the amount of vesicles and the oxidized nature of much of the formation (Read and Monger, 1976; Hulbert, 1997). Rare pillows and pillow breccia near the base of the Nikolai suggests that at least part of the volcanic sequence was erupted in a subaqueous environment. These basalts have been interpreted as the product of oceanic plateau volcanism (Lassiter *et al.*, 1995). Thin carbonate layers at the top of the volcanic sequence have yielded upper Norian conodonts. Up to several hundred metres of carbonate with Norian microfossils, the Chitistone Limestone, overlie the Nikolai formation. The McCarthy Formation, a sequence of alternating calcareous and carbonaceous mudstones and siltstones, also of Norian age, rests conformably above the Chitistone Limestone. These siliciclastic rocks probably grade into overlying Jura-Cretaceous sedimentary rocks of the Tatamagouche succession and the Dezadeash Formation (Israel *et al.*, 2006).

In southern Yukon, large bodies of gabbro and ultramafic rocks intrude the Paleozoic section of Wrangellia. Collectively these intrusions have been included in the Kluane mafic-ultramafic suite and consist of gabbro, peridotite, dunite and pyroxenite characteristically forming semi-zoned bodies with sill-like geometry, but also locally cross-cutting units at high angles. A U-Pb zircon age of 232 ± 1 Ma from the Maple Creek gabbro, one of the Kluane intrusions, constrains the upper limit of the suite (Mortensen and Hulbert, 1991). Phlogopite from a peridotite body yielded a cooling age of *ca.* 228 Ma. Hulbert (1997) interpreted intrusions of the Kluane mafic-ultramafic suite as feeders to the extensive Nikolai flood basalt. Ni-Cu-PGE mineralization, including the Wellgreen deposit (43 Mt grading 0.36% Ni, 0.35% Cu, 0.51g/t Pt and 0.34 g/t Pd), is associated with these mafic-ultramafic intrusions. In southern Alaska, intrusion of a Cretaceous pluton in the Nikolai formation and Chitistone Limestone produced the Kennecott copper replacement deposit, one of the richest ever mined.

Alexander Terrane

The Alexander Terrane is a crustal fragment with a regionally variable character. In southeastern Alaska, it consists of Late Precambrian to early Paleozoic volcanic arc rocks without obvious continental underpinnings, and continentally derived sedimentary strata that contain Precambrian detrital zircon populations with peaks at 1.0-1.2 (dominant), 1.35-1.39, 1.48-1.53, 1.62-1.68, 1.73-1.77, 1.8-2.0, and 2.5-3.0 Ga, a pattern very unlike northwestern Laurentia, but showing strong Grenvillian influence and a possible connection with Baltica (Bazard *et al.*, 1995; Gehrels *et al.*, 1996; compare with dominant 1.8-2.0 Ga northwestern Laurentian peaks in Gehrels *et al.*, 1995 and Gehrels and Ross, 1998). In far northwestern B.C., southern Yukon and far eastern Alaska, the Alexander Terrane comprises lower Paleozoic continental shelf-platform strata, overlain by minor, late Paleozoic greenstone and associated volcaniclastic rocks (Dodds and Campbell, 1992; Mihalynuk *et al.*, 1993). Silurian stromatolite faunas from Alexander Terrane are very similar to those in the Ural Mountains, as well as those of the Farewell Terrane (Soja and Antoshkina, 1997). This evidence, combined with paleomagnetic and detrital zircon constraints, and northern Alexander platformal stratigraphy, corroborates an Arctic, continent-proximal setting of the terrane in mid-Paleozoic time. In northwestern B.C. and southeastern Alaska, the Alexander Terrane includes Norian basalts that are confined to a single rift zone that hosts the giant Windy Craggy Besshi-type volcanogenic massive sulphide (VMS) deposit in B.C. (BC MINFILE, 2007) and the Greens Creek VMS mine in Alaska. In southwestern Yukon, the Alexander Terrane is juxtaposed to Wrangellia along the Duke River fault (Plate 1; Fig. A9).

Dezadeash Formation

The Dezadeash Formation is a northwest-trending belt of mainly deep-marine siliciclastic strata, 10-40 km wide and 150 km long, bounded to the southwest by the Denali fault and flanked to the northeast by the Kluane Schist (Plate 1; Lowey, 2007). It was deposited in Late Jurassic to Early Cretaceous time, in a collapsing backarc basin between the Intermontane terranes, to the northeast, and the Insular terranes, to the southwest. It forms the central part of the Gravina-Nutzotin belt of Berg *et al.* (1972) that unconfomably overlies both Wrangellia and Alexander terranes.

