Dease Lake Geoscience Project, Part I: Geology and Mineralization of the Dease Lake (NTS 104J/08) and East-Half of the Little Tuya River (NTS 104J/07E) Map Sheets, Northern British Columbia

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KEYWORDS: QUEST-Northwest mapping, Geoscience BC, regional bedrock mapping, integrated multi-disciplinary studies, geochemistry, copper-gold metallogeny, molybdenite, Triassic, Jurassic and Cretaceous plutonism, Tsaybahe, Stuhini, target generation, GIS

INTRODUCTION

The British Columbia Geological Survey's Dease Lake Geoscience Project is part of Geoscience BC's QUEST-Northwest initiative, a program launched in 2011 to stimulate exploration in the north western part of the province along Highway 37 (Figure 1). Geoscience BC has committed $3.25 million in funding for two high resolution (250 m line-spaced) airborne magnetic surveys, collection of new regional stream sediments data, reanalysis of stream sediment samples and the bedrock mapping described in this paper. The 2011 program of bedrock mapping and mineral deposit studies undertaken by the British Columbia Geological Survey is complementary to the geophysical and geochemical programs directly administered through Geoscience BC (Jackaman, 2012; Simpson, 2012). Collectively these programs will provide detailed, high quality geoscience data that is intended to enhance metallic mineral exploration in an area of prospective geology.

The Dease Lake study area is situated within the Stikine terrane, an extensive subduction-generated island arc magmatic system responsible for recurring calcalkaline and/or alkaline plutonic events and associated Cu-Au mineralization, mainly during Late Triassic and Early Jurassic time. Prospective Mesozoic volcanic rocks exposed around the margins of the Bowser Basin form an arcuate belt containing porphyry deposits that include KSM (MINFILE 104B 103), Galore Creek (MINFILE 104G 090) and Shaft Creek (MINFILE 104G 015) deposits to the west, and the Kemess deposits

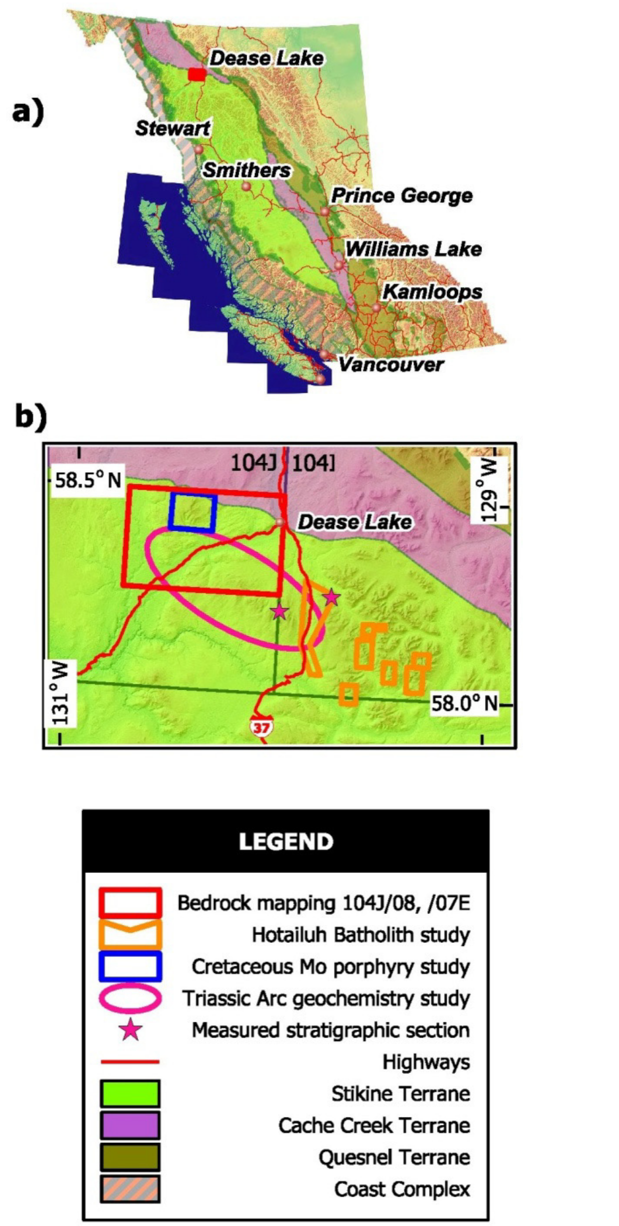

Figure 1. Location of the QUEST-Northwest mapping: British Columbia Geological Survey Dease Lake Geoscience Project on the a) BC terrane map (after Massey *et al.*, 2005); b) Detailed view straddles NTS 104J and NTS 104I 1:250 000 map areas at Dease Lake, showing the locations of the bedrock mapping study (NTS 104J/08, 07E), the Hotailuh batholith study, theSnow Peak pluton study and the Triassic arc geochemistry study.

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(MINFILE 094E 094) to the east. The Dease Lake study area is located at the apex of this arcuate belt, immediately north of the Red Chris Cu-Au porphyry deposit (MINFILE 104H 005) and adjacent to the Hotailuh batholith, a large composite intrusive complex similar in age to the intrusions hosting porphyry mineralization at the Galore and Shaft Creek deposits.

Numerous small plutons intrude mainly Late Triassic arc stratigraphy in the Dease Lake area. Neither the plutons nor the volcano-sedimentary rocks have undergone a thorough regional geological re-evaluation for mineral potential since being mapped by the Geological Survey of Canada in the late 1970s and early 1980s (Gabrielse *et al.*, 1980; Anderson 1983, 1984). Modern detailed bedrock mapping is essential to characterize time–space relationships of this arc segment, which will allow an improved assessment of the potential for mineralization, comparison with mineralized arc segments elsewhere, and integration with the airborne magnetic program. In addition, the project will provide supplementary databases including rock geochemical classification, magnetic susceptibility and geochronology. These data will integrate with regional stream geochemical survey data and airborne geophysics to ensure cost effective exploration targeting for porphyry-style mineralization.

In 2011, the British Columbia Geological Survey completed four field-based geology studies located within a 70 km radius of the Dease Lake community (Figure 1). The four components, which collectively make up the Dease Lake Geoscience Project are:

- Dease Lake regional bedrock mapping
- Hotailuh batholith: intrusive phases, ages and related mineralization
- Snow Peak pluton: age, emplacement and molybdenum mineralization
- Tsaybahe group: lithological and geochemical characterization of Middle Triassic volcanism.

DEASE LAKE REGIONAL BEDROCK MAPPING

The main component of the Dease Lake Geoscience Project consisted of systematic regional bedrock mapping of the Dease Lake (NTS 104J/08) and the east half of Little Tuya River (NTS 104J/07) map sheets, with the following objectives:

1) Publish 1:50 000 scale geological maps for NTS 104J/07 east half and 104J/08, a cumulative area of 1275 km^2, located immediately west of Dease Lake;
2) Determine U-Pb and $^{40}Ar/^{39}Ar$ ages for layered and intrusive rock units as well as mineralized rocks in order to constrain magmatic and mineralizing events;
3) Establish the geological controls on mineralization, and compare these with regional metallogenic epochs between 220 and 190 Ma [*i.e.* Late Triassic (Cu-Mo±Au), Late Triassic to Early Jurassic (Cu-Au-Ag) and Cretaceous to Tertiary (Cu-Mo-W)], related to alkaline and calcalkaline plutonism elsewhere in Stikinia;
4) Determine the history of magmatism, tectonism and mineralization in the Dease Lake transect for comparison to other parts of the Stikine magmatic arc system.

This paper reports the preliminary results of this field mapping. Bedrock mapping traverses were helicopter supported and completed by three 2-person mapping teams over the course of nine weeks between late June and August.

PREVIOUS WORK AND REGIONAL GEOLOGY

Kerr (1925; 1948) carried out the earliest geological bedrock mapping surveys in the area around Dease Lake. Systematic regional mapping by the Geological Survey of Canada began in 1956 with Operation Stikine, a reconnaissance mapping program covering four adjoining 1:250 000 map sheets in northwestern British Columbia (Geological Survey of Canada, 1957). Mapping and thematic studies conducted between 1956 and 1991 in the NTS 104I and 104J map areas are summarized by Gabrielse (1998). Most relevant to the current study is Anderson's work on the Hotailuh and Stikine batholiths (1983; 1984) and, more recently, 1:250 000 scale geological mapping of the Iskut River area (Anderson, 1993). Read of Geotex Consultants Ltd. (Vancouver, British Columbia) has conducted detailed mapping for the Geological Survey of Canada in the Stikine Canyon area (Read, 1983, 1984; Read and Psutka, 1990). Regional mapping projects by the British Columbia Geological Survey include work to the south by Ash *et al.* (1997) around Tatogga Lake and further west by Brown *et al.* (1996) in the Stikine River area.

The Dease Lake map area (NTS 104J/08, 07E) straddles the early Middle Jurassic thrust-imbricated boundary between the Cache Creek and Stikine terranes (Figure 2). The boundary between the terranes is marked by the south-vergent King Salmon fault (KFS). North of the KSF, the King Salmon allochthon (Cache Creek terrane) comprises oceanic basalt, siliciclastic rocks and limestone of Carboniferous to Early Jurassic age (Figures 2, 3). In places, the fault zone is marked by serpentinized ultramafic rocks and zones of listwanite alteration. The latter are dun to orange weathering foliated zones containing various amounts of chrome-rich mica, quartz veining and often pyrite.

The structurally lowest panel of the King Salmon allochthon consists of massive metabasite, tuff and limestone of presumed Carboniferous-Permian age. Structurally overlying this panel, to the west of the south

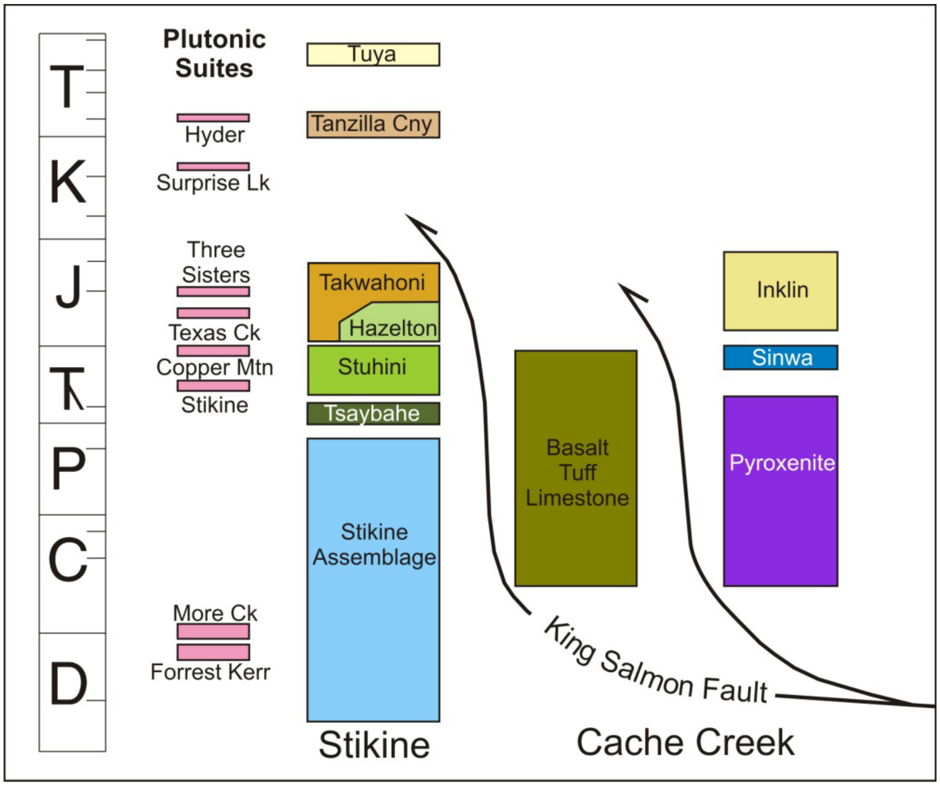

Figure 2. Schematic stratigraphic, plutonic and structural relationships for Stikine and Cache Creek terrane rocks within the map area (Abbreviations: Ck, creek; Cny, canyon; Mtn, mountain).

end of Dease Lake, are a large pyroxenite body and three west trending large outcrops of recrystallized massive limestone correlated with the Upper Triassic Sinwa limestone (Gabrielse, 1998). Apparently overlying these units are fine grained, foliated Jurassic clastic sediments of the Inklin Formation. The Inklin Formation underlies the northeastern part of the map area, which includes the southeastern margin of the Whitehorse Trough (Figure 2).

