Atlin TGI: Geological highlights and mineralization, Nakina Transect

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Abstract

Geological field studies under the aegis of the Targeted Geoscience Initiative have shown that the Nakina transect area contains geological environments that are prospective for a variety of deposit types as well as hydrocarbons. This work has also begun to unravel the structural complexities of the Cache Creek complex and it has forever changed the way that we view its paleotectonic origins.

Of key importance has been the discovery of submarine felsic volcanic rocks of Late Permian to Middle Triassic age; coeval with those hosting volcanogenic massive sulphide accumulations at Kutcho Creek. Volcanic quartz in detrital sediments from a variety of places across the map area points to widespread felsic volcanism within or on the margins of the ancient Cache Creek ocean basin. Indeed, most of the volcanic rocks within the northern Cache Creek terrane are now known to have an intra-oceanic arc affinity. The possibility that Cache Creek felsic or mafic volcanic successions might be associated with mineralized exhalites is demonstrated by vigorous fossil hydrothermal system that comprises the Thunder Alley occurrence. Thermal maturation of Cache Creek strata northeast of Thunder Alley may be related to the hydrothermal system responsible for the exhalite. Our follow-up mapping and stream sediment sampling around Thunder Alley occurrence is expected. More prospecting and geochemical evaluation of the area is required to properly assess the potential for mineralization in the area.

The origin of massive copper sulphide at the new Joss'alun discovery is uncertain, but sulphide lenses appear to be at least partly concordant, and possibly syngenetic with submarine volcanic rocks (see Joss'alun Discovery Update).

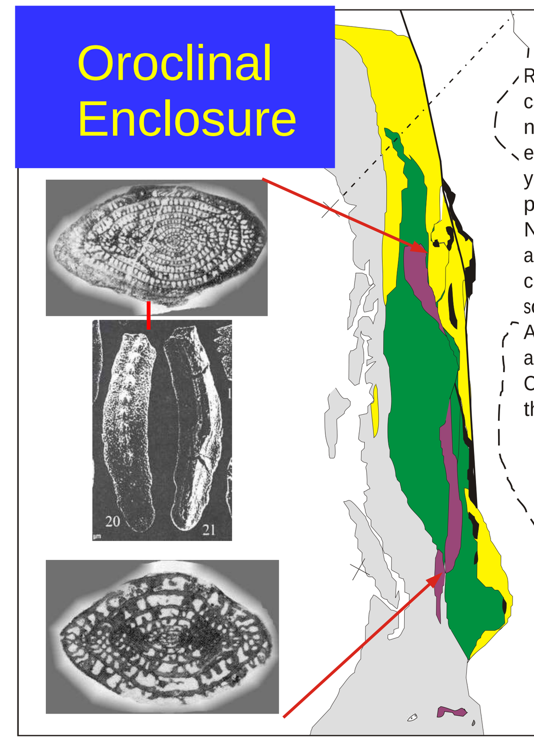
Structural and stratigraphic advances in our understanding of the Nakina transect have benefitted from the rapid expansion of paleontological and isotopic age data. Production of 1:50 000 scale maps will be aided by ~140 new radiolarian collections; & ~65 new collections of Carboniferous to Permian fusulinaceans.