The Dezadeash Formation comprises approximately 3000 m of thick- to thin-bedded sandstone/mudstone and sandstone/siltstone couplets (turbidite), massive sandstone and minor conglomerate, volcaniclastic rocks and limestone (Eisbacher, 1976; Lowey, 2007). The age of the Dezadeash Formation is constrained by pelecypods of Late Jurassic (Oxfordian) to Early Cretaceous age (Valanginian; Eisbacher, 1976). Paleocurrent indicators suggest a general eastward to northeastward paleoflow direction (Lowey, 2007). Detrital zircon from the broadly equivalent Gravina belt, in southeastern Alaska, indicate a mixture of sources in contemporaneous Jura-Cretaceous arc-related plutons and Paleozoic rocks of the Alexander Terrane, to the west, and in middle Paleozoic and older rocks of the Yukon-Tanana and related terranes, to the east (Kapp and Gehrels, 1998). The Dezadeash Formation may gradationally overlie Triassic rocks of the McCarthy Formation of Wrangellia, based on occurrences of Early Jurassic fossils in the Tatamagouche succession, a Triassic to Cretaceous sedimentary sequence that may be in part equivalent to the lower Dezadeash Formation (Read and Monger, 1976; Israel *et al.*, 2006). In southern Alaska, the Nutzotin Mountains sequence is possibly an equivalent of the Dezadeash Formation that was offset by ~370 km to the northwest along the dextral strike-slip Denali fault system in Eocene time (Eisbacher, 1976; Lowey, 1998).

TRIP LOG

From Whitehorse we will be traveling west (north) along the Alaska Highway, retracing part of the previous day travel to the junction with Mayo road (North Klondike Highway). The following trip log starts at Mayo road. Distances are measured along the Alaska Highway. The first three stops will further examine rocks of Stikinia and Whitehorse trough. We will then visit outcrops of the Coast Plutonic Complex, and the Insular terranes and their Jura-Cretaceous overlap sequence to the west.

km 1437.1	Junction with North Klondike Highway (Mayo road).
km 1441	Outcrop of upper Lewes River Group lithic sandstone (Aksala formation, Casca member).

Stop 5-1 – Mandanna member – Takhini Fire Hall

UTM 8v, 483090E, 6742250N, elev. 760 m

km 1443: Park on the shoulder to the right in front of outcrop and across from firehall; alternatively, continue another 200 m to large pullout area beside mailboxes and walk back to the outcrop.

These distinctive maroon outcrops are typical of the Mandanna member (Aksala formation) of the Lewes River Group (Figs. 4-1, 5-1a). They are younger or time-equivalent with the upper Norian carbonate unit (Hancock member), as seen on Grey Mountain in Whitehorse (Fig. 4-7). Here, the Mandanna is composed of laminated fine- to medium-grained sandstone and siltstone, and minor massive sandstone. Abundant bioturbation in the sand-mud facies indicate an intertidal environment (Long, 2005; Fig. 5-1b). The sandstone is generally immature and locally contains pebble- to cobble-sized mudstone intraclasts. According to Long (2005), the lower part of the outcrop represents intertidal mud flat deposits overlain by a tidal channel. Fine heavy-mineral laminae are locally well defined (Fig. 5-1c). Two green intermediate dykes (Eocene?) cut across Mandanna strata in this outcrop (Fig. 5-1a).

In some places, malachite can be seen on fracture surfaces. The many drill holes at the top of the outcrop are paleomagnetic sites that were sampled for the study by Wynne *et al.* (1998), which documented a regional Late Cretaceous remagnetization event. This stone is popular as decorative crush gravel around Whitehorse.

Resume westward travel along the Alaska Highway.