At this latitude, the Stikine terrane comprises three overlapping island arc successions; the Stikine assemblage, and the Stuhini and Hazleton groups that span 200 Ma from Devonian to Middle Jurassic. Their genetically related plutonic suites include the Devono-Carboniferous Forrest Kerr suite, the Late Triassic Stikine and Copper Mountain suites, the Early Jurassic Texas Creek suite and the Middle Jurassic Three Sisters suite (Anderson, 1983, 1993; Brown *et al.*, 1996; Logan *et al.*, 2000). These plutonic suites are the roots of cospatial arc rocks exposed along the Stikine arch, an east-trending area of uplifted Jurassic and older rocks that bound the northern margin of the Bowser Basin. Long-lived arc magmatism in the Stikine arch has produced diverse styles of magmatism (calcalkaline and alkaline) and large Cu–Au–Ag±Mo mineral deposits associated with some intrusive centres (*i.e.*, KSM, Snip [MINFILE 104B 004], Galore Creek, Schaft Creek and Kemess).

Paleozoic to Late Triassic sedimentary, volcanic and plutonic arc rocks of the Stikine terrane underlie the majority of the study area. Early Jurassic sedimentary rocks of the Takwahoni Formation overlie the Stikine terrane and comprise the immediate footwall to the King Salmon fault. An equidimensional latest Cretaceous/Palaeocene granodiorite body intrudes the Early Jurassic Takwahoni sedimentary rocks and columnar basalts of the Miocene to Pliocene Tuya Formation unconformably cap some of the highest peaks in the area. Preserved beneath these young basalts in the southwest corner of the map are lower Tertiary coal-bearing sedimentary rocks of the Tanzilla Canyon Formation.

Cache Creek terrane

MISSISSIPPIAN TO PERMIAN CACHE CREEK COMPLEX

Metabasalt, serpentinite, tuffaceous greenstone, limestone and minor chert comprise a fault bounded lozenge at the base of the King Salmon allochthon that extends 15 km east from Snow Peak pluton to Tatsho Creek. These rocks were assigned to the Cache Creek complex (Monger, 1975; Gabrielse, 1998). The trace of the northern faulted margin is marked by isolated outcrops of listwanite altered serpentinite along its length. The location of the southern fault is poorly constrained other than at its eastern end where it rejoins the northern fault and at its western end on the north-trending hillside east of Snow Peak pluton.

Dark green coloured, aphyric to locally fine pyroxene porphyritic, massive to weakly foliated metabasalt dominates the package. Vague pillowed forms were

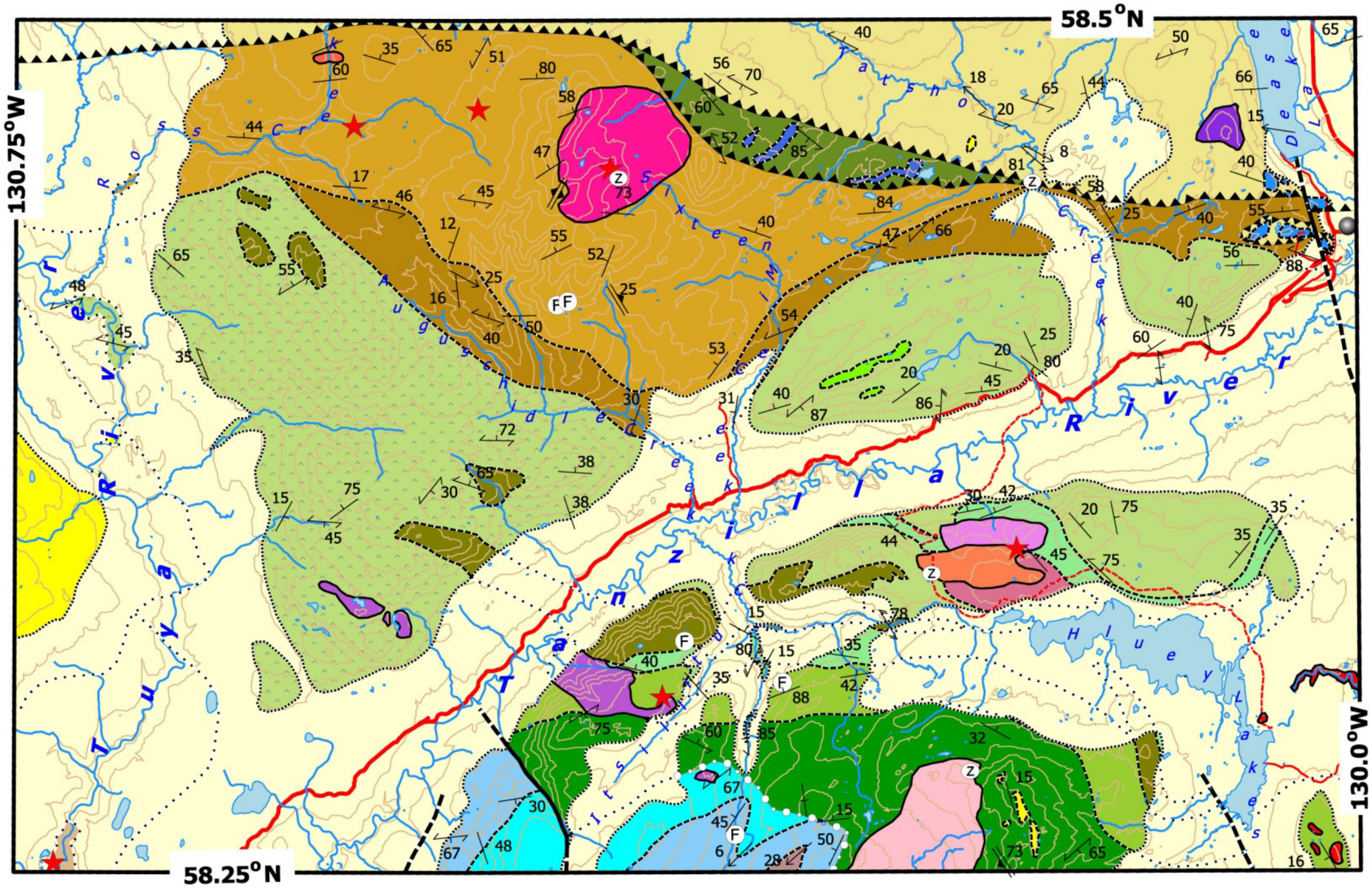

Figure 3. Generalized geology of the Dease Lake (NTS 104J/08) and east half of the Little Tuya River (NTS 104J/07E) map areas, including work by Ryan (1991) and Gabrielse (1998). Abbreviations: congl, conglomerate; sndst, sandstone; slstn, siltstone; mudstn, mudstone; crse, coarse; plag, plagioclase; px, pyroxene; brcc, breccia; xstl, crystal; hnbl, hornblende; qtz, quartz; bio, biotite; monzn, monzonite Symbols: F; fossil location, Z; U-Pb, zircon sample location.

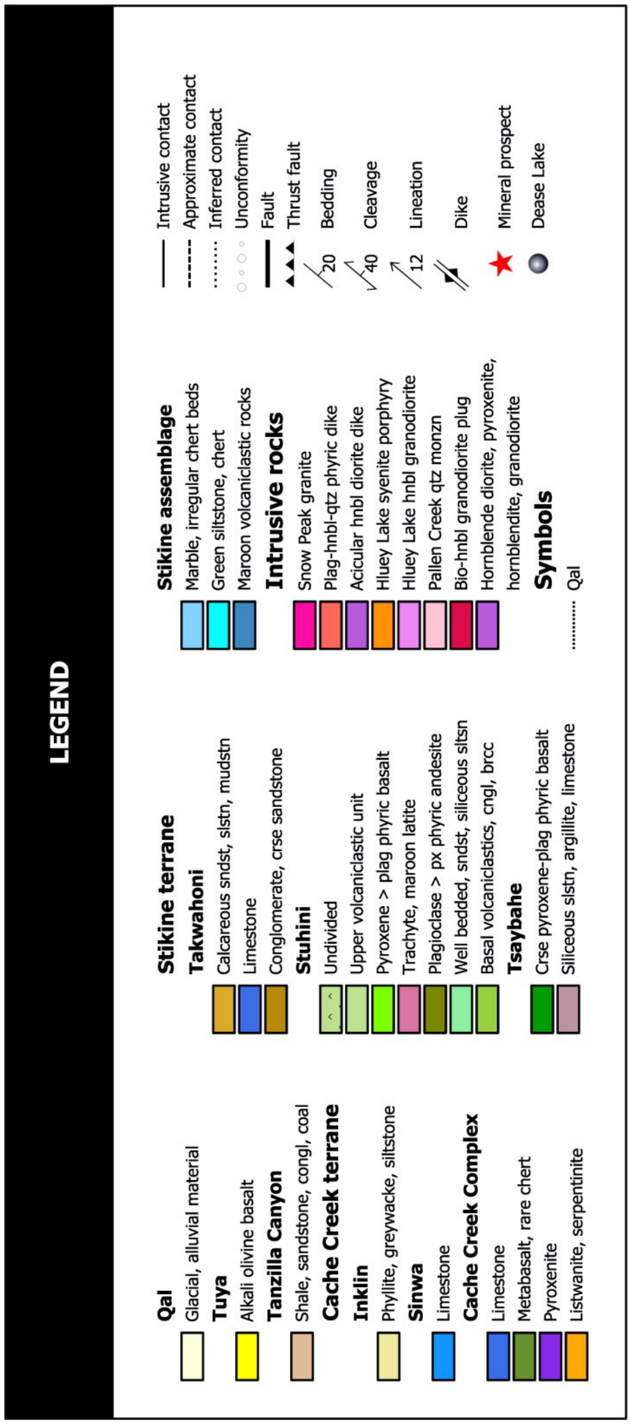

Figure 3. Continued.

noted. Locally pink-grey and black cherty alteration defined the margins of pillow tubes, but more often alteration masked the primary textures of the basalts. Commonly the metabasalt is microfractured and filled by chlorite, epidote, quartz, calcite, pyrite and locally hematite. Small bodies of dark green polished serpentinite are also present. The basalts are interleaved with schistose metavolcanics and greenstone which pass upwards into stratigraphically overlying limestone more than 50 metres thick. The limestone is medium bedded and recrystallized. It varies from white, grey to black and weathers smoke grey; it is thinly foliated and often layered with yellow weathering thin cherty horizons. Overlying the limestone and interlayered with it are thinly foliated, cherty lapilli to block mafic tuffs. These basalts are bleached, pyritized and silicified to a pale grey colour and comprise at least an 80 m-thick section which structurally overlies the limestone.

Whole rock chemical analysis from one sample of metabasalt plots in the subalkaline basalt field on major oxide and trace element rock classification diagrams and as a E-MORB on tectonic discrimination diagrams. Two limestone samples were collected and submitted to the Geological Survey of Canada, Vancouver for conodont extraction and identification. Results are pending.

LATE TRIASSIC SINWA FORMATION

The type section for the Sinwa Formation is 200 km northwest of Dease Lake in the Tulsequah map area (NTS 104K). There the Sinwa limestone is overlain by Lower Jurassic clastic metasedimentary rocks of the Inklin Formation in the hangingwall of the King Salmon Fault (Souther, 1971) and as such belongs to the Cache Creek complex. In the Dease Lake map area, Upper Triassic limestone designated as Sinwa Formation (Gabrielse, 1989) forms isolated high-standing white bluffs west of the community of Dease Lake. These limestones comprise two generally west-trending belts that are interpreted to be part of the Cache Creek complex and occupy a similar structural position above the King Salmon fault. The southernmost Sinwa limestone exposures are interpreted to represent a klippe of Cache Creek rocks preserved on top of the Takwahoni Formation conglomerates. Contact relationships between the Sinwa limestone and clastic rocks of the Inklin and Takwahoni formations in this area are equivocal. Alternate interpretations for the distribution of Late Triassic limestone outcrops south of the King Salmon fault are that they represent large olistostromes of Late Triassic Sinwa within the Takwahoni Formation or are Stuhini basement rocks. Thick accumulations of Stuhini limestone was not encountered during the present mapping so the latter interpretation is thought to be less likely.