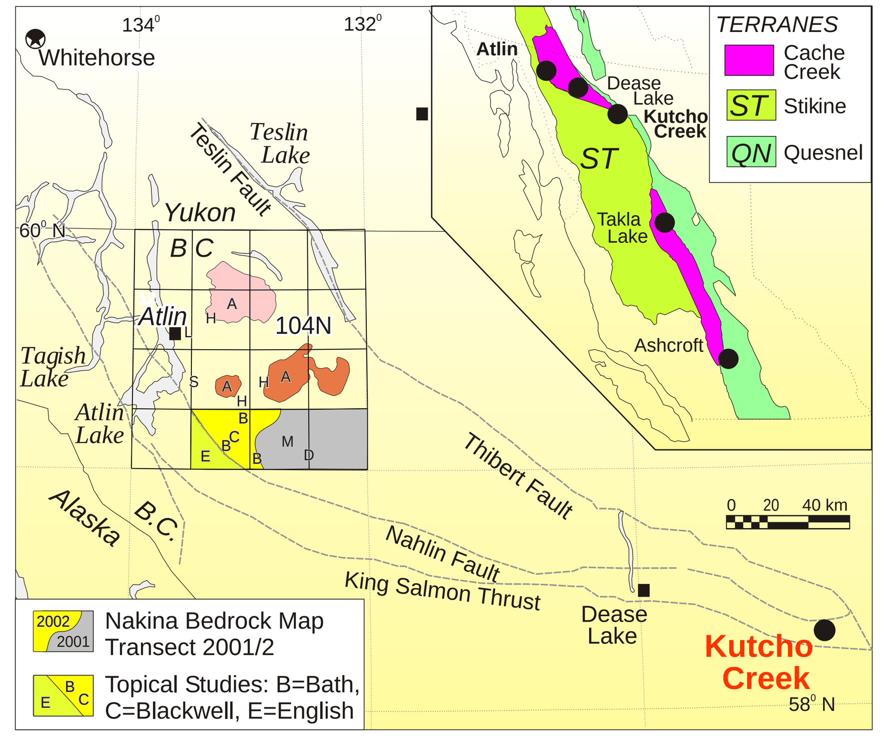
Introduction

We report on the second and final year of geological mapping in the Nakina area, conducted under the Atlin Targeted Geoscience Initiative (TGI). Principal aims of the TGI are to create a legacy of high quality geoscience data that will stimulate geological resource exploration, and regional economic development (see Atlin TGI - Part I). Geological maps produced as part of the project portray base-line data required for informed land-use decisions or other studies where bedrock geology is a consideration.

Since 1898, when Fritz Miller and his partner Kenneth McLaren discovered rich placers on Pine Creek (Billsland, 1952), the economic well-being of the Atlin region has been largely tied to the price of gold. Yet, good potential for economic diversification in the mining sector exists because the Atlin area contains a diversity of prospective geological environments. Results of geological mapping in the Nakina area in 2001 (Mihalynuk et al., 2002) affirmed such potential. Results included the discovery of submarine felsic volcanic rocks and extensive hydrothermal deposits of exhalative magnetite; deposits that are common in mining camps where copper, lead and zinc are produced from volcanogenic massive sulphide accumulations. A key host rock in many of these camps is submarine dacite or rhyolite. Felsic volcanic rocks, and the sediments derived from them, have long been considered uncharacteristic of the Cache Creek rocks in the Atlin area. Our mapping showed that clastic strata include felsic volcanic rocks are relatively common. Further evidence for prospectivity of Cache Creek rocks comes from discoveries during 2002. Mineralization includes massive sulphide lenses in ultramafic and volcanic rocks at the new Joss'alun discovery (see Joss'alun Discovery Update), massive pyrrhotite that is probably related to Eocene skarn, a broad zone of quartz-sericite schist in a side canyon of the Nakina River, and industrial mineral occurrences of sepiolite.