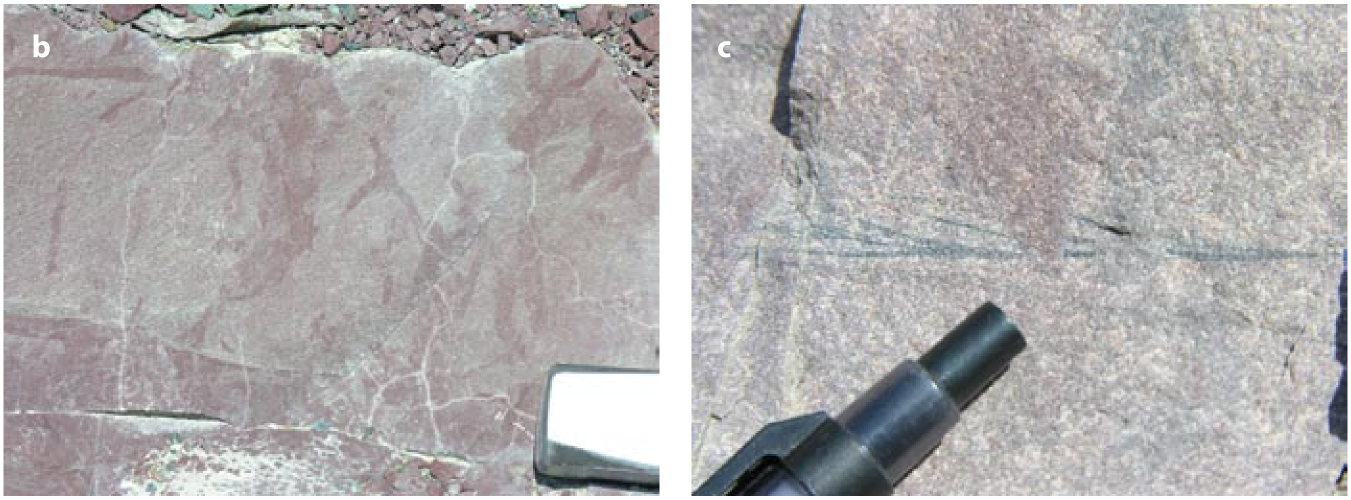


***Figure 5-1. (a)** Outcrop of Mandana member, Aksala formation, near Takhini fire hall; **(b)** trace fossils in the Mandana member; **(c)** heavy mineral cross-bedded laminations in the Mandana member.*

Stop 5-2 – Laberge Group conglomerate

UTM 8v, 476497E, 6746461N, elev. 720 m

km 1452: Spectacular outcrops of polymictic, clast-supported, boulder and cobble conglomerate of the lower and middle Laberge Group are present in the curve to the left. Park after you pass the curve, on the wide shoulder at the start of a straight stretch of highway. Additional exposures of this conglomerate can also be accessed via a short road on the left, another 400 m down the highway (private property).

The Laberge Group conglomerate in this exposure comprises a wide variety of clast types that are predominantly very well rounded and very large (Fig. 5-2). They include a variety of granitoids and hypabyssal rocks, typical of Laberge conglomerates, but also shale, limestone, lithic sandstone, augite-phyric basalt, and feldspar-phyric andesite (the latter being most apparent on top of the outcrop). Boulders are up to 1.3 m-wide, but most clasts are typically in the 30-40 cm range. The Laberge Group conglomerates in this region are interpreted as mass-flow deposits in a submarine fan environment (Dickie and Hein, 1995; Johannson *et al.*, 1997). The conglomerate was originally given formation status in the Laberge Group (Tempelman-Kluit, 1984; Hart, 1997), but recent studies of the Whitehorse trough show that it occurs at various stratigraphic levels within the Richthofen and Tanglefoot formations (Fig. 4-1; Lowey, 2004, 2005).

Granitic cobbles from this outcrop (and another one nearby) have yielded U-Pb zircon ages between 205 and 215 Ma (Hart *et al.*, 1995). They are likely sourced from the plutonic root of the Lewes River arc. A sample of the lithic sandstone matrix from this outcrop was collected for detrital zircon analysis (M. Colpron and G.E. Gehrels, unpublished data, 2005). As with the sandstone of the Richthofen formation (see Stop 4-7), the majority of zircons yielded ages between 180 and 230 Ma, with peaks in age probability at 189 and 209 Ma, and a small population of Mississippian grains (Fig. 4-15b). Again, these ages match well the local source terranes surrounding the Whitehorse trough (Fig. 4-15). Considering the apparent local provenance of these clasts, it is remarkable how well rounded they are (Fig. 5-2).

Figure 5-2. *Boulder conglomerate of the Laberge Group near Takhini Crossing (Stop 5-2).*

km 1469.3 Takhini River bridge.

km 1474.2 Vista to southwest – this location marks the approximate boundary between the Intermontane and the Coast physiographic belts. So far the topography has been marked by rounded hills, large broad valleys and composed of sedimentary and altered volcanic rocks. Looking towards the southwest, the mountains are composed dominantly of granite with erosional remnants of metamorphic rocks.

Outcrops to the right are part of the Annie Ned batholith. This granite, part of the Nisling Range suite, is a high-level, quartz-rich, miarolitic, coarse-grained biotite granite, with distinctive dipyramidal, smokey grey quartz-eyes. Locally this suite contains accessory fluorite. This suite forms huge batholiths in the Coast Plutonic Complex but only small, circular plutons and subaerial volcanic complexes in the Intermontane terranes to the east. The Annie Ned batholith is dated at 58 Ma.

Stop 5-3 – Takhini assemblage

UTM 8v, 452869E, 6745060N, elev. 737 m

km 1476.2: Turn left onto decommissioned gravel road. Park alongside the road, near the gravel berm. Walk down the road to the far end of the gravel pit, approximately 400 m.