In the Dease Lake map area, the Sinwa Formation consists of grey and white massive recrystallized limestone that weathers to a light grey or brownish colour. It forms large rounded, generally structureless massifs that locally are foliated and rarely thinly laminated. Typically, the limestone is a light brown amorphous rock cut by a dense stockwork of white calcite veinlets.

Few fossils have been recovered from the Sinwa Formation. However a hexacoral *Isastrea vancouverensis*, characteristic of the Upper Triassic Coral Reef Fauna of western North America was collected by Kerr approximately 2 km southwest of Dease Lake (Gabrielse, 1998).

EARLY JURASSIC INKLIN FORMATION

The Inklin Formation comprises interbedded phyllite and phyllitic greywacke, with minor limestone and conglomerate. It weathers recessively, and is only well exposed in stream cut-banks along Tatsho Creek, and along the shoreline of Dease Lake.

The phyllite is medium grey to black, and varies from homogeneous to laminated. It is well cleaved throughout, generally phyllitic, but slaty in places. Locally it contains concretions that are wrapped by the cleavage and limonitic spots are also abundant in places. Grey phyllite is generally non-calcareous, but there are some minor, cm-scale grey limy phyllite and banded argillic limestone layers.

The phyllitic greywacke, which is commonly calcareous, contains mostly sand-sized detrital grains wrapped by a wispy recrystallized phyllitic matrix. It is generally medium sand-sized, but coarser layers up to granule conglomerate are present. The greywacke is typically green-grey coloured and well cleaved, with abundant limonite spots. Graded bedding is locally developed and some of the coarser layers contain abundant black cm-scale mud rip-up clasts (Figure 4). Calcareous phyllitic greywacke locally contains abundant tremolite in clots up to 1 cm long. Tremolite is aligned parallel to the foliation and defines a mineral lineation. In rare instances, phyllitic greywacke contains lenses and thin continuous layers (up to 8 cm thick) of streaky white and grey recrystallized limestone.

Greywacke and phyllitic greywacke commonly form rhythmically layered sequences, with cm-scale alternations between the two rock types. In Tatsho Creek and at Dease Lake, the two rock types are present in roughly sub-equal proportions. Elsewhere, the unit is characterized by phyllite-rich intervals with subordinate greywacke. Phyllitic greywacke layers are typically 1-10 cm thick, but in rare instances greater than 1 m.

Age constraints for the Inklin are limited to areas as far away as Atlin Lake (NTS 104 N) where fossils of possibly Hettangain, but certainly Early Sinemurian to Late Toarcian ages have been identified (H.W. Tipper; in Gabrielse, 1998).

INTRUSIVE ROCKS

Ultramafic Rocks

West of the south end of Dease Lake there is a 2.2 km^2 ultramafic body of variably serpentinized, dun-

Figure 4. Lithologies in the Inklin Formation. a) Cm-scale alternations of dark phyllite and greenish coloured greywacke. b) Lenses of limestone within a calcareous greywacke (tremolite-bearing) layer.

weathering, chrome spinel-bearing peridotite. On weathered surfaces the peridotite is characterized by resistive equant pyroxene grains between 3 and 5 millimetres in a recessively weathering serpentine-altered olivine groundmass. The main body of peridotite is thoroughly serpentinized along its' southern margin and is cross cut by closely spaced orthogonal sets of serpentine veinlets throughout (Figure 5). Magnetic susceptibility values are 2 orders of magnitude higher (>100) on the serpentinized southern margin compared with those in the centre of the body, In thin section the rock contains 70-75% fractured and serpentine-altered subhedral olivine, large poikilitic orthopyroxene crystals characterized by deformation lamellae (25%) and approximately 5-10% subhedral clinopyroxene crystals. Large (1.0 mm) orange coloured idiomorphic crystals of spinel are conspicuous and form up to 1.5%.

In addition to peridotite, Gabrielse (1998) distinguished a coarse grained to pegmatitic unit of gabbro along the southeastern end of the intrusion, which also crops out along the lake shore as several small listwanite-altered exposures approximately 800 m north (Logan *et al.*, 2012b).

Figure 5. Serpentinized peridotite (Zn 9, UTM 437542E, 6480783N).

Serpentinite / Listwanite

A number of small ultramafic bodies occur along the trace of the King Salmon fault. These bodies, up to 100 m thick, consist of serpentinite that has been variably altered to listwanite. The listwanite comprises an orange weathered fine grained yellowish aggregate of white silica, talc, iron carbonate and diagnostic fuchsite that has replaced the primary mineralogy and textures of the protolith (Gabrielse, 1998). One of the best exposures of listwanite occurs where the fault crosses Tatsho Creek. At this location well-foliated listwanite in the hangingwall of the fault has been intruded by a nonfoliated hornblende-plagioclase porphyry dike with a preliminary U-Pb age of 155.2 ±1 Ma.

Stikine terrane

PERMIAN AND OLDER (?) STIKINE ASSEMBLAGE

The oldest rocks in the map area comprise Permian and older carbonate, siliceous siltstones and volcaniclastic rocks of the Late Paleozoic Stikine assemblage (Brown *et al.*, 1991; Gunning *et al.*, 1994; Logan *et al.*, 2000). They crop out within a northeast trending structural culmination in the southwest corner of the map area.

Maroon and light green coloured, foliated volcaniclastic rocks comprise the stratigraphically lowest unit beneath the Permian limestone. Fragments of vesicular, lapilli-size aphyric maroon basalt and intermediate plagioclase phyric andesitic basalt sit in a calcareous crystal-ash matrix. Overlying the volcaniclastic rocks is a section of pale grey, green and maroon siltstone and well bedded grey and black chert. Only a few outcrops of each of these units were encountered during mapping.

Thick accumulations of Paleozoic limestone are a diagnostic feature of the Early Permian sections of the Stikine assemblage in northwestern Stikine terrane. White and buff weathering, medium to thickly bedded limestone, thin to medium thickly bedded, buff-coloured limestone with thin phyllitic partings, limestone with black or yellow chert nodules and interbedded chert layers form the west-facing cliffs above the Tanzilla River in the southwest corner of the map and in the headwaters of Itsillitu Creek (Figure 3). These lithologies are correlative with Early Permian Ambition Formation that crops out 140 km south in the type section at Scud River (Gunning *et al.*, 1994).

Fusulinid packstone from well bedded and deformed limestone outcropping near Itsillitu Creek were collected and submitted for identification to the Geological Survey of Canada, Calgary. The fossils were identified as schwagerinid fusulinaceans of Early or Middle Permian age and the limestone was correlated with the Ambition Formation (Bamber, 2011). Conodonts from this same limestone but collected approximately 700 m south of the map boundary (Geological Survey of Canada location C-87099) are Early Permian, Artinskian age (M. Orchard, in Gabrielse, 1998).

EARLY TO MIDDLE TRIASSIC TSAYBAHE GROUP

In the vicinity of the Stikine canyon, the “Tsaybahe group” (Read, 1984; Read and Psutka, 1990) was named informally for sedimentary and volcanic rocks characterized by abundant coarse pyroxene porphyry breccias and Early and Middle Triassic fossils. They distinguished it from the Stuhini Group which they characterized as being primarily sedimentary and Late Triassic in age. Subsequent workers (Gabrielse, 1998, Evenchick and Thorkelson, 2005) could not distinguished the volcanic and sedimentary rocks of the “Tsaybahe” from those of the Stuhini Group on a regional basis and therefore assigned all Triassic units to the Stuhini Group.

In this study we have retained the Tsaybahe nomenclature as defined by Read (1984) to include a two-fold sedimentary package and an overlying characteristic coarse grained crowded pyroxene porphyry breccia unit. The sedimentary packages consist of a siliceous siltstone, argillite and limestone unit and overlying pyroxene and plagioclase crystal-rich volcanic sandstone and siltstone unit. These are intruded by pyroxene porphyritic dikes and sills, and abruptly overlain by coarse breccias of the same composition.

Tsaybahe Sedimentary Rocks

Dark grey chert and interbedded siliceous argillite overlie Early Permian limestone in a southwest plunging, west dipping overturned syncline centered on the southern boundary of the study area (Figure 3). Fossil control is lacking but the lithology and stratigraphic position suggest that these sediments are likely Early-Middle Triassic Tsaybahe sedimentary rocks. They include deformed, grey and purplish coloured, 10 cm-thick bedded chert separated by 2 cm thick cleaved mudstone and siltstone beds. Along strike are purple slates, rusty fine sandstone and chert interbedded with thinly laminated green limestone.

Limestone was sampled and submitted to the Geological Survey of Canada, Vancouver for conodont extraction and identification; results are pending.

Tsaybahe Volcanic Breccias

Unconformably overlying the foliated limestone, chert and metavolcanic rocks of Late Paleozoic age and the lower chert and siliceous argillaceous sedimentary units are coarse pyroxene volcaniclastic and breccia units of the Tsaybahe. This unit is characterized by thick accumulations (200-270 m), of crowded augite porphyritic basalt breccia and volcanic-derived clastic rocks exposed at the tops of the ridges in the southern part of the map. In hand sample the rock contains 3-5 mm, dark green euhedral pyroxene phenocrysts (20-30%) and 1-2 mm, stubby white plagioclase laths (5-20%) within an aphanitic, often vesicular or amygdaloidal green or orange-weathering matrix (Figure 6).

Early work on adjoining map sheets to the south (Read, 1983 and 1984) reported Early and Middle Triassic paleontologic ages from cherty sedimentary rocks and from limestone horizons within coarse pyroxene breccia units of the “Tsaybahe group”. However, no direct age constraints are known for the pyroxene breccias in the current study area.

LATE TRIASSIC STUHINI GROUP

A volcaniclastic dominated sequence of mafic to intermediate volcanic rocks assigned to the Late Triassic Stuhini Group underlies the central third of the study area. They overlie, apparently unconformably, the Early to Middle Triassic sedimentary and volcanic rocks of the Tsaybahe group to the south and are overlain unconformably (?) by quartz-bearing polylithic conglomerates and sandstones of the Early Jurassic Takwahoni Formation to the north.

The Stuhini Group in the study area is dominated by coarse to medium grained, massive to medium bedded volcaniclastic rocks (>60%), roughly equal proportions of augite dominated (10%) and plagioclase dominated (10%)

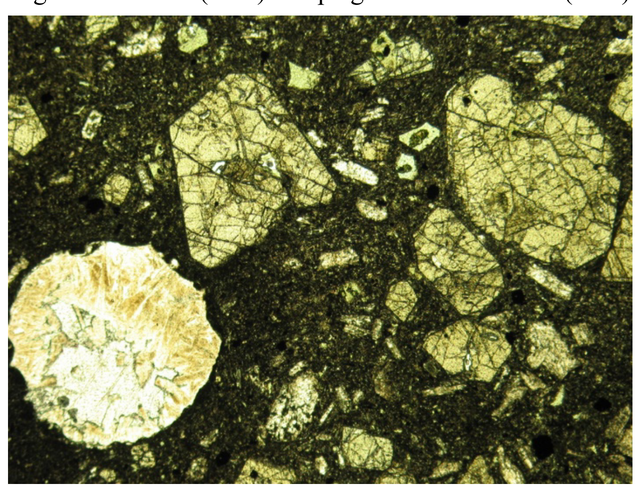

Figure 6. Photomicrograph of vesicular crowded pyroxene porphyritic basalt. Field of view = 3 mm. Plane-polarized light.

coherent flows and breccias with the remainder comprising fine grained siliceous siltstone and sandstone (10%) and an areally restricted unit of trachyte, and maroon latite. The units trend generally west to northwesterly, dip and face to the north. Because cleavage development and major folding was not observed, the succession is assumed to young northwards.

The Stuhini Group has been subdivided into six map units. From oldest to youngest these are: (1) a basal volcaniclastic unit of mixed, massive to thickly bedded reworked volcanic rocks and rare basalt flows that generally fine upwards into, (2) a well-bedded section of sandstone-siltstone with Upper Triassic (?) bivalves. Units 1 and 2 are overlain by, (3) a thick package of coarse plagioclase porphyritic andesitic basalt flows and subordinate clastic rocks and (4) isolated, thin units of alkalic, sparse K-feldspar phyric latite and maroon basalt. Unit 5 is pyroxene±plagioclase porphyritic monomict flow breccia and rarely pillowed basalt that are interlayered within, (6) an upper unit of massive volcaniclastic rocks containing plagioclase and pyroxene-phyric basalt clasts.