Tectonic Setting & Location

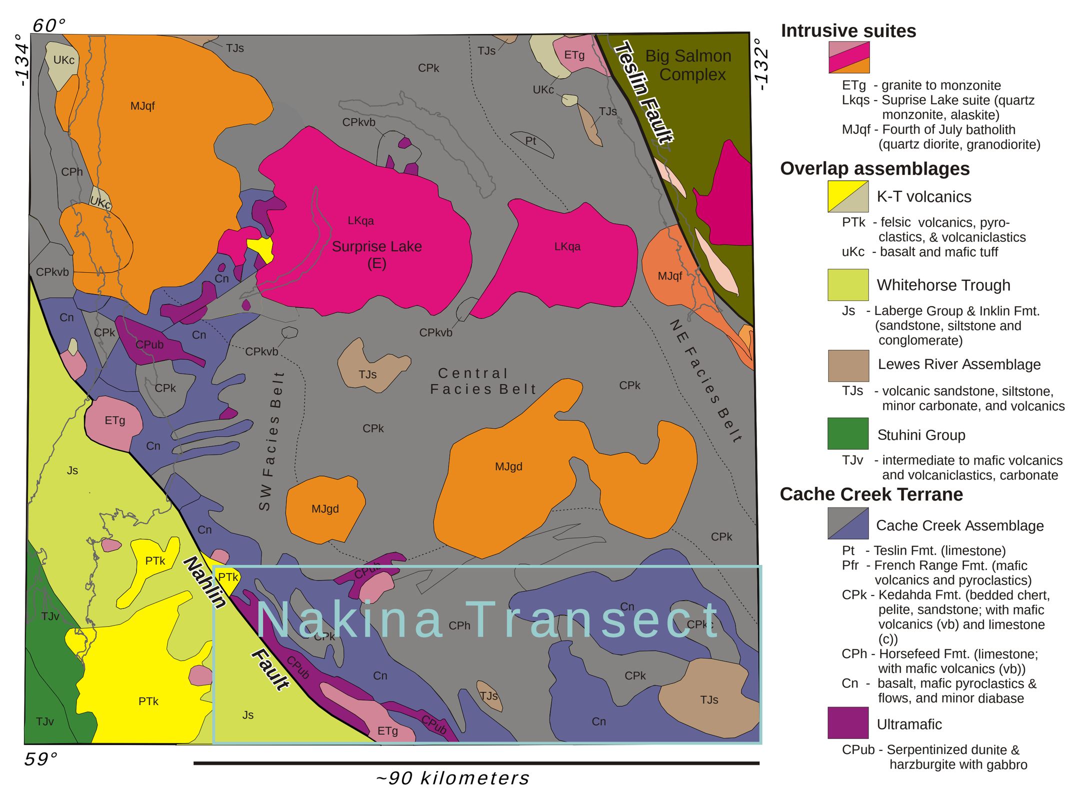




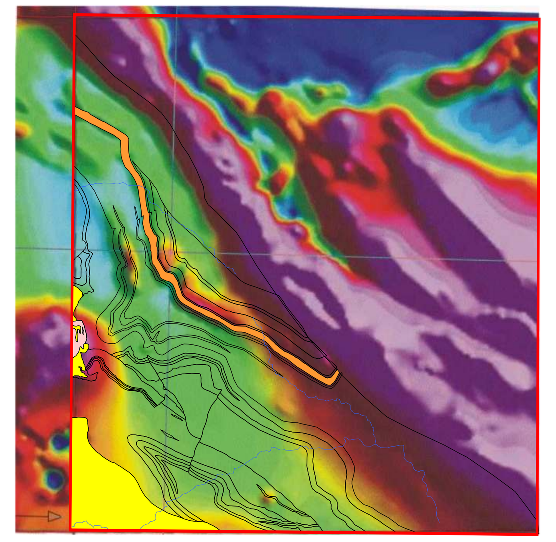
Permian and Triassic fossils within the Cache Creek Terrane, like the spiral fusulinid and goniodont jaw plate shown above (from: Monger, 1975; Orchard et al., 2000), occur nowhere else in North America, but are the dominant species in the Tethyan realm of central Asia (Himalaya to Mediterranean). Just how these exotic rocks came to be enclosed by increasingly less exotic rocks has been the focus of several tectonic models. One explanation is that the pericratonic and arc belts (yellow and green) formed a more-or-less continuous belt that was subsequently folded around the Cache Creek terrane in oroclinal fashion.

Fieldwork in 2002 was originally planned to complete mapping of NTS mapsheet 104N/2 as well as the Sloko River mapsheet, 104N/3. Reduced financial support for field programs in 2002 hampered mapping progress, resulting in incomplete mapping over about 25% of the 104N/3 sheet. Mapsheet 104N/1, 2 and 3 together cover an area of approximately 2400 km² that spans a region between 38 and 115 kilometres southeast of the town site of Atlin. It is herein referred to as the "Nakina transect". Access to the Nakina transect is most effectively achieved using a helicopter charter based out of Atlin. Parts of the transect can also be accessed from lakes large enough for floatplanes. There are no all-season roads within the area. One rough, fire abatement road extends to Kuthai Lake at the northern limit of 104N/3; about a 2.5-hour drive from Atlin.