These outcrops of metavolcanic rocks are part of the Takhini assemblage, the oldest unit of Stikinia in this region. The Takhini assemblage occurs within a northwest-trending belt (up to 12 km wide) of discontinuous exposures west of Whitehorse. These rocks were originally considered to be deformed equivalents to volcanic and volcano-sedimentary rocks of the Upper Triassic Lewes River Group (Povoas formation) because of their compositional similarities. However a U-Pb zircon date from felsic metavolcanic rocks within the Takhini assemblage yielded a concordant age of 322.9 ± 1.2 Ma, indicating an Upper Mississippian age for the unit (Hart, 1997). These rocks form the westernmost exposures of Stikinia adjacent to the Coast Plutonic Complex. For the most part, they occur as xenoliths within the Coast Plutonic Complex. To the east, the contact between the Takhini assemblage and the Lewes River Group is poorly defined but corresponds to a sharp decrease in the intensity of the deformation fabrics. Hart (1997) speculated an unconformity beneath the Upper Triassic strata.

Here the rock is predominantly strongly foliated, dark green chlorite-biotite schist, which is intruded by two sets of felsic dykes (Fig. 5-3). Locally, near the contact with surrounding intrusive rocks (western end of the outcrop), the Takhini assemblage is amphibolite with felsic layers ('sweats') along the dominant foliation (likely related to Jurassic intrusion?). Garnet occurs in the schist, in the woods on the upper part of the outcrop. The chlorite-biotite schist commonly contains metamorphic segregations and epidote veins that are typically aligned along the dominant foliation. The dominant foliation dips moderately to the south, and contains a mineral-elongation lineation (smears of chlorite and biotite) which plunges shallowly to moderately to the southwest. The dominant foliation is folded by a series of tight, northwest-trending and shallow-plunging folds that are similar in style to folds affecting Jurassic strata in the Whitehorse trough to the east (Hart, 1997). Left-lateral shear bands are locally developed within the foliation.

The Takhini assemblage is intruded by two sets of felsic dykes, both of which cut across the dominant foliation. The older dykes are likely related to the Early Jurassic (186 Ma) Little River batholith. They are weakly foliated and folded by the northwest-trending folds. The younger set of dykes is quartz-feldspar porphyry and cut across all ductile structures. They are probably related to the late Paleocene (58 Ma) Annie Ned pluton. A series of brittle faults postdate these dykes and locally result in offsets in the order of a few centimetres.

Greenstone of the Takhini assemblage have the geochemical characteristics of island arc tholeiites, and Nd and Hf isotopic compositions are indicative of derivation from juvenile, depleted mantle sources within an arc system (S.J. Piercey, pers. comm., 2006). Based on their age and stratigraphic position, rocks of the Takhini assemblage are likely correlative with the Stikine assemblage of northwestern B.C., a sequence of Devonian to Permian volcanic and carbonate rocks and related calc-alkaline intrusions (Logan *et al.*, 2000; Gunning *et al.*, 2006). These Paleozoic arc volcanic and sedimentary rocks are coeval, but of uncertain correlation, with similar rocks in Quesnellia and Yukon-Tanana Terrane.

Vista to the southeast is of the Ibex Valley.

Resume westward travel along Alaska Highway.

km 1482.9	Turnoff to rock quarry in Annie Ned granite (UTM 8v, 447283E, 6742475N, elev. 714 m). The quarry at the end of the short access road (200 m; note that access from the highway is very steep) displays characteristic outcrops of the 58 Ma Annie Ned granite batholith, part of the Coast Plutonic Complex. Here it is intruded by a north-trending mafic dyke regionally dated at 52 Ma.
km 1487.5	Lookout – Glacial Lake Champagne.
km 1490	Road to Kusawa Lake.

Figure 5-3. *Two phases of granitic dykes intrude chloritic schist of the Takhini assemblage (Stop 5-3).*

Stop 5-4 – Coast Plutonic Complex

UTM 8v, 438606E, 6736033N, elev. 711 m

km 1493.6: Outcrop over the next ~4 km display multiple intrusive phases of the Coast Plutonic Complex. Pull over on shoulder after the curve, near the end of this outcrop. The following description is mainly from Johnston *et al.* (1993).

This outcrop displays the relationships of one pluton intruding into another. The host rock is a medium-grained, mesocratic, slightly foliated, brown and black biotite-rich quartz diorite to diorite orthogneiss. This unit is crudely gneissic, with some very mafic phases and a northwest-striking fabric. It resembles part of the Kluane Schist exposed farther to the west (Stop 5-5). The country rock is intruded by a medium- to coarse-grained, leucocratic, biotite and hornblende granite with local, small pegmatitic dykes of white K-feldspar, brown biotite and grey to lavender quartz. This granite is a deeper phase of the late Paleocene (58 Ma) Annie Ned batholith. There are two phases of leucocratic granite in this outcrop: an older phase hosts the xenoliths, the younger one cuts across both xenoliths and their host. Angular xenoliths average 20 cm in size, but are locally up to 1.5 m wide (Fig. 5-4). All phases are cut by north-trending, shallowly west-dipping, mafic dykes that are probably related to 52 Ma dykes dated further to the east.