Unit 1 - Basal Volcaniclastic Rocks

Reworked volcaniclastic units derived from mafic to intermediate volcanism comprise the basal and the uppermost units of the Stuhini Group in the map area. Pale orange weathering, volcaniclastic deposits of the basal unit are exposed in a narrow west-trending belt north of the crowded pyroxene breccias of the Tsaybahe group. This unit includes thick, massive clast and matrix-supported lapilli and block breccias containing abundant clasts of green pyroxene porphyry, with sparse clasts of maroon pyroxene porphyry and pale grey limestone. These coarse deposits, which are typically 1-10 m thick are interlayered with volcanic granule conglomerates, 30 cm thick volcanic sandstone layers and rare thin layers (<10 cm) layers of well bedded fine-grained sandstone/siltstone. Clasts and matrix are almost identical in their composition. Parts of the unit are dominated by thick (1-3 m) beds of weakly graded granule conglomerate to medium grained volcanic sandstone, which comprise almost exclusively of fresh detrital pyroxene and plagioclase crystals.

Unit 2 - Well-Bedded Sandstone-Siltstone

Gradationally overlying the basal volcaniclastic unit are green, grey and black coloured, medium bedded to thinly laminated volcanic sandstone, siliceous siltstone and siliceous tuff. This generally fining upwards sequence of epiclastic volcanic material is characterized by its overall well-bedded nature, relative continuity and ~400 m thickness. The rocks display normal grading in the sandstone-siltstone couplets and load casts that indicate the north-dipping section is upright facing. Parallel, planar bedding laminations characterized the finer grained units. On the ridge above Tanzilla River the well-bedded section is cut by pyroxene porphyry and plagioclase porphyry dikes oriented roughly orthogonal to bedding. Similar fine grained bedded horizons occur throughout the Stuhini section but are typically only 1-10s of metres thick, discontinuous or display chaotic bedding attitudes suggestive of slumping. A particularly thick and continuous horizon of these fine grained, well bedded rocks within the upper volcaniclastic rocks of unit 6 is exposed along the Hluey Lake Road (Figure 3).

Unit 3 - Plagioclase Porphyritic Basalt

Orange weathering massive outcrops of plagioclase-phyric basalt define a 2 km wide westerly trending belt separating the basal volcaniclastic units from the upper volcaniclastic unit. The unit can be traced from south of Hluey Lakes into Hluey Creek, across the Tanzilla River and in isolated outcrops another 10 km northwest towards the Stuhini-Takwahoni unconformity (Figure 3). The basalts contain abundant white to cream coloured, 2-8 mm euhedral plagioclase phenocrysts, sometimes glomeroporphyritic, in a fine grained green matrix (Figure 7). Intergrown plagioclase and clinopyroxene form the matrix, and sparse pyroxene phenocrysts are also locally present. Minor interlayers of reworked pyroxene porphyry breccia are also contained within this unit. The plagioclase porphyry flows are generally coherent, unlike fragment-rich breccia deposits of the monolithic pyroxene porphyries elsewhere.

Immediately south of Ross Creek is a distinctive trachytic plagioclase porphyritic basalt characterized by glassy 4-7 mm euhedral plagioclase crystals (5-7%) within a very fine grained dark matrix that locally is glassy green and characterized by spherulitic devitrification textures. This unit was collected, and submitted for U-Pb, zircon age dating but did not contain sufficient zircons.

Unit 4 - K-feldspar Porphyritic Latite

A distinctive package of salmon pink weathering porphyritic latite, trachyte, and maroon weathering basalt and epiclastic rocks crop out northwest of Hluey Lakes along the Hluey Lake service road adjacent to the pink weathering syenite porphyry. Unit 4 rocks comprise the

Figure 7. Plagioclase porphyry basalt (Zn 9, UTM 417135E, 6464463N).

immediate country rock to the monzosyenite and (?) granodiorite phases of the Hluey Lake pluton. The rocks are characteristically potassic and mineralogically similar to the intrusive syenite phase of the pluton (Figures 8a, b). They include maroon-coloured basalt/latite with abundant calcite-filled vesicles, and phenocrysts of plagioclase, K-feldspar and biotite in an aphanitic matrix.

Porphyritic flows contain sparse mm-scale K-feldspar and biotite phenocrysts that locally display trachytic flow textures in the pink to brown coloured aphanitic matrix. The maroon rocks surrounding the Hluey Lake syenite are friable and variably altered by introduction of potassium and iron carbonate likely from the syenite. It is uncertain whether the alkaline character of these rocks is primary and they are extrusive equivalent rocks to the intrusion or can be attributed entirely to alteration from the syenite. Orthoclase and biotite porphyritic breccias/diatremes are well known Upper Triassic porphyry Cu-Au mineralized intrusive centres in this part of Stikinia (Logan *et al.*, 2000).

Unit 5 - Coherent Pyroxene Porphyritic Basalt

Pyroxene porphyritic basalt flows, breccias and volcaniclastic rocks are the hallmark of the Stuhini Group in northwestern Stikinia (Souther, 1971, 1972; Anderson, 1993; Gabrielse, 1998; Logan *et al.*, 2000) and these rock types are widely developed in the study area. Coherent flow units are often complexly interlayered with identical coarse pyroxene porphyritic clastic and reworked epiclastic units and could generally not be mapped separately. Where distinguished, single flow units are commonly from 5 to 12 m thick, with massive interiors and flow top breccias. Basalt types include; those with subequal amounts of pyroxene and plagioclase phenocrysts to those which contain pyroxene >>plagioclase phenocrysts. The former is characterized by typically quite small (~1-2 mm), sub-equal proportions of green or black pyroxene and white plagioclase laths in a fine grained green matrix. The pyroxene porphyry flows consists of typically 2-8 mm euhedral augite phenocrysts in a fine grained green matrix.

Unit 6 - Pyroxene and Plagioclase-Phyric Volcaniclastic Rocks

A ~450 m thick sequence of orange weathering pyroxene and plagioclase porphyry clast-dominated volcaniclastic succession with minor basalt flows underlies the area east of Sixteen Mile Creek and north of the Tanzilla River. Massive, cliff-forming units of chaotic, non-graded matrix-supported cobble to pebble-size volcanic conglomerate comprise the majority of outcrops (Figure 9). Metre-thick beds of pyroxene and plagioclase crystal-rich sandstone and siltstone occur throughout the package, as evidenced by bedding measurements (Figure 3). Many of the sandstones contain fresh, euhedral vitreous pyroxene and plagioclase crystals, making some of them difficult to distinguish from igneous rocks. Pyroxene porphyry basalt flows of unit 5 comprise a minor component of the section. The pyroxene phenocrysts within the porphyry clasts and fragments which dominate the volcaniclastic units are commonly 4-8 mm and much coarser than the 1-2 mm pyroxene phenocrysts in many of the porphyry flows.

The Stuhini rocks in the Dease Lake and Little Tuya River map areas form part of a continuous belt that is poorly dated and occupy the northern flank of the Stikine arch (Gabrielse, 1998). Correlative lithologies exposed in the Stikine River to the south indicate Late Triassic, Carnian to Norian ages (Read, 1983; 1984). Two new macrofossil collections from the basal volcaniclastic and the well bedded siliceous siltstone units within the map area contain *Spiriferinid* brachiopod (?) and *Posidoniid* bivalves, probably *Halobia* that suggest a probable Late Triassic, but possibly as old as Middle Triassic age (Poulton, 2011). A single detrital zircon sample was collected from medium-grained sandstone of the upper Stuhini volcaniclastic member exposed along the Hluey Lake road. Results are pending. In addition, limestone horizons were collected for conodont studies and age determinations from unit 1 and unit 2. These have been submitted to the Geological Survey of Canada, Vancouver for identification.

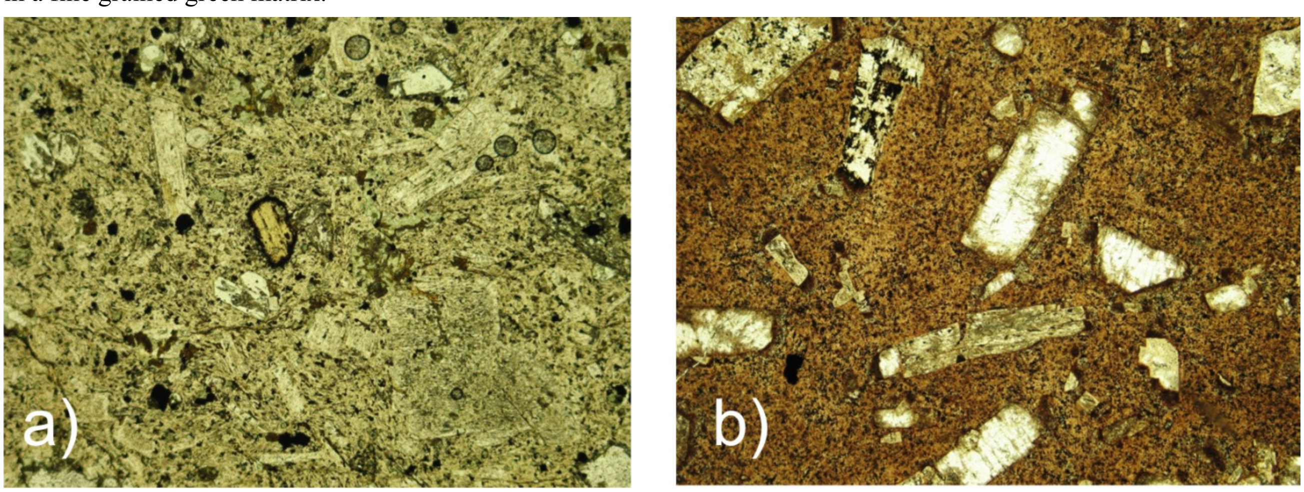

Figure 8. Photomicrographs of a) Maroon basalt/latite of Stuhini Unit 4 with phenocrysts of plagioclase, K-feldspar and biotite in an aphanitic matrix. b) K-feldspar, biotite porphyritic monzosyenite of Hluey Lake pluton. Field of view = 3mm. Plane-polarized light.

Figure 9. Weakly stratified matrix-supported augite porphyry volcanic clast-dominated conglomerate of Unit 6, upper volcaniclastic rocks, Stuhini Group (Zn 9, UTM 433593E, 6467919N).

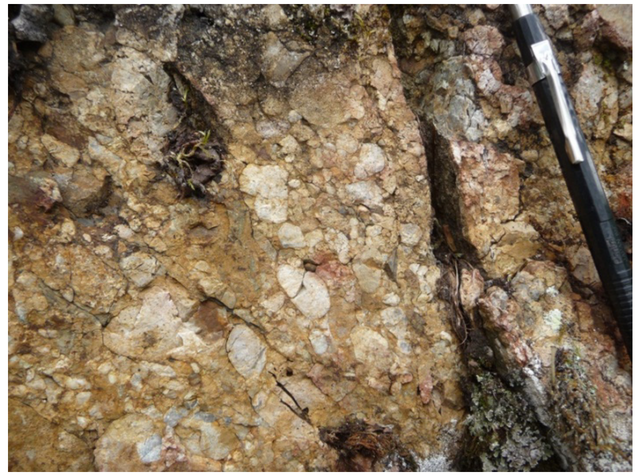

Figure 10. Well rounded, poorly sorted quartz, granitic and aphyric chert grey and green volcanic granule conglomerate of the Takwahoni Formation (Zn 9, UTM 433563E, 6478435N).

EARLY JURASSIC TAKWAHONI FORMATION

Clastic sedimentary rocks assigned to the Takwahoni Formation underlie an east trending and narrowing belt in the northern part of the map area that apparently pinches out against the Gnat Pass fault at the community of Dease Lake. East of the fault, the section comprises a five km wide belt of rocks that has been traced southeastward for more than 90 km (Gabrielse, 1998). In both cases these rocks occupy the immediate footwall to the King Salmon thrust fault.

The Takwahoni Formation consists mainly of an upper dark grey fine-grained sandstone-siltstone unit, and a lower coarse grained conglomerate-dominated unit with subordinate sandstone and siltstone layers. These are locally separated by a narrow discontinuous grey micritic limestone and orange brown weathering calcareous sandstone units.