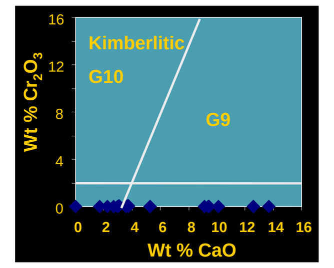
Regional Geology

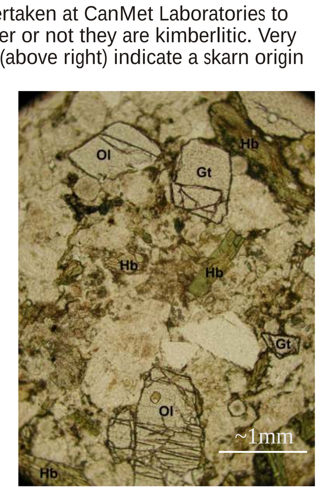


Garnetiferous Wacke



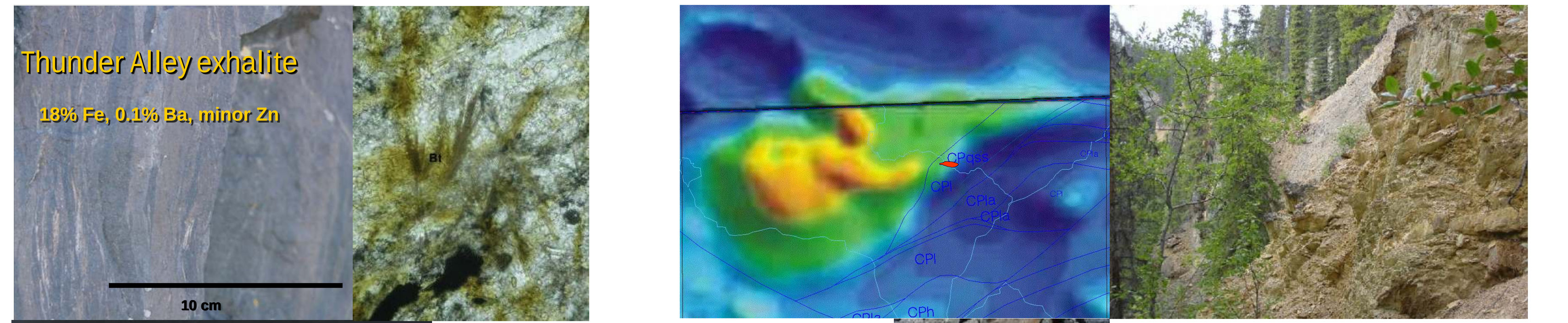
A distinctive wacke unit within the Laberge Group contains up to 3% detrital garnet and sparse, very fresh olivine grains (Photo right). Plagioclase-hornblende porphyry clasts of sand to pebble size are common. The unit is abnormally magnetic (15-22 x10^{-3} SI) and correlates with magnetic anomaly that is well portrayed on the regional aeromagnetic survey map (Dumont et al., 2001; Figure above). Because coexistence detrital garnet and olivine are potential diamond indicators, and because diamonds have reportedly been recovered from Wilson Creek (Casselman and Harris, 2002) ~25 km to the north, microprobe analyses of the garnet were undertaken at CanMet to determine whether or not they are kimberlitic. Very high Ca/Cr ratios (above right) indicate a skarn origin for the garnet.





A heavy mineral separate currently in preparation for detrital U/Pb isotope analysis will also be investigated in order to fully negate the possibility of chromian garnets and coexisting diamond indicator mineral phases.