Figure 5-4. *Xenolithic granite of the Paleocene Annie Ned pluton (Stop 5-4).*

Resume westward travel along Alaska Highway.

Stop 5-5 – Kluane Schist at Otter Falls

UTM 8v, 387927E, 6748881N, elev. 650 m

km 1547.4: Turn into Otter Falls rest area adjacent to the restored Canyon Creek bridge.

Outcrops on the west side of the bridge and in the canyon of the Aishihik River are monotonous, brown-weathering, medium-grained, quartz-plagioclase-muscovite-biotite schist assigned to the Kluane Schist (Muller, 1967; or Kluane metamorphic assemblage, Erdmer, 1991; Mezger *et al.*, 2001b). The Kluane Schist is an enigmatic belt of metamorphic rocks of unknown age and origin. It is bounded to the southwest by flysch of the Jura-Cretaceous Dezadeash Formation along an inferred fault, and intruded by Eocene granodiorite of the Ruby Range batholith to the northeast. Regionally, the Kluane Schist consists of carbonaceous schist and garnetiferous paragneiss, with minor orthogneiss and isolated serpentinite bodies (Mezger *et al.*, 2001b). Eisbacher (1976) suggested that the Kluane Schist was a metamorphosed equivalent of the Dezadeash Formation (see Stop 5-5 below). Subsequent geochemical and isotopic studies, however, indicate a mixture of juvenile (Insular terranes?) and evolved (continental margin) sources for the Kluane Schist (Mezger *et al.*, 2001b).

In this outcrop, discontinuous lenses of quartz are common and locally define tight to isoclinal intrafolial folds. A penetrative, steeply southeast-dipping foliation is well-developed. A quartz-rodding lineation along the foliation plane is parallel to isoclinal fold hinges.

Regionally, metamorphic mineral assemblages from the Kluane Schist record an early, syntectonic Late Cretaceous medium pressure-temperature event (*ca.* 7 kbar, 500°C) followed by a lower pressure event related to emplacement of the Eocene Ruby Range batholith (Mezger *et al.*, 2001a). The schist is intruded by micaceous pegmatite and leucocratic two-mica granite.

Continue westward travel along the Alaska Highway.

km 1578.5	Haines Junction – turn right and continue driving west along the Alaska Highway. The Kluane Ranges, on the left, from Haines Junction to Kluane Lake are primarily underlain by sedimentary strata of the Jura-Cretaceous Dezadeash Formation, which overlaps Wrangellia and Alexander Terrane.

Stop 5-6 – Dezadeash Formation (Bear Creek)

UTM 8v, 353293E, 6740713N, elev. 605 m

km 1589.1: Turn left onto the Bear Creek road. Drive south past turn-around point (~0.8 km) onto dirt road. Cross small creek at ~1.5 km. Park vehicle near the outcrop in opening in the road at ~2.7 km.

These outcrops are of weakly to moderately metamorphosed, locally strongly sheared, sandstone/siltstone turbidites of the Jura-Cretaceous Dezadeash Formation. They occur near the structural base of the formation, where it is faulted against Paleozoic or Triassic metabasalt and metasedimentary rocks farther down the Alsek valley (Eisbacher, 1976). The mountains to the south are composed entirely of Dezadeash Formation but of generally lower metamorphic grade.

Return to Alaska Highway and resume travel to the west.

km 1617.6	Outcrop of Eocene granite. The Denali fault is located in the valley to the southwest.

Stop 5-7 – Kluane Lake overlook

UTM 7v, 644934E, 6767722N, elev. 920 m

km 1634.4: Turn into parking lot near overlook platform with view of Kluane Lake.

This location provides a unique vantage point to see the main geological features of the Insular terranes. Kluane Lake and this observation point are located just north of the trace of the Denali fault. Post-Early Cretaceous movement on the Denali fault is estimated at 350-400 km of right lateral offset (Plafker *et al.*, 1989b; Lowey, 1998). The Denali fault is presently active with recent slip rates on the Alaska portion of the fault measured at between 8.4-9.4 mm/yr (Matmon *et al.*, 2006).

To the north, the Ruby Ranges are underlain by rocks of the Kluane Schist and Eocene intrusions of the Ruby Range batholith. Looking west, the frontal Kluane Ranges are underlain by rocks of Wrangellia. The lower slopes consist primarily of northeast-dipping basaltic strata of the Upper Triassic Nikolai Group underlain by Paleozoic sedimentary rocks of the Skolai Group (Fig. 5-5). The prominent valley that intersects the Slims River is underlain by the Duke River fault, which separates Wrangellia from carbonates and siliciclastic rocks of the Alexander Terrane. The deformation history of this fault is dominantly one of post-Early Cretaceous strike-slip, however, post-Pliocene thrusting is indicated by folding of the Neogene Wrangell lavas where they overly the trace of the Duke River fault. This fault is still active today with dozens of small earthquakes occurring every year. It continues into Alaska where it becomes the Totschunda fault, an active splay of the main Denali structure. The obvious orange-weathering strip of rock on the north side of Sheep Mountain is the trace of the Bocks Creek fault, a Denali-parallel structure internal to Wrangellia.