The structural and stratigraphic lowest Takwahoni rocks are massive clast and matrix-supported polylithic conglomerate and coarse feldspathic, quartz-bearing sandstone that overlie volcaniclastic rocks of the upper Stuhini Group. The conglomerate forms positive topographic relief and cliff exposures within Auguschilde and Sixteen Mile creek drainages. It is generally polylithic with cobble to pebble-sized clasts of coarse-grained granite, hornblende quartz porphyry, aphyric grey and green volcanic rocks, argillite, chert and recrystallized limestone (Figure 10). Some of the clasts contain evidence for ductile deformation prior to their deposition.

In general, the sandstones are well sorted arenaceous rocks dominated by feldspar and variable amounts of quartz and lithic clasts and carbonate, clay and silica cement. In many rocks in the lower part of the formation quartz is a minor constituent. Thick bedded sandstones display sharp upper and lower planar contacts with 1-2 cm thick alternating parallel laminated pale grey-green and black siltstone and mudstone. Primary sedimentary structures within the latter include load casts, flaser bedding, cross and wavy laminated bedforms, and contorted bedding. Subordinate beds of granule to cobble conglomerate within the sandstone contain subrounded to subangular clasts of granite, limestone, volcanic clasts, laminated black mudstone chips, vein quartz, and sparse very fine grained, emerald-coloured clasts. Some of the conglomerate has a limy matrix.

Thermally altered fine clastic rocks comprising the upper Takwahoni Formation display a mauve coloration and locally contain fine shreds of secondary biotite, with cordierite developed adjacent to the Snow Peak pluton (see Moynihan and Logan, this volume).

An Early Jurassic age for the Takwahoni Formation is provided by a rich ammonite fauna of Sinemurian age contained within a basal conglomerate and shale-tuff unit located east of the McBride River (Tipper, in Gabrielse, 1998). Overlying this unit is a younger succession of interbedded greywacke and shale, with thin interbeds of polylithic pebble conglomerate of Pliensbachian age (Tipper, 1978). Limestone clasts collected from nearby but separate locations in the Takwahoni Formation approximately 5 and 5.1 km south of Snow Peak contain ichthyoliths and conodonts of Late Triassic, Norian age that have been correlated with the Sinwa Formation (Orchard, in Gabrielse, 1998). A single detrital zircon sample was collected from the coarse conglomerate member of the basal Takwahoni Formation exposed in Sixteen Mile Creek. Results are pending.

EOCENE TANZILLA CANYON FORMATION

Poorly consolidated Lower Tertiary sedimentary rocks of the Tanzilla Canyon Formation crop out in the southwestern corner of the map along the Tuya and Little Tuya rivers and further south along the Tanzilla River (Ryan, 1991; Gabrielse, 1998). The sediments are poorly consolidated conglomerate, sandstone and mudstone that comprise a stratigraphic section approximately 500-600 m thick. The lower 200-300 m consists of mudstones and sandstones in the west and sandstones and chert-pebble conglomerate in the east and contains high volatile B bituminous coal in a seam 5-30 m thick. The lower unit is overlain by an upper unit at least 300 m thick of volcanic pebble-conglomerate, sandstone and volcanic rocks (Ryan, 1991).

Palynology (Vincent, 1979; De Nys, 1980) indicates the coal-bearing rocks as not younger than Early Eocene and no older than Paleocene (Ryan, 1991) which is age equivalent to the Brothers Peak Formation of the Sustut Group (Eisbacher, 1974). However, due to the fault-controlled nature of the basin (Tuya basin) and its' locally derived sediment, Yorath (1991) assigned these rocks to the Sifton assemblage.

MIOCENE–PLEISTOCENE TUYA FORMATION

The map area abuts against the eastern flank of the Miocene to Pleistocene Level Mountain shield volcano. Isolated outcrops of alkali basalts associated with this edifice crop out along the Tuya River and overlie one of the highest peaks in the southern part of the map area. In the latter area, the basalt is distributed across the peak in six isolated outcrops. It varies from 50-75 m thick and is columnar jointed with vertical to reclined dipping orientations (Figure 11). The basalt is grey to brown and contains mm-size phenocrysts of yellowish green olivine and vitreous plagioclase phenocrysts within a fine grained plagioclase, pyroxene, olivine-rich trachytic matrix. Whole rock chemical analysis from a sample of columnar basalt plots in the alkali basalt field on major oxide and trace element rock classification diagrams.

Whole rock potassium-argon ages for the Level Mountain volcanic rocks range from 14.9 to 5.3 Ma (Hamilton, 1984; in Gabrielse, 1998).

Intrusive rocks

Regionally, three distinct plutonic suites comprise the Hotailuh batholith (Anderson, 1983) and characterize

Figure 11. Columnar basalts of the Miocene to Pliocene Tuya Formation. View towards west from 6 km southwest of Hluey Lakes on top of repeater hill (Zn 9, UTM 431065E, 6458474N).

magmatism along the Stikine arch (Anderson, 1984; van Straaten *et al.*, this volume). They include the Late Triassic Stikine (Cake Hill, Beggerlay Creek and Gnat Lake plutons), the Early Jurassic Texas Creek (McBride River pluton) and the Middle Jurassic Three Sisters (Three Sisters pluton, Anderson, 1983; Anderson and Bevier, 1990) suites. The ~2300 km^2 Hotailuh batholith adjoins the southeast corner of the map area and many of the small satellite plutons that intrude the mainly Late Triassic arc stratigraphy in the Dease Lake map area are thought by corollary to have ages similar to these three main plutonic suites.

Preliminary U-Pb crystallization ages for the Pallen Creek pluton attests to this but ages for the Hluey Lake pluton and a hornblende plagioclase porphyry dike that cross cuts the King Salmon Fault returned ages that are not commonly reported from the Stikine arch. These preliminary ages were acquired by Laser Ablation ICP-MS analyses of zircons at the University of Washington (pers. comm., Paul O'Sullivan, 2011). Complete data sets, techniques and finalized ages will be reported elsewhere.

LATE TRIASSIC

Late Triassic ultramafic, mafic and granitic rocks of the Gnat Lakes, Beggerlay and Cake Hill plutons comprise the majority of the Hotailuh batholith (*e.g.* van Straaten *et al.*, this volume). However, Late Triassic intrusive rocks have not been recognized in the current study area.

EARLY JURASSIC (?)

A series of small to medium sized mafic intrusions define a 16 km long southeast trending corridor that straddles the Tanzilla River approximately 30 km southwest of the community of Dease Lake. The intrusions vary in size from less than 0.5 to 6 km^2 in area. They are coarse to medium grained bodies comprised of pyroxenite, hornblende gabbro or more often diorite to monzodiorite that locally was intruded and veined by leucocratic hornblende monzonite to granodiorite phases. A similar mafic-ultramafic dike is intruded into the Takwahoni Formation west of Snow Peak. The largest body crops out on a north-facing slope above the Tanzilla River. This unit has some of the highest magnetic susceptibility measurements in the map area and a mean value of 92.6 ±43 x 10^{-3} S.I. units.

Hornblende separates from the diorite have been submitted to Pacific Centre for Isotopic and Geochemical Research (PCIGR) at the Department of Earth and Ocean Sciences, University of British Columbia for $^{40}Ar/^{39}Ar$ step-heating analyses to determine cooling ages of the intrusion. Results are pending.

MIDDLE JURASSIC

The Pallen Creek pluton is a homogeneous biotite-hornblende-quartz monzonite to monzodiorite locally containing K-feldspar megacrysts (Anderson, 1980; this study). The northwest (this study) and northeast (Anderson, 1980) sides of the pluton are characterized by a more mafic, hornblende diorite marginal phase that is intruded by the main quartz monzodiorite phase. The main quartz monzonite unit has moderate magnetic susceptibility measurements with a mean value of 32.5 ±3.4 x 10^{-3} S.I. units.

K-Ar cooling ages from hornblende (197 ±18 Ma and 165 ±8 Ma) and from biotite (145 ±7 Ma) have a substantial range (Wanless *et al.*, 1972; Stevens *et al.*, 1982), but a new U-Pb crystallization age determined by Laser Ablation ICP-MS analyses of zircons from a sample of K-feldspar porphyritic biotite hornblende monzodiorite taken at the north end of the pluton gave a Middle Jurassic, Bajocian age of 173.6 ±0.7 Ma (personal communication, Paul O'Sullivan, 2011). This age suggests that the Pallen Creek pluton is part of the Three Sisters plutonic suite.

EARLY CRETACEOUS

A 4 by 2 km east trending composite intrusion located northwest of Hluey Lakes on the north-facing cliffs above the Tanzilla River was described by Gabrielse (1998) and grouped with the Early to Middle Jurassic plutonic rocks of the region. The Hluey Lake pluton is a composite body comprised of at least two main lithologies. A medium grained homogeneous biotite hornblende granodiorite with minor inclusions of hornblende diorite comprises the older northern part of the pluton. It is equigranular, locally weakly foliated (eastern exposures) and consists of 2 mm subhedral white plagioclase, interstitial K-feldspar, euhedral 2-4 mm hornblende crystals and anhedral crystal aggregates of biotite. Magnetite is common and accompanies mineralization and alteration.

Intruding the granodiorite and comprising the southern portion is a pink weathering monzonite to syenite porphyry. The potassic phase comprises massive, equigranular (2-4 mm) phases and K-feldspar ±plagioclase and biotite porphyritic (5-10 mm) phases characterized by a fine-grained salmon pink K-feldspar matrix (Figures 8, 12). Aligned plagioclase and K-feldspar phenocrysts locally define trachytic textures in the porphyry. Abundant fine-grained dikes (?) with sparse K-feldspar phenocrysts intrude the hornblende diorite. This unit has moderate magnetic susceptibility measurements with a mean value of 33.4 ±22.8 x 10^{-3} S.I. units.

The K-feldspar biotite porphyritic monzonite was collected and submitted for isotopic age determinations. Preliminary Laser Ablation U-Pb zircon geochronology suggests there are two separate age populations. The majority of the zircons (n=45) gave a Middle Jurassic, Bathonian age of 164.9 ±0.8 Ma, similar to dating by van Straaten (this volume) of the Three Sisters potassic phase. However, 10% of the data (n=5) indicate a separate

Figure 12. Pink K-feldspar, plagioclase, biotite porphyritic monzosyenite of Hluey Lake pluton. Salmon pink matrix comprised of fine grained matrix K-feldspar. Note rounded monzodiorite xenolith.

thermal event in the Early Cretaceous *ca.* 127.7 ±2.0 Ma (personal communication, Paul O'Sullivan, 2011).

Biotite from the monzonite has been submitted to PCIGR at the Department of Earth and Ocean Sciences, University of British Columbia for $^{40}Ar/^{39}Ar$ step-heating analyses to determine the cooling age of this phase. Results are pending.

LATE CRETACEOUS TO EARLY PALEOCENE

The Snow Peak pluton is a steep sided 15 km^2 equidimensional body that was intruded into Early Jurassic rocks of the Takwahoni Formation in the Late Cretaceous/Palaeocene (Gabrielse, 1998; Moynihan and Logan, this volume). The intrusion is a biotite hornblende monzodiorite to granodiorite with equigranular and locally K-feldspar porphyritic textures. Molybdenum mineralisation is developed along west-northwest trending brittle fracture planes in the central part of the pluton. A conspicuous, rusty weathering contact metamorphic aureole developed within the slate, siltstone and sandstone of the fine-grained member of the Takwahoni Formation. This hornfelsed zone extends for 2-3 km outwards from the contact of the intrusion coincident with a roughly circular magnetic high on the first vertical derivative magnetic map.

Magnetic susceptibility measurements of samples from the Snow Peak pluton indicate two populations. The higher readings have a mean value of 28.3 ±6.9 x 10^{-3} S.I. units and the lower population a mean value of 1.3 ±0.01 x 10^{-3} S.I. units. The variability has no spatial association or zonation.

A K-Ar cooling age of 73.5 ±4.2 Ma for hornblende from the Snow Peak granite was reported by Stevens *et al.* (1982). A sample collected during regional mapping has a Laser Ablation U-Pb zircon crystallization age of 64.4 ±0.5 Ma as reported by Moynihan and Logan (this volume).

