Terrace Regional Mapping Project, Year 3: Contributions to Stratigraphic, Structural and Exploration Concepts, Zymoetz River to Kitimat River, East-Central British Columbia (NTS 103I/08)

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INTRODUCTION

Now in its third year, the Terrace regional mapping and mineral potential evaluation project focuses on bringing modern geological concepts to bear on the region around Terrace, BC — an area that has seen comparatively little recent exploration-oriented regional geological work (Fig 1; *see* Nelson et al., 2006a; Nelson and Kennedy, 2007a).

Geological mapping in the summer of 2007 has now extended coverage into the Christ Creek map area, 103I/08, continuing south from the Usk (103I/09) area to the north completed in 2005 (Nelson et al., 2006b). Two and a half months were spent in the area, with traverses by four-wheel drive along main roads; on foot, bicycle and horse on decommissioned and overgrown forest roads; and out of helicopter-accessed remote camps on foot and ski, the last made necessary due to exceptional snow levels from the winter of 2006–2007.

The most important new geological and exploration-related observations include

- recognition of an extensive Paleozoic metavolcanic unit that stratigraphically underlies Lower Permian limestone over a strike length of 25 km, from Zymoetz River to Chist Creek and probably beyond;
- recognition of the exploration potential of the Paleozoic volcanic unit, in that it contains broad zones of syngenetic alteration (quartz-sericite schist) accompanied by local occurrences of volcanogenic sulphide occurrences;
- definition of regional northeast-trending folds within the combined Paleozoic to Early Mesozoic stratigraphy;
- delineation of two felsic marker units that serve as a basis for stratigraphy within the Telkwa Formation;
- probably continuation of the Eocene Skeena River detachment fault system into the lowest elevations along Williams Creek, Chist Creek and the Kitimat River.

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PREVIOUS WORK

The first modern geological mapping in the Terrace area is by G. Woodsworth and colleagues (Woodsworth et al., 1985; Gareau et al., 1997a, b; G. Woodsworth, unpublished 1:100 000 scale maps), which has provided an invaluable framework for subsequent study. As part of that project, M. Mihalynuk completed a MSc thesis, which involved mapping of ridges south of the Zymoetz (Copper) River (Mihalynuk, 1987); this, along with his unpublished field maps, gave us a much-appreciated introduction to stratigraphy and structure in the Chist Creek map area.

GEOLOGY

Overview

Stratified units in the Chist Creek map area range in age from pre-Early Permian to Early Jurassic (Fig 2, 3). They include volcanic, volcaniclastic and overlying carbonate strata of the Permian and older Zymoetz Group (Nelson et al., 2006a), overlain by extensive exposures of the mainly subaerial volcanic Howson facies of the Early Jurassic Telkwa Formation (*see* Tipper and Richards, 1976). The sequence is deformed into a broad, regional northeasterly plunging anticline cored by the pre-Permian volcanic unit. On the limbs, faulted panels of Telkwa Formation strata dip to the east and north-northeast (Fig 2, 3). This folded Paleozoic to Early Mesozoic stratigraphic sequence, along with Early Jurassic granitoid rocks of the Kleanza pluton, lies in the hangingwall of the Skeena River fault system. The Skeena River fault system is a zone of regional detachment located within the Skeena River valley, with interpreted early thrust and later, Eocene normal, top-to-the-northeast sense of motion (Gareau et al., 1997a, b; Nelson and Kennedy, 2007a, b). A few outcrops of ductilely deformed metavolcanic and plutonic rocks in the Williams Creek, Chist Creek and Kitimat River valleys probably constitute a continuation of the detachment surface. Undeformed granite and granodiorite of the Williams Creek pluton cuts both the hangingwall panel and the ductilely deformed zones. This pluton is assumed to be of Eocene age, in that it closely resembles the Carpenter Creek pluton in the Usk map area to the northwest.

Stratified Units

ZYMOETZ GROUP

The name Zymoetz Group was proposed by Nelson el al. (2006a) for a section of Permian volcanogenic and marine sedimentary strata overlain by limestone that outcrops