Mineral & Hydrocarbon Potential

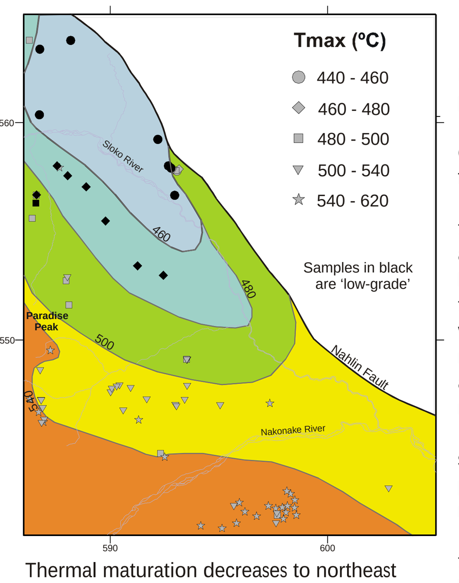


Thunder Alley exhalite consists of black wispy-laminated magnetite in fine-grained tuffite. Magnetite-rich rock comprises up to 50% of true thicknesses in excess of 5 metres. Analysis of a 5.3 metre chip sample yielded 16% Fe and 900-1200 ppm Ba. Similar bands occur across a width of 25 metres and can be traced for more than 700 metres. One area, 3 km northeast of Thunder Alley displays evidence of thermal alteration with development of biotite within partings in argillite and ribbon chert, but no associated metallic mineralization.

The Thunder Alley occurrence shows that large, vigorous hydrothermal systems can be preserved in Cache Creek terrane. The Joss'alun Discovery shows that economically interesting accumulations of base metal sulphides can also be found (see Joss'alun Discovery update).

A rust-weathering zone of quartz-sericite-pyrite mineralization crops out along ~200m of "Tumblepack Creek" (Photo above). Pyrite comprises up to 15% of the most altered outcrops; however, geochemical analysis did not reveal metal concentrations of interest. The cause of this mineralization is not known; although, it does occur on the margin of a positive magnetic anomaly salient (above left) - probably a buried intrusion.

Boulders of massive pyrrhotite up to 40 by 20 by 15 cm (Photo at left) occur within a talus fan near Paradise Peak. Geochemical analysis of the boulder did not return values of interest.

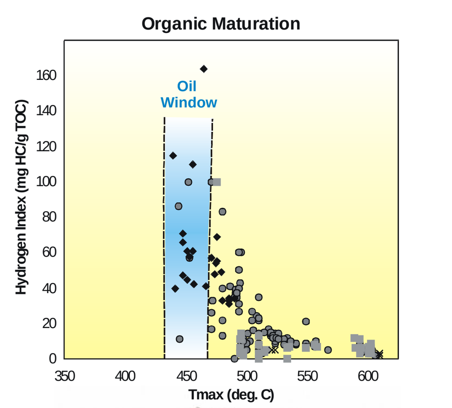


Thermal maturation decreases to northeast towards the Nahlin Fault. Area of figure is approximately western 2/3 of 104N/2 sheet.

Cache Creek rocks in the Nakina area are prehnite-pumpellyite grade and have CAI's > 4. This indicates that they are overmature and not prospective for hydrocarbon exploration.

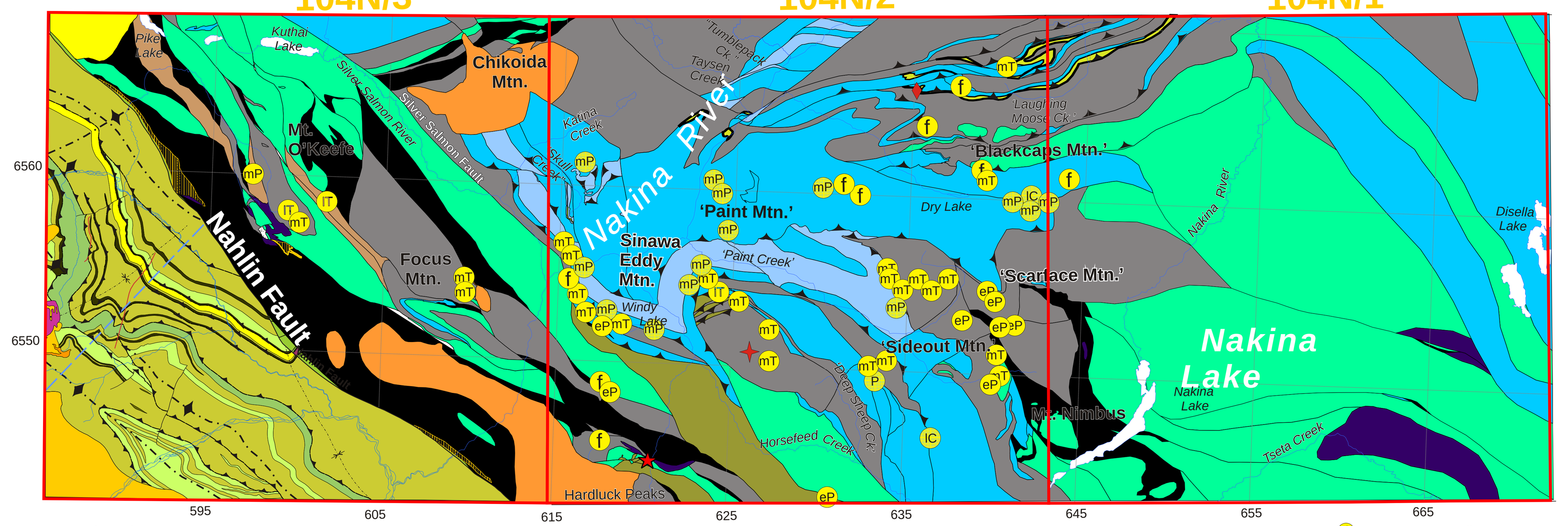
Potential source rocks within the Laberge Group in the Nakina and Chakluk areas are gas-prone. Programmed pyrolysis indicates that some of the samples fall within the oil window (Figure at right). However, many sample sites are overmature and have no remaining generative potential. Mature organic-rich, gas prone source rocks occur in the northern part of the Sloko River (104N/3) map-area (Figure at left).