MINOR HYPABYSSAL PLUTONS AND DIKES

Metre-wide, mafic pyroxene±plagioclase and bladed plagioclase±pyroxene porphyry dikes and acicular hornblende porphyry dikes intrude stratified rocks as young as late Triassic. The acicular hornblende porphyry dikes are preferentially oriented northwesterly.

A cream to white coloured, crowded biotite plagioclase porphyry plug is exposed along Ross Creek in the northwest corner of the map. It is a medium grained locally porphyritic biotite quartz diorite (Gabrielse, 1998). Mineralogically it is similar and probably genetically related to the hornblende-plagioclase±quartz porphyritic dike swarm that cross cut the Takwahoni sedimentary rocks in the area. The biotite phenocrysts have been altered and replaced by chlorite and the plagioclase intensely sericitized.

Quartz-hornblende-plagioclase porphyry (QFP) dikes and sills crosscut folded and penetratively deformed sedimentary rocks of the Takwahoni Formation in the vicinity of Snow Peak (Moynihan and Logan, this volume). Field relations indicate that the dike swarm is crosscut by the Early Paleocene Snow Peak pluton and is therefore older than 64.4 ±0.5 Ma. A lower age constraint for emplacement of these post-tectonic dikes is evident in Ross Creek where they can be seen crosscutting footwall Takwahoni Formation and hangingwall serpentinite of the King Salmon Fault. Southwest-directed motion was active between early Toarcian and middle Bajocian (Tipper, 1978), suggesting intrusion was after ~170 Ma.

Similar white weathering hornblende-bearing quartz plagioclase porphyries are located in the eastern portion of the map area. At one location well-foliated listwanite in the hangingwall of the fault has been intruded by a nonfoliated hornblende-plagioclase porphyry dike with a preliminary U-Pb age of 155.2 ±1 Ma (personal communication, Paul O'Sullivan, 2011).

STRUCTURE AND METAMOPRPHISM

The King Salmon fault is the dominant structure in the area, oriented approximately east it marks the boundary between the Cache Creek and Stikine terranes. The trace of the fault is marked by a number of small ultramafic bodies (listwanite and/or serpentinite) that range in size from 10s to 100s of metres. Rocks to the north of the KSF are penetratively foliated and have undergone extensive metamorphic recrystallization. Actinolite+epidote+plagioclase assemblages in metabasite suggest greenschist facies conditions during deformation.

In contrast, penetrative fabrics are only sporadically developed in Mesozoic units to the south and the rocks have not been fully metamorphically recrystallized. In general, rocks retain their primary volcanic/sedimentary textures, with metamorphic mineral growth restricted to grain boundaries, veins and heavily altered areas. Epidote-quartz veins are widespread and mafic phenocrysts have been variable replaced by epidote and/or chlorite.

Structures in each of the units are described below, in order of decreasing age. Equal area lower hemisphere stereonet projections of the structural data from the Paleozoic Stikine assemblage, Tsaybahe/Stuhini groups, Takwahoni and Inklin formations is presented in Figure 13.

Paleozoic Rocks/Lower Tsaybahe sediments

Southwest-trending folds are outlined by Paleozoic stratigraphy in the area west of the Pallen Creek pluton. The Paleozoic rocks are penetratively deformed, with a northwest-dipping foliation and southwest plunging stretching lineation. Locally, the foliation is overprinted by Z-folds with southwest-plunging axes (Figure 14). These minor folds may be parasitic with respect to larger structures but this was not definitively established. The map-scale folds appear to be truncated by the Paleozoic-Tsaybahe Group unconformity and overlying rocks are not penetratively deformed.

Stuhini Group

Bedding in the Stuhini Group dips predominantly north (Figure 13b), but like the overlying Takwahoni Formation, bedding and stratigraphic contacts are affected by map scale, upright, north-trending folds. Penetrative fabrics are almost completely absent from rocks of the Stuhini Group, though in rare instances a semi-penetrative, north dipping scaly fabric was observed in fine grained volcaniclastic rocks.

Takwahoni Formation

Rocks belonging to the Takwahoni Formation are generally unfoliated, but a mostly north dipping phyllitic foliation is locally developed in fine grained and limy lithologies. In a conglomerate close to the base of the formation, limestone clasts are also flattened parallel to the matrix foliation.

Bedding dips approximately towards the north (NW to NE), but there is considerable variation due to the effects of two phases of folding (Figure 13c). The first phase produced folds trending roughly east, but these have only been observed in the northern part of the formation around Snow Peak (Moynihan and Logan, 2012).

Second phase folds trend approximately north, have steeply dipping axial planes and are generally gentle-open. Metre-scale folds are locally evident (Figure 15), but this fold generation manifests itself primarily in map-scale deflections of bedding and stratigraphic contacts with fold wavelengths of 100s of metres to several kilometres (Figure 3).

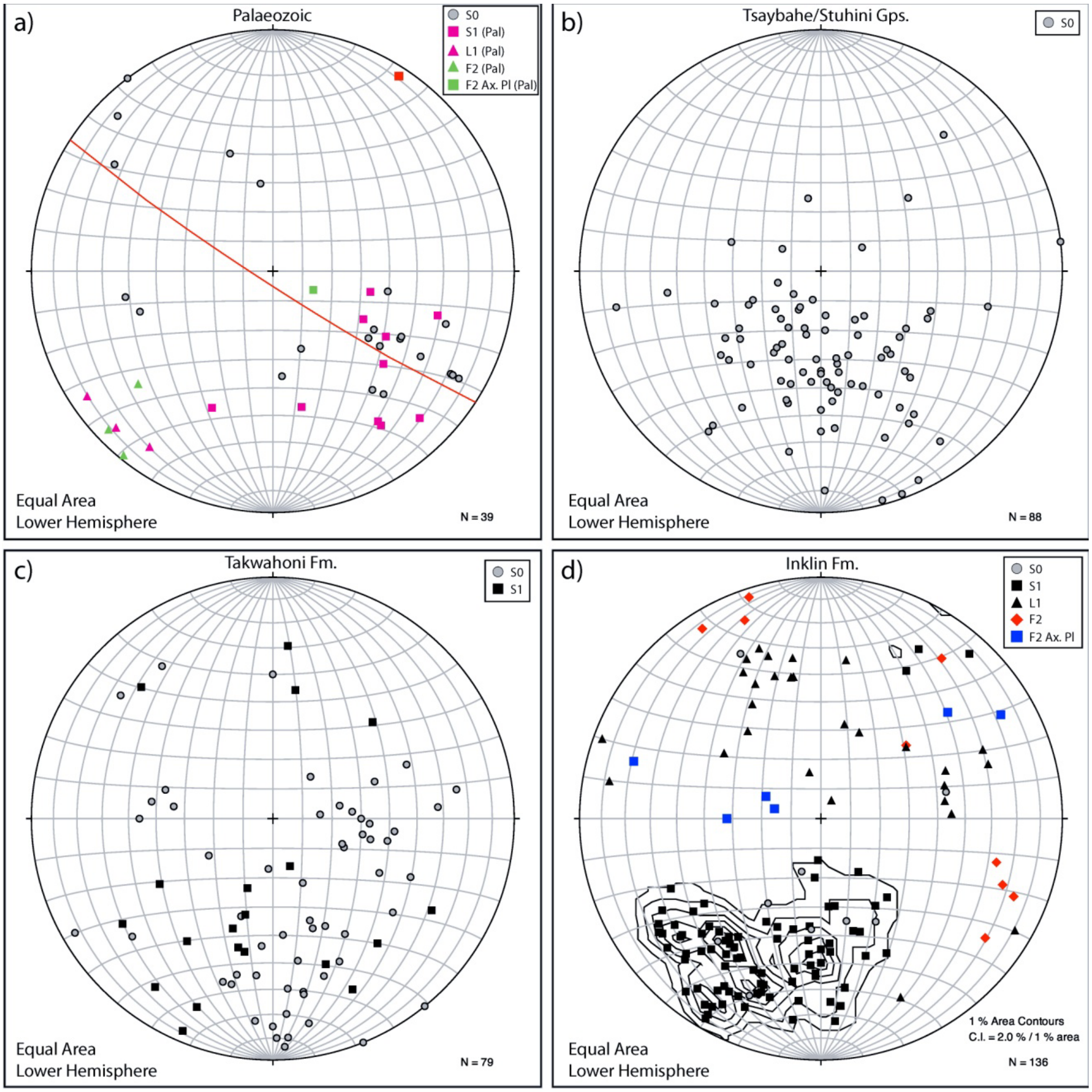

Figure 13. Equal area lower hemisphere stereonet projections of structural data from the Dease Lake and Little Tuya River map areas. a) Paleozoic Stikine assemblage rocks, b) Tsaybahe/Stuhini groups, c) Takwahoni Formation, d) Inklin Formation. The labels S_1(Pal) *etc.* refer to structures that are restricted to Palaeozoic rocks. In a), L_1(Pal) includes intersection and stretching lineations. In d), L_1 includes minor fold axes and intersection lineations.

Inklin Formation

A penetrative tectonic fabric is well developed throughout the Inklin Formation (Figure 13d). Cleavage (S_1) dips mostly to the north and northeast at variable angles and is axial planar to folds that range from open to almost isoclinal. Stretching lineations, defined by aligned metamorphic minerals and stretched limonite spots, plunge approximately down the dip of S_1. The orientation of fold axes (F_1) and intersection lineations (L_1) varies widely, from subhorizontal to steeply pitching, implying the presence of curvilinear fold hinges.

In outcrops in the northern part of the area, intersection lineations have approximately constant orientations over exposed areas 100s of metres long; however, the orientations of fold axes/intersection lineations are more variable in outcrops close to the trace of the King Salmon fault. For example, on Tatsho Creek many folds are tighter than those observed further north (Figures 16a, b). In these outcrops, a relationship was noted between the orientation of fold axes/intersection lineations, and the angle between bedding (S_0) and cleavage (S_1). In places where a high angle between bedding and cleavage is preserved, intersection lineations plunge gently, whereas rocks with subparallel S_0/S_1 have steeply pitching fold axes and intersection lineations. This relationship between fold orientation and tightness suggest that variation in the orientation of folds reflects tightening and rotation of fold hinges towards the stretching lineation during progressive deformation.

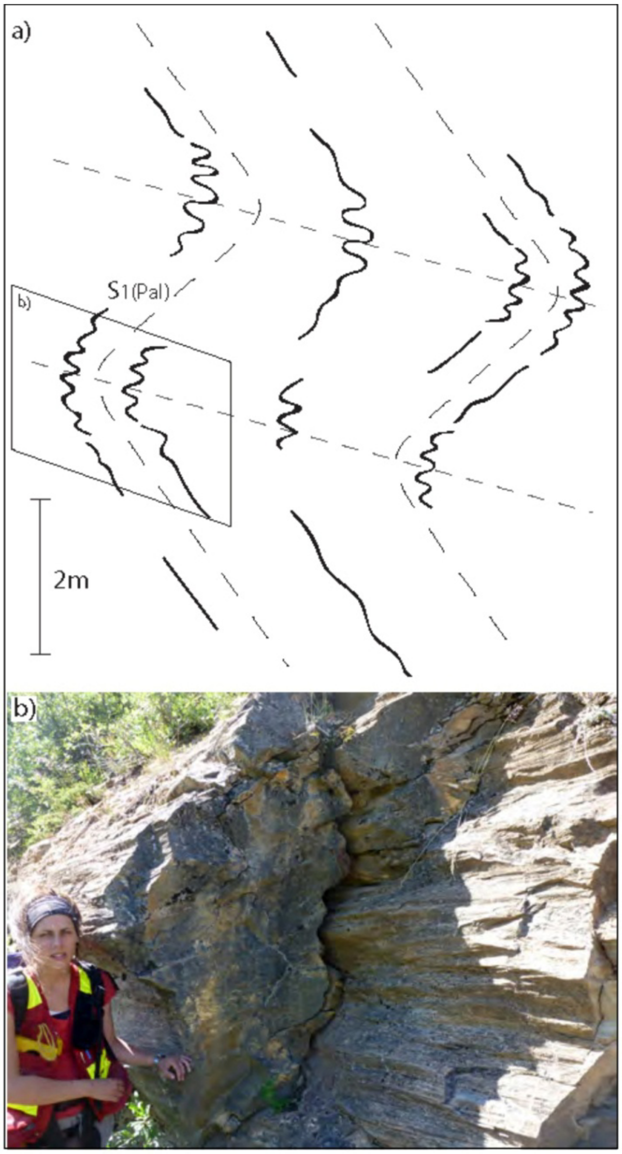

Figure 14. Sketch and matching photograph of (F_2Pal) Z-fold affecting Palaeozoic limestone in upper Itsillitu Creek. Sketch viewed down-plunge towards the southwest (approximately 225°).