Continue westward travel along the Alaska Highway.

Stop 5-8 – Nikolai basalt (Wrangellia)

UTM 7v, 634812E, 6768234N, elev. 810 m

km 1650.6: Turn left into the parking area at the start of the Soldier Summit trail. (Note at time of writing [July 2007], this portion of the Alaska Highway was undergoing major reconstruction. Access to this stop may vary in future).

The large blocks in this rock slide are of typical basalts of the Nikolai formation, which underlie the dip-slope above. Maroon to olive green basalt of the Nikolai formation are locally plagioclase- and pyroxene-phyric, but are more commonly massive and highly vesicular and amygdaloidal. Amygdules are filled by chlorite, quartz, epidote and zeolites. These basalts are Upper Triassic in age; they are the hallmark of Wrangellia, as they characterize the terrane from southern Vancouver Island to southern Alaska. Current models suggest that they are the result of a mantle plume that formed under the Paleozoic strata of Wrangellia (Hulbert, 1997). Note that part of the island on the right is made up of slide debris.

This stop marks the end of this transect of the northern Canadian Cordillera. From here, we drive back to Whitehorse, ~250 km.

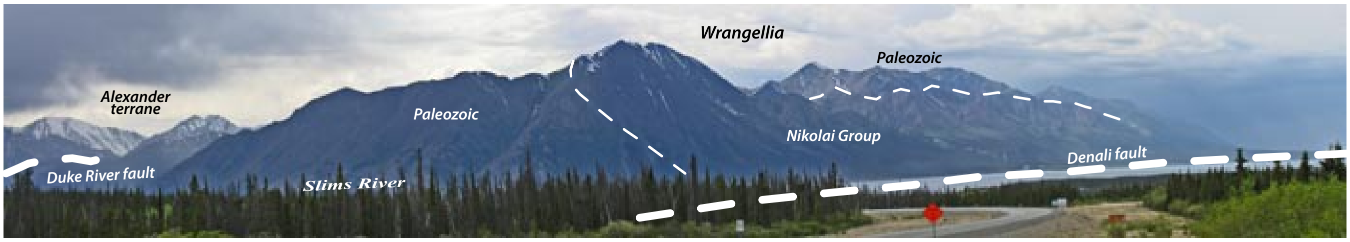


Figure 5-5. *Looking west at the Kluane Ranges from the Kluane Lake overlook (Stop 5-7). Slopes in the foreground are underlain by Triassic basalt of the Nikolai Group, which rest unconformably on Paleozoic strata of Wrangellia. Distant peaks to the left are underlain by the Alexander Terrane.*

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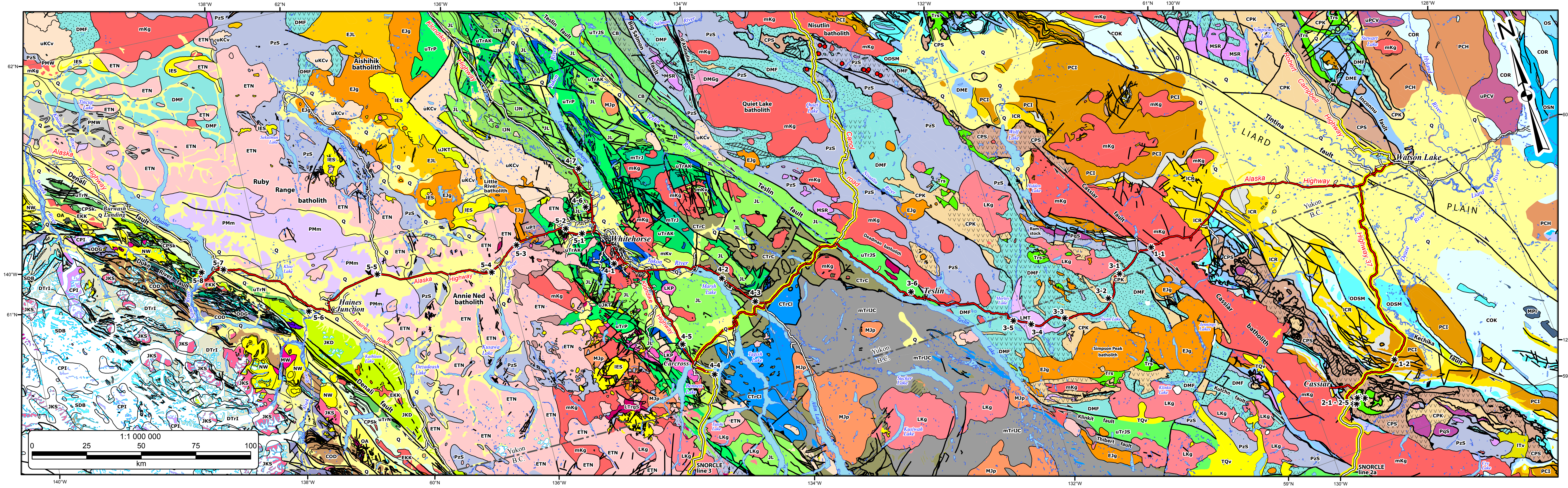