Large antiforms (lower right) that are doubly plunging have huge closure volumes and may represent good structural traps.



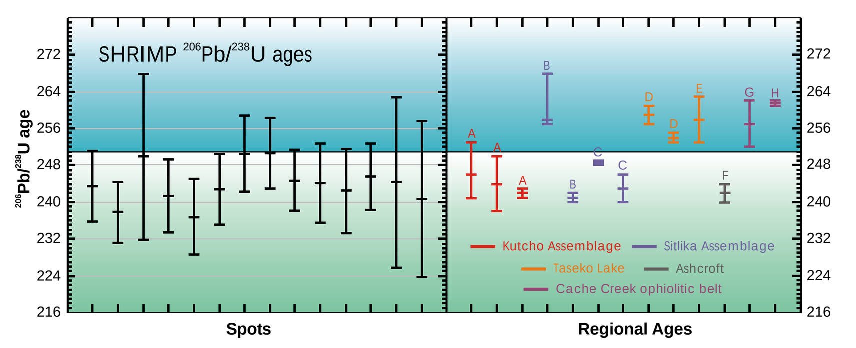
Sepiolite is a hydrated magnesium silicate: Mg2Si3O8·2H2O. It has a hollow, tube-like molecular structure, producing a lightweight molecular sieve. Industrial applications are numerous: environmental absorbants, paint thickeners, deodorizers, livestock feed supplements, rubber strengtheners, among others. Sepiolite normally occurs as compact earthy masses, rarely in crystalline form with fibres up to 2cm. These sepiolite fibres (above) are nearly 20 cm long, and comprise veins that occur as gashes within quartz-carbonate-chromian mica-altered ultramafite (listwanite).