The contrast with structures in the Inklin Formation observed further north suggests an increase in strain towards the King Salmon fault.

The dominant cleavage (Sn) in the Inklin Formation is widely overprinted by sets of conjugate kink-bands (F_2) with gently plunging chevron kink axes (Figures 16d, e). Millimetre to centimetre-scale kink bands are commonly visible, and larger scale kinks can be inferred from variations in the orientation of S_1 between outcrops. Locally, the hinge zones of kink folds are marked by minor faults.

Listwanite and mafic rocks of Cache Creek

Outcrops of listwanite along the trace of the KSF are massive to foliated. The foliation dips moderately steeply towards the north, parallel to foliation in the adjacent Inklin Formation. The foliation in the listwanite is locally

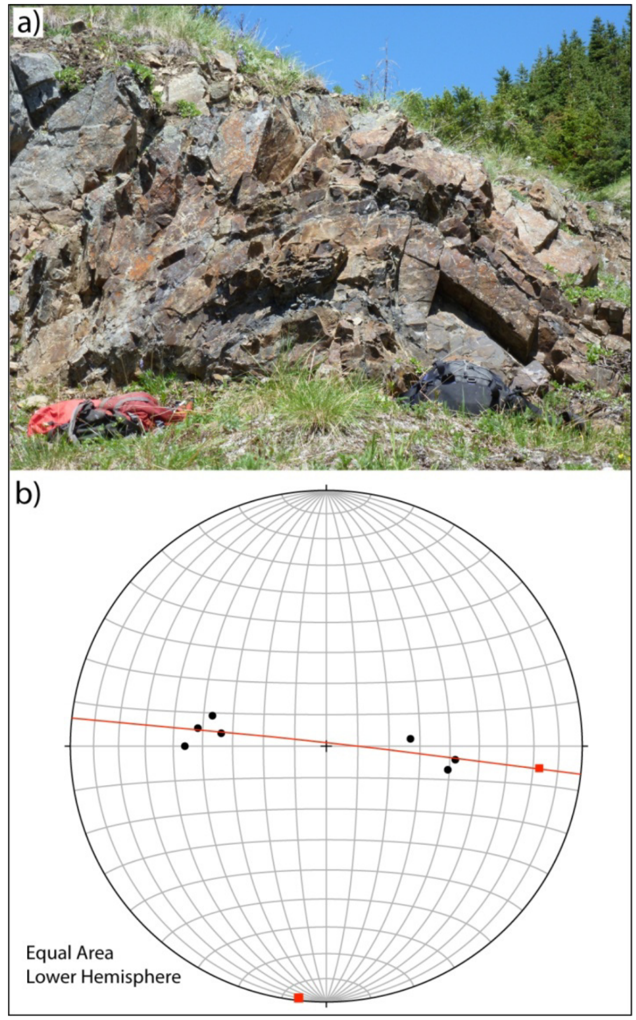

Figure 15. a) North-trending fold in the Takwahoni Formation south of Snow Peak. b) Equal area lower hemisphere stereonet projection of poles to bedding.

tightly folded around gently plunging axes, with axial planes parallel to the overall orientation of the foliation (Figure 17). Metabasaltic rocks on the north side of the KSF are also foliated, whereas limestone of the Sinwa Formation is mostly thoroughly recrystallized and massive. Rare darker argillaceous layers within the mainly white limestone define a weak wavy foliation.

The metabasalts are massive competent units and rarely possess a well developed penetrative foliation, however the overlying block and lapilli tuff breccia unit is well foliated. The foliation dips moderately steeply to the north with trends that swing northwesterly to follow the trace of the fault.

Summary

Penetrative deformation is largely restricted to Paleozoic rocks and to the region north of the KSF, whereas the whole area was affected by late east-west shortening. It appears that folding and penetrative deformation in the Paleozoic rocks (termed D_1PAL) predated deposition of Mesozoic units. Although this is based on limited data from a small part of the map sheet it

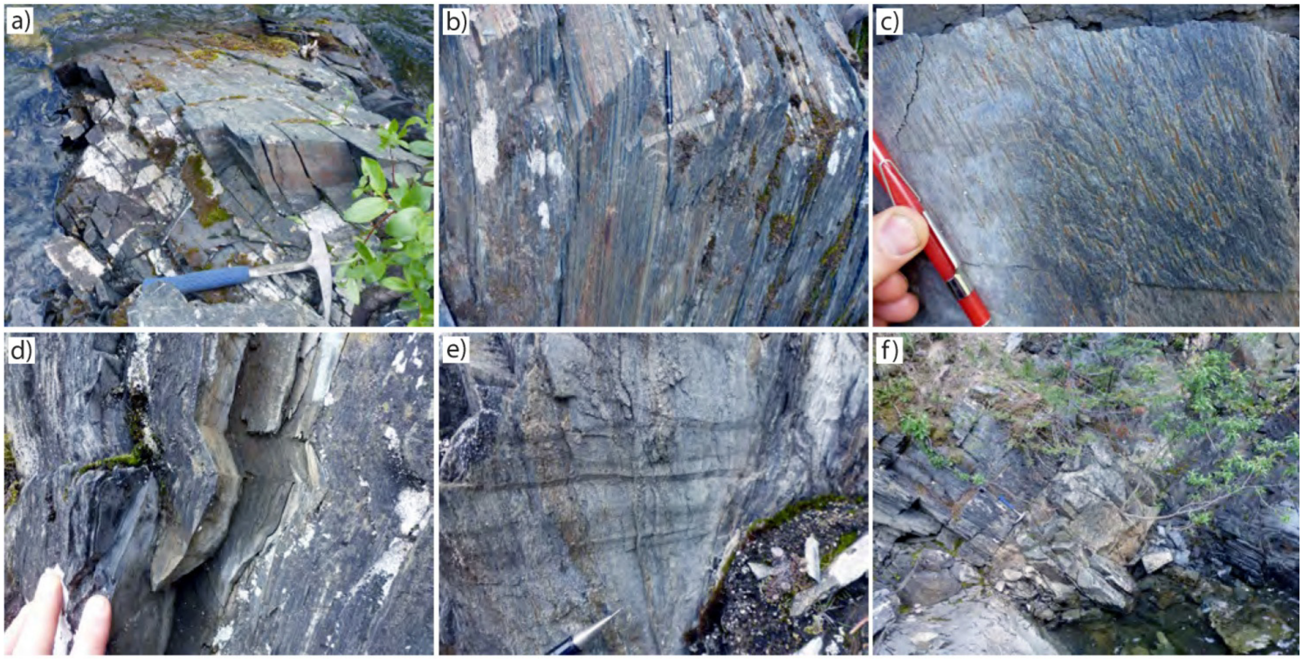

Figure 16. Structures in the Inklin Formation. a) Open fold with axial planar cleavage, northern Tatsho Creek. b) Parallel bedding and cleavage in outcrop close to the trace of the KSF. c) Stretching lineation in phyllite defined by elongate limonite aggregates. d) Profile view of kink fold (F_2) with subhorizontal axial plane overprinting the phyllitic foliation. e) F_2 kink folds viewed looking onto the S_1 surface. f) Diorite dike crosscutting phyllite of the Inklin Formation, northern Tatsho Creek.

Figure 17. a) Conspicuous green Cr-rich sheet silicate in listwanite along the trace of the KSF, Tasho Creek. b) North-dipping foliation in listwanite along the trace of the KSF, Tatsho Creek. The foliation is parallel to that in the adjacent Inklin Formation. c) Tight fold with gently plunging axis in listwanite on Tatsho Creek. The axial plane is parallel to the north-dipping foliation that is developed throughout the outcrop.

corroborates similar conclusion made by Read *et al.* (1983) for a late Permian or Early Triassic deformation and metamorphic event.

Post Triassic-pre Early Jurassic regional deformation is marked by the angular unconformity separating Late Triassic Stuhini Group from the Early Jurassic Hazelton Group in the Unuk River (Henderson *et al.*, 1992), Schaft Creek (Logan and Drobe, 1993), Strata Creek (Brown *et al.*, 1996) and Stikine River (Read, 1984). In addition, Early Jurassic granitic boulder conglomerates and sandstones nonconformably overlie late Triassic plutons of the Hotailuh batholith (Anderson, 1983).

However, the earliest Cordilleran deformation event which produced penetrative deformation (D_1) in the Cache Creek terrane, in the adjacent Takwahoni Formation and juxtaposed these units along the KSF was during the Middle Jurassic (Gabrielse, 1998). This area forms part of the south-vergent fold and thrust belt that formed during amalgamation of the Cache Creek and Stikine terranes in the Middle Jurassic (Gabrielse, 1998; Mihalynuk *et al.*, 2004).

The age of the north-trending folds that give rise to map-scale undulations in stratigraphy has not been established in the map area. Late north-trending folds in the Inklin Formation were identified by Gabrielse (1998) in the Dome Mountain area to the east. Ryan (1991) described north-trending folds in the Tuya River basin, to the west of the mapped area. These folds, which may be correlative with those observed, affect Tertiary sedimentary rocks.

MINERALIZATION

Metallic mineral occurrences within the map area include two alkalic porphyry Cu-Au prospects located south of the Tanzilla River in massive volcaniclastic rocks of the Stuhini Group. A porphyry Mo-Cu-W prospect (Mack; MINFILE 104J 014) within the Cretaceous Snow Peak pluton that intruded Takwahoni strata near the headwaters of Sixteen Mile Creek. Ag–Pb–Zn±Au quartz vein showing (Mac; MINFILE 104J 064) is associated with dikes cutting Takwahoni sedimentary rocks west of the Mack prospect. The Hu alkalic porphyry Cu-Au prospect (MINFILE 104J 013) is associated with an east-trending multiphase monzosyenite-granodiorite intrusion adjacent to the Hleuy Lake hydroelectric power station. The Tan showing (MINFILE 104J 036) is related to a southeast-trending composite pyroxenite-hornblendite-monzonite body (Table 1).

Geochemical rock samples (n=15) characterizing alteration and base and precious metal mineralization were collected during the course of mapping. These were analysed for 41 elements by Inductively Coupled Mass Spectrographic analyses (ICP-MS) and Au by fire assay fusion and ICP-ES at Acme Labs in Vancouver, British Columbia. The concentrations of Au plus a number of selected intrusive-related mineralization pathfinder elements from these samples are tabulated together with their location information in Table 2.

Regional Lithogeochemical Sampling

The King Salmon fault is characterized along its length by pods of carbonate altered ultramafic rocks that consist of a listwanite assemblage of rusty orange quartz-talc-carbonate-chrome bearing sheet silicate (mariposite or fuchsite) and locally iron sulphides. Listwanite alteration is structurally controlled along faults and fracture systems that provide pathways for CO_2-rich fluids and this alteration is well known for its association with lode gold mineralization (Ash and Arksey, 1990; Dubé and Gosselin, 2007). Grab samples of listwanite alteration were collected from three separate outcrops exposed along the King Salmon fault (Figure 3). As expected, geochemical analyses returned high Ni, Co and Cr values characteristic of ultramafic rocks and in addition elevated Sb and As values, however precious and base metal values are low to below detection levels at all three sites (11JLO8-65, 12-105 and 29-296-3; Table 2).

Hu, Huey (MINFILE 104J 013)

The Hu is located on the Tanzilla Plateau approximately 2 km northwest of Hluey Lakes. It extends northward onto the steep north-facing slope of the Tanzilla River. The area is underlain by well bedded sedimentary rocks, massive volcaniclastic rocks and maroon basalt and latite of the Stuhini Group that was intruded by a hornblende biotite granodiorite and younger pink weathering variably textured porphyritic biotite monzosyenite. The monzosyenite intrudes and alters the granodiorite along the northeastern contact exposed in Stain Creek. The granodiorite and syenite were assigned an Early to Middle Jurassic age by Gabrielse (1998), however other workers (Sellmer, 1973; Kasper, 1991) thought these intrusions were older and correlated them with the Late Triassic to Middle Jurassic Hotailuh batholith (Anderson, 1983). The Huey syenite is mineralogically similar and likely correlative with the potassic phase of the Three Sisters pluton (see van Straaten, this volume).