Plate 1

Bedrock geology along the Alaska Highway transect (1:1 000 000 scale)

compiled by
Maurice Colpron

after Gordey and Makepeace (1999),
Massey et al. (2005) and Colpron (2006)

This map accompanies:
Arizona Geological Society
Ores and Orogenesis Symposium
September 2007
Field Trip No. 15

Yukon Geological Survey
Energy, Mines and Resources
Government of Yukon
Open File 2007-3

A transect through the accreted terranes of the northern Canadian Cordillera:
From Cassiar, B.C. to Kluane Lake, Yukon

Maurice Colpron[1], JoAnne Nelson[2] and Steve Israel[1]
[1] Yukon Geological Survey; [2] B.C. Geological Survey

Quaternary

Q unconsolidated sediments

Post-accretionary units of SW Yukon

Miocene-Pliocene (and younger)

NW *Wrangell Lavas*: mafic to felsic volcanic rocks

Middle to Late Miocene

MW *Wrangell suite*: granodiorite, diorite, gabbro

Oligocene

OT *Tkope suite*: granite, granodiorite

Paleocene-Oligocene

OA *Amphitheatre Formation*: sandstone, conglomerate

Late Early Cretaceous

EKK *Kluane Ranges suite*: granodiorite, diorite

EKP *Pyroxenite Creek ultramafic*: gabbro, pyroxenite

Late Jurassic-Early Cretaceous

JKS *St. Elias suite*: granodiorite, tonalite

Chugach Terrane

Cretaceous and older(?)

KV *Valdez Group*: argillite, lithic sandstone

Insular overlap sequence

Upper Jurassic-Lower Cretaceous

JKD *Dezadeash Formation*: lithic sandstone, siltstone, argillite

Wrangellia

Upper Triassic

uTrC *Chitistone and McCarthy fms*: limestone, argillite

uTrN *Nikolai formation*: basalt, andesite

Pennsylvanian to Permian

CPSk *Skolai Group*: arc volcanic and sedimentary rocks

Late Triassic

PTrK *Kluane ultramafic suite*: gabbro, peridotite, dunite

Alexander Terrane

Late Pennsylvanian-Early Permian

CPI *Icefield Ranges suite*: quartz monzodiorite, diorite

Paleozoic (?)

PSC *Steele Creek suite*: gabbro

Devonian to Upper Triassic

DTrI *Icefield group*: pelite, carbonate and volcanic rocks

Silurian-Devonian

SDB *Bullion Formation*: limestone, argillite

Lower Ordovician-Devonian

ODG *Goatherd assemblage*: mudstone, siltstone, limestone

Cambrian-Ordovician

COD *Donjek assemblage*: lithic sandstone, greenstone

Windy-McKinley Terrane

Devonian-Cretaceous?

PMW ultramafic rocks, greenstone, chert, carbonate

Coast Plutonic Complex

Paleocene-Eocene

ETN *Nisling Range suite:* granite, granodiorite, diorite

Paleozoic?-Mesozoic?