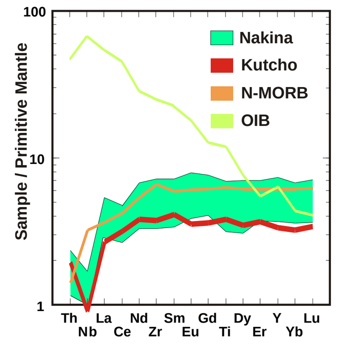
Nakina Geology

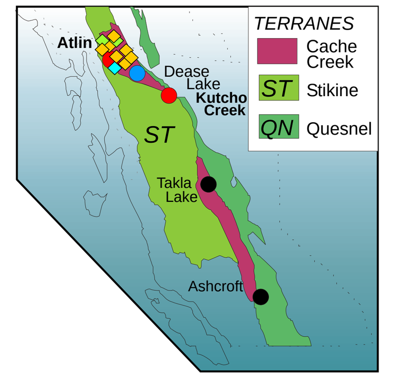


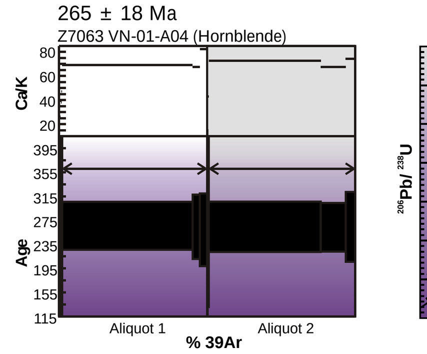
Layered Rocks: Eocene Sloko Group; Intermediate volcanic; Basal conglomerates; dykes + sills; Lower to Middle Jurassic Laberge Group: Garnetiferous wacke; Coarsening-up sequences; Massive siltstone & argillite; Cobble-boulder conglomerate; Massive bedded greywacke; Siltstone and argillite; Carboniferous - Early Jurassic Cache Creek complex: Wacke; Mélange; Argillite and argillaceous or well bedded carbonate; Carbonate; Chert; Mafic volcaniclastic rocks - 'Blackcaps' Assemblage. Igneous Rocks and Metamorphic: Diorite; Early Eocene Sloko diorite to tonalite; Mid-Jurassic hornblende-biotite granodiorite; Oceanic crustal intrusions; Ultramafite: harzburgite tectonite and serpentinite mélange / listwanite alteration. Radiolarian fossils; Fusulinacean fossils; Thunder Alley; Felsic tuff; Joss'alun discovery.

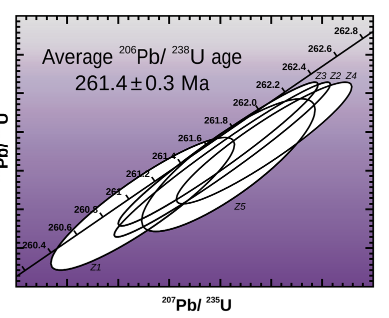
Geochronology & Geological History

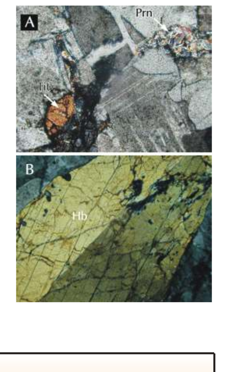


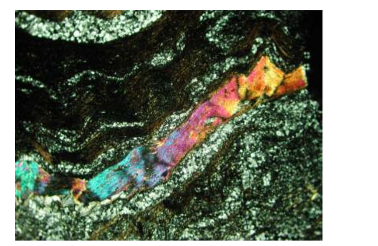


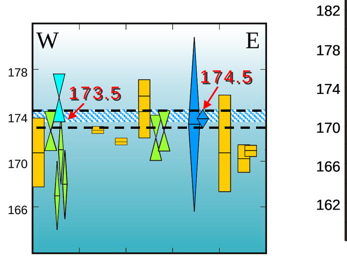


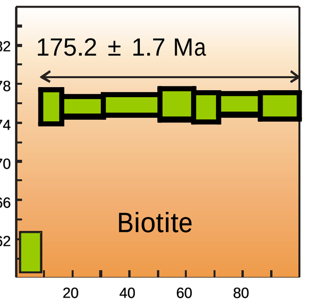












New structural, stratigraphic and age data, in combination with petrochemical studies (see English et al. poster), permit the following tectonic history:

Middle to Late Permian rupture of oceanic crust and initiation of the intra-oceanic Kutcho arc. Primitive arc volcanics (top right two figures), and forearc? crust (as shown by the plagiogranite and age data, middle row) extend perhaps more than 2500 km. Submarine massive sulphide mineralization accumulates within the arc setting, possibly until Early Triassic time.

Strata incorporated into the forearc and accretionary complex retain an oceanic signature until Middle or Late Triassic time when quartz-rich detritus is derived from exhumation of the Kutcho arc (top left two figures).

By Early Jurassic time, detritus carries Devono-Mississipppian zircons signalling influx from Stikine, Quesnel and/or Yukon-Tanana terranes (may all be broadly considered parts of the same arc complex). The northern Quesnel arc segment amalgamated with an ancestral continental margin assemblage at 186 Ma (Nixon et al., 1993).