The most favourable alteration and mineralization on the Hu property is exposed along Stain Creek where monzosyenite and granodiorite have intruded sedimentary and volcanic rocks of the Stuhini Group. Alteration, including K-feldspar and carbonate are concentrated along northeast trending brittle faults and the intrusive contact between monzosyenite and granodiorite. Grab samples from an altered mineralized syenite (11JLO28-285) and pyritized hornblende granodiorite (11JLO-28-287) returned elevated Cu values only for the former (Table 2). Although, chip samples as high as 1.7 g/t Au, 6.9g/t Ag and 0.03% Cu and grab samples 1.3 g/t Au, 5.6g/t Ag and 0.03% Cu are known from this area (Kasper, 1991). Fractured, heavily altered and chalcopyrite mineralized argillite and maroon volcaniclastic rocks occur north and south of the monzosyenite (11DMO33-284 and 35-309; Table 2). This mineralization includes chalcopyrite-bearing quartz-carbonate veins and replacement sulphides in laminated siltstones.

Table 1. MINFILE BC mineral occurrences for Dease Lake NTS 104J/08 and the east-half of Little Tuya River NTS 104J/07 map areas.

MINFILE NO	NAME	STATUS	ZONE	UTMN	UTME	COMMODITIES	DEPOSIT TYPE
104J 013	HU, HUEY	PROS	9	6467707	430291	Cu, Au, Mo	Alkalic porphyry Cu-A
104J 014	MACK, SNOW PEAK	PROS	9	6480395	417285	Mo, Cu, Au, Wo	Porphyry Mo
104J 036	TAN	SHOW	9	6463105	418615	Cu	Alkalic porphyry Cu-A
104J 064	MAC	SHOW	9	6482412	413015	Au, Ag, Zn, Pb, Cu	Polymetallic veins
104J 154	BUD	ANOM	9	6481956	408947	Au	-
104J 041	TATSHO MOUNTAIN	SHOW	9	6477888	439393	LS	Limestone
104J 044	TUYA RIVER	PROS	9	6457905	398643	CL	Bituminous coal

Table 2. Selected elements from Inductively Coupled Mass Spectrographic analyses (ICPMS) of samples collected in the Dease Lake area.

Sample Number	Location		Lab Number	Ag	As	Au	Ba	Bi	Cd	Ce	Co	Ca	Cr	Cu	Fe	K	Mn	Mo	Ni	Pb	S	Sb	Sn	Th	W	Y	Zn	Zr
	UTM Zone 9		Detection Limit	0.1	1	2	1	0.1	0.1	1	0.2	0.01	1	0.1	0.01	0.01	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1
	UTME	UTMN	Measure unit	PPM	PPM	PPB	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	%	%	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM
OIV-3-38	428828	6E+06	62149	<0.1	2	3	308	<0.1	0.2	10	39.5	8.16	204	102	6.56	1.42	1485	3.1	43.2	5.8	1.5	0.1	0.6	0.7	<0.1	12.9	80	27
JLO-8-65	436103	6E+06	62145	<0.1	82	<2	7	<0.1	<0.1	<1	56.4	0.29	831	4.6	3.13	<0.01	499	0.2	1132	0.2	<0.1	8.9	<0.1	<0.1	0.3	0.2	28	<0.1
JLO-12-105	423171	6E+06	62146	0.2	64	4	87	<0.1	0.2	<1	54.4	0.22	883	6.6	4.21	0.27	735	<0.1	824	0.7	<0.1	5	<0.1	<0.1	0.2	0.5	26	<0.1
LDI-19-164a	424421	6E+06	62147	<0.1	31	21	64	0.2	0.2	70	48	3.66	173	39	6.44	1.08	581	0.3	131	4.6	2.7	1.4	2.9	2.2	0.4	19.6	56	95
LDI-19-164b	424421	6E+06	62148	<0.1	3	14	141	0.2	0.3	80	42.1	9.71	139	41.7	7.56	3.54	737	<0.1	115	4.8	2.4	1.4	3.1	2.7	0.3	29.2	77	44
JLO-24-244-2	417876	6E+06	62150	<0.1	3	7	566	<0.1	<0.1	11	27.4	5.34	12	158.1	6.64	1.2	1377	0.3	9.6	1.1	<0.1	0.6	0.6	0.7	0.5	15.7	62	44
JLO-24-249	417295	6E+06	62151	<0.1	7	<2	170	<0.1	0.2	14	21.5	9.34	71	113.4	4.95	0.48	1167	1.7	20	1.2	0.6	0.2	0.5	1	1.7	19.2	77	46
JLO-28-285	430650	6E+06	62152	<0.1	10	21	1490	0.1	0.2	84	17.2	3.21	17	1216.6	6.13	4.22	533	6.7	7.3	2.9	<0.1	2	2.2	22	1.7	23.5	36	278
JLO-28-287	430492	6E+06	62153	<0.1	13	4	199	0.1	0.1	65	24.1	3.1	17	127	6.18	3.78	995	1.8	8.2	7	1.3	2	1.9	13.5	1	22.2	32	104
JLO-29-296-3	431174	6E+06	62154	<0.1	108	<2	47	<0.1	0.1	<1	58.5	7.21	971	9.7	4.06	0.01	685	0.6	1208	0.1	<0.1	7.6	<0.1	<0.1	0.9	0.3	35	0.5
JLO32-319	451832	6E+06	62156	0.6	5	41	510	0.1	0.2	16	7.5	0.48	32	7221.4	1.26	5.76	221	16.7	3.7	6.9	0.5	1	0.6	1.8	0.6	7.8	32	24
DMO-6-49	415975	6E+06	62157	0.1	26	<2	20	<0.1	0.1	5	5.8	12.5	15	37.6	3.63	0.03	877	0.2	4.8	0.9	<0.1	0.2	0.3	0.3	0.5	8.4	27	23
JLO50-501 (BLK)	-	-	62158	<0.1	<1	<2	3	0.1	<0.1	<1	0.8	<0.01	215	17.3	0.35	<0.01	15	0.2	6.4	0.7	<0.1	<0.1	0.2	<0.1	<0.1	0.2	1	<0.1
DMO-33-284	427351	6E+06	62159	0.3	81	10	18	0.3	<0.1	7	141	10.5	116	1120.9	16.1	0.03	2709	1.8	61.5	9.7	4.8	6.5	1.1	1	0.4	24.5	41	70
DMO-35-309	430125	6E+06	62160	<0.1	7	7	338	0.5	<0.1	30	19.8	3.78	86	>10000.0	6.66	1.51	1090	0.8	5.8	2	1.3	5.9	1	1.5	12	18.7	12	48
DMO-35-309Dup	430125	6E+06	62155	<0.1	9	9	192	0.6	<0.1	28	20.4	3.42	82	>10000.0	6.87	1.46	1098	0.9	5	1.6	1.5	5.8	0.9	1.4	14	18.1	13	45
Reference Materials																												
STD OREAS24P	-	-	STD	<0.1	2	-	271	<0.1	0.2	36	45.7	6.01	196	45.3	7.22	0.66	1075	1.1	137	3.2	<0.1	0.3	1.5	2.8	0.4	20.3	108	134
STD OREAS45C	-	-	STD	0.1	10	-	272	0.2	0.1	52	97.8	0.46	925	591.2	18.5	0.34	1113	2.6	302	25	<0.1	0.8	3	10.7	1.2	12.1	79	173
Blank	-	-	BLK	<0.1	<1	<2	<1	<0.1	<0.1	<1	<0.2	<0.01	<1	<0.1	<0.01	<0.01	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1

Tan showing (MINFILE 104J 036)

At the Tan showing a large gossan has developed within cherty siltstone and fine sandstone of the well bedded sedimentary unit of the Stuhini Group adjacent to its northwest trending faulted (?) contact with the composite pyroxenite-hornblendite-monzonite pluton. Grab samples from weakly altered and mineralized volcanic rocks were collected in the vicinity of the Tan showing. One comprised a plagioclase phyric basaltic andesite (11JLO24-244-2) the other an aphyric mafic lapilli tuff (11JLO24-249), both samples contained disseminated pyrite and chalcopyrite but returned low metal values (Table 2).

Mac (MINFILE 104J 064)

The Mac showing is located approximately 3 km west of Snow Peak pluton on the edge of a circular magnetic high centered on the intrusion. The magnetic high extends several kilometres beyond the intrusion and is interpreted to reflect pyrrhotite within hornfelsed country rock developed peripheral to the intrusion and evident on the first vertical derivative of the total field magnetic. Mineralization at the Mac is quartz vein hosted and associated with easterly trending quartz feldspar porphyry (QFP) dike swarms which are common in the area. These dikes and presumably the mineralization at the Mac predate intrusion of the Snow Peak pluton and development of the hornfels. Pyrite, galena, chalcopyrite ±galena, sphalerite and tetrahedrite in decreasing order of abundance are reported to occur within the quartz veins and as selvages in altered country rock. ICP-ES analyses of quartz veins and mineralized QFP dikes returned elevated base and precious metal values and up to 26.8 g/t Au and 137.1 g/t Ag from grab samples (Swenson, 2006).

Mack (MINFILE 104J 014)

Late Cretaceous Mo and Cu-Mo mineralization is a well-established Cordilleran-wide metallogenic event. Porphyry Mo±Au, W mineralization is present in the Cretaceous Snow Peak pluton (Gabrielse, 1998) and is described in a separate paper by Moynihan and Logan (this volume).

Coal and Limestone

Along Tuya Creek, at the southwestern margin of the map (Figure 3) from 5 to 30 m of high volatile B bituminous coal occurs within the Lower Tertiary, Paleocene sediments of the Tuya River coal basin (Ryan, 1991). The Tuya River (MINFILE 104J 044) prospect was not visited during the current mapping program.

Massive white limestone (Tatsho Mountain, MINFILE 104J 041) forms a west-trending ridge that overlooks the community of Dease Lake north of the airport. The white weathering limestone massif extends for approximately 2.5 km westward towards Tatsho Mountain and is correlated with the Upper Triassic Sinwa Formation.

PRELIMINARY OBSERVATIONS AND CONCLUSIONS

Polydeformed phyllite, greenstone and Early Permian limestone of the Stikine assemblage are overlain by less deformed Early to Middle Triassic cherty sediments and crowded pyroxene porphyry basalt breccias that pass up section through a dominantly volcaniclastic sequence of the Late Triassic Stuhini Group. A progression from proximal volcanic to distal epiclastic rocks northwards is similar to the facies changes observed for Triassic rocks in the Tulsequah map area (Monger, 1980).

Preliminary Laser Ablation U-Pb zircon ages have identified some Late Jurassic and Early Cretaceous thermal events not previously recognized in rocks of the Stikine arch.

Recognition that not all pyroxene porphyritic basalts are Middle or Late Triassic in age, but can comprise identical thick sections in the Jurassic (Brown *et al.*, 1996; Iverson *et al.*, this volume) requires careful mapping and age dating.

The British Columbia Geological Survey Dease Lake Geoscience Project is part of the new QUEST-Northwest Mapping initiative by Geoscience BC. The bedrock mapping project reported on here is one of 4 field-based integrated research projects designed to investigate the stratigraphy, magmatic evolution and metallogeny along the Stikine Arch in the vicinity of Dease Lake. The results of the mapping project will be released as a British Columbia Geological Survey Open File Map and a Geoscience BC publication.

ACKNOWLEDGMENTS

The authors acknowledge contributions from many people regarding various aspects of this study. Discussions with G. Nixon of the British Columbia Geological Survey and B. Anderson of the Geological Survey of Canada where important at the inception stage and ongoing phases of the study and are much appreciated. Capable and enthusiastic assistance throughout the 2011 field season was provided by O. Iverson, M. Hogg, T. McCarron and C. Young. The cooperation and free discussion of geological ideas with various mineral exploration companies made this study possible from its earliest stage. Safe and courteous flying by Pacific Northwest Helicopters in Dease Lake was the norm and much appreciated.

Patricia McIntosh is thanked for opening her home and ranch for the team's use during the summer mapping project and for providing two gracious hosts; cook, J. Anderson and bull cook and local historian D. Callison.

Geoscience BC provided financial support for the field and analytical programs, and salary support for B.I. van Straaten, D. Moynihan, O. Iverson and the field assistants.

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