PMm *Kluane Schist:* carbonaceous schist, paragneiss, serpentinite

Post-accretionary units of the Intermontane terranes and Ancestral North America

Miocene-recent

TQv *Miles Canyon, Rancheria basalts:* basalt

Lower Eocene

IES *Skukum Group:* rhyolite flows and breccia

Lower Eocene

ITv *Ross group:* rhyolite, basalt, clastic rocks

Upper Cretaceous

uKCv *Carmacks Group:* basalt, andesite, dacite

Late Cretaceous-Tertiary

LKP *Prospector Mountain suite:* quartz monzonite, granodiorite, granite

Late Cretaceous

LKg *Seagull suite:* granite

Mid-Cretaceous

mKv *Mount Nansen Group:* andesite, dacite, rhyolite

mKg *Cassiar, Whitehorse suites:* granite, quartz monzonite, granodiorite

Middle Jurassic

MJp *Fourth of July, Teslin Crossing suites:* monzonite, granite, syenite

Whitehorse trough

Upper Jurassic-Lower Cretaceous

uJKT *Tantalus Formation:* conglomerate, sandstone, shale, coal

Lower to Middle Jurassic

JL *Laberge Group:* lithic sandstone, shale, conglomerate

Lower Jurassic

lJN *Nordenskiold formation:* dacitic tuff

Intrusive suites of Stikinia and Quesnellia

Early Jurassic

EJL *Long Lake suite:* quartz monzonite, granite, aplite

EJg *Aishihik suite:* granodiorite, diorite, monzodiorite

Stikinia

Late Triassic

LTrgS *Stikine suite:* gabbro, quartz diorite, diorite, granodiorite

Upper Triassic

uTrAKc *Hancock member, Aksala formation:* limestone

uTrAK *Aksala formation:* lithic sandstone, conglomerate, shale

uTrP *Povoas formation:* augite- or feldspar-phyric andesitic basalt

Middle Triassic

mTrJ *Joe Mountain Formation:* basalt, gabbro

Upper Paleozoic

uPT *Takhini assemblage:* greenstone, metawacke, marble

Cache Creek Terrane

Permian-Jurassic

mTrIJC *Kedahda Formation:* chert, shale, siltstone, lithic sandstone

Pennsylvanian-Permian

CTrCl *Horsefeed Formation:* limestone

Mississippian-Pennsylvanian

CTrC *Nakina Formation:* basalt, chert, serpentinite

Quesnellia

Upper Triassic-Lower Jurassic

uTrJS *Shonektaw Formation:* augite-phyric volcanic/volcaniclastic rocks

Upper Devonian-Pennsylvanian

CB *Boswell assemblage:* greenstone, marble, siltstone, conglomerate

Synorogenic clastic rocks related to Yukon-Tanana, Slide Mountain and Ancestral North America

Middle to Upper Triassic

Trs calcareous siltstone, shale, sandstone, limestone, conglomerate

Middle to Upper Permian

PSL *Simpson Lake Group:* conglomerate, sandstone, siltstone, shale

Yukon-Tanana Terrane

Late Permian

PqS *Sulphur Creek suite:* augen granite, metaporphyry

Middle Mississippian-Lower Permian

CPK *Klinkit assemblage:* metavolcaniclastic/volcanic rocks, marble, conglomerate

Middle Mississippian

LMT *Tatlmain suite:* granite, granodiorite, quartz diorite

Upper Devonian-Lower Mississippian

DMF *Finlayson assemblage:* metavolcanic rocks, carbonaceous pelite

Early Mississippian

MSR *Simpson Range suite:* foliated granodiorite, diorite, tonalite

Late Devonian-Early Mississippian

DMGg *Grass Lakes suite:* augen granite, monzonite, granodiorite

Upper Devonian and older

PzS *Snowcap assemblage:* quartzite, psammite, pelite, marble, amphibolite

Slide Mountain Terrane

Upper Devonian-Permian

CPS *Slide Mountain assemblage:* basalt, chert, argillite, gabbro, serpentinite

Ancestral North America (including Cassiar platform)

Lower Mississippian

MPr *Prophet Formation:* limestone, shale

Upper Devonian-Lower Mississippian

DME *Earn Group:* dark grey shale, chert-quartz grit/conglomerate

Ordovician-Devonian

ODSM *Sandpile, McDame, Askin groups:* dolostone, limestone, sandstone

ODR *Road River Group:* black shale, chert

Upper Ordovician-Silurian

OSN *Nonda Formation:* dolostone

Middle Ordovician

OS *Sunblood Formation:* dolostone, limestone

Upper Cambrian-Ordovician

COK/COR *Kechika Gp./Rabbitkettle Fm.:* calcareous phyllite, silty limestone

Lower Cambrian

ICG *Gull Lake Formation:* shale, siltstone, mudstone, greenstone

ICR/ICS *Rosella, Sekwi formations:* archeocyathid limestone

ICB *Boya Formation:* quartz arenite, argillite, siltstone

Neoproterozoic-Lower Cambrian

uPCV *Vampire Formation:* sandstone, siltstone, argillite

PCB *Backbone Ranges Formation:* sandstone, siltstone, argillite

PCH *Hyland Group:* sandstone, grit, slate, limestone, greenstone

PCI *Ingenika Group:* sandstone, shale, limestone

Legend symbols

plutonic rocks
layered rocks
volcanic facies
basinal facies
(Finlayson assemblage, YTT)
gabbro, serpentinite

Map symbols

geological contact
thrust fault
dextral strike-slip fault
undefined fault
● ● eclogite (Mississippian, Permian)
✱ field trip stop
road
transect route
SNORCLE seismic transect
ice

1:250 000-scale topographic
base data produced by
CENTRE FOR TOPOGRAPHIC
INFORMATION,
NATURAL RESOURCES CANADA

Albers Equal-Area Conic Projection
Standard Parallel 61°40'N and 68°N
Central Meridian 132°30'W
North American Datum 1983