In Early Middle Jurassic time (~173 Ma) the Stikine arc segment and intervening Cache Creek complex collided with the Quesnel arc segment. Because the Quesnel arc was already welded to an inboard continental domain (North America or an outboard ribbon continent; e.g. Johnston, 2001), it acted as a rigid backstop, and drove the intervening Cache Creek accretionary complex, and blueschist (bottom left photomicrograph) southwest over the forearc Laberge Group strata of the Stikine arc segment. Southwest-verging fold and thrust belt deformation in the previously undeformed Laberge Group records the collision. Superposition of this deformational episode on thrust faulted accretionary complex resulted in (re)folding, reactivation, and or reimbrication by younger thrust faults.

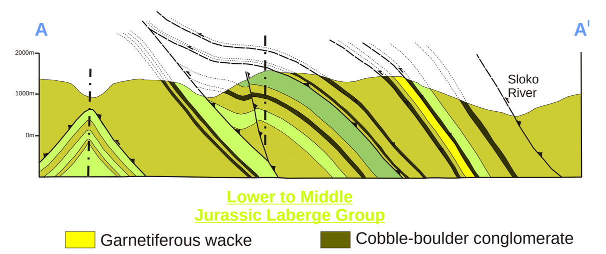
Emplacement-related structures in Cache Creek terrane are extensively cut by Middle Jurassic plutons ~172Ma (bottom middle); older plutons display some evidence of synkinematic emplacement (bottom right). The maximum best blueschist age is only ~1 m.y. older than the youngest error limits on the oldest pluton ages, indicating transfer from subduction zone to deformed margin in <1 m.y. (middle bottom).

Dextral motion on the Nahlin fault occurred, at least intermittently, until Eocene time. Motion around 55 Ma may have facilitated crustal transit of Sloko Group magma and eruption of continental arc volcanic rocks and comagmatic plutons. Extensive zones of listwanite at deflections in the fault trace may record hydrothermal fields related to Sloko magmatism. Post Sloko dilation resulted in gash veins infilled with sepiolite.

Structural Styes

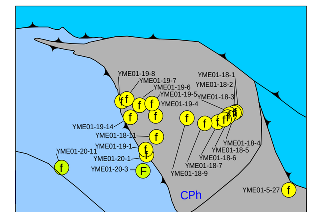
A most profound control on structure and distribution of different rock types is the Nahlin fault, which separates mantle tectonite and accretionary mélange of the Cache Creek complex, from Lower to Middle Jurassic Laberge Group strata. Laberge Group strata are deformed in a southwest-verging fold and thrust belt (below). .

Many parts of the Nakina transect east of the Nahlin Fault are so intensely deformed that structural complexity must be portrayed schematically, at scales of 1:50 000 or smaller. Thus, previous maps (i.e. Aitken, 1959; Monger, 1975), as well as the transect at centre, under-represent structural complexity. Our mapping at 1:20 000 scale, compiled at 1:50 000, and further simplified here is of sufficient detail to show several structural features not reported prior to the Nakina transect mapping.



A general northwest structural fabric parallels the Nahlin body and the Nahlin fault, although local trends can change direction radically. For example, a south-verging fold and thrust belt occupies northeastern 104N/2.

Nearly continuous canyon exposures along the Nakina River and northern tributaries afford a close look at the extreme structural complexity that characterizes the northern margin of the carbonate belt. Excellent canyon exposures of thick-bedded, white carbonate that is thrust imbricated with dark, thin-bedded carbonate in more than 20 southeast-verging fault panels (Photo collage at left).



On the southwest flank of Sinawa Eddy Mtn., high angle faults cut the thrust imbricated package (Photo near left).

Good fossil control in an antiformal closure permit us to map thrust faults with confidence. For example, in central 104N/2, an extensive succession of Middle Triassic chert (Figure above, yellow dots are Middle Triassic radiolarian localities) in the footwall of a sheet of Permian carbonate (green symbols are Permian fusulinacean and conodont collection sites).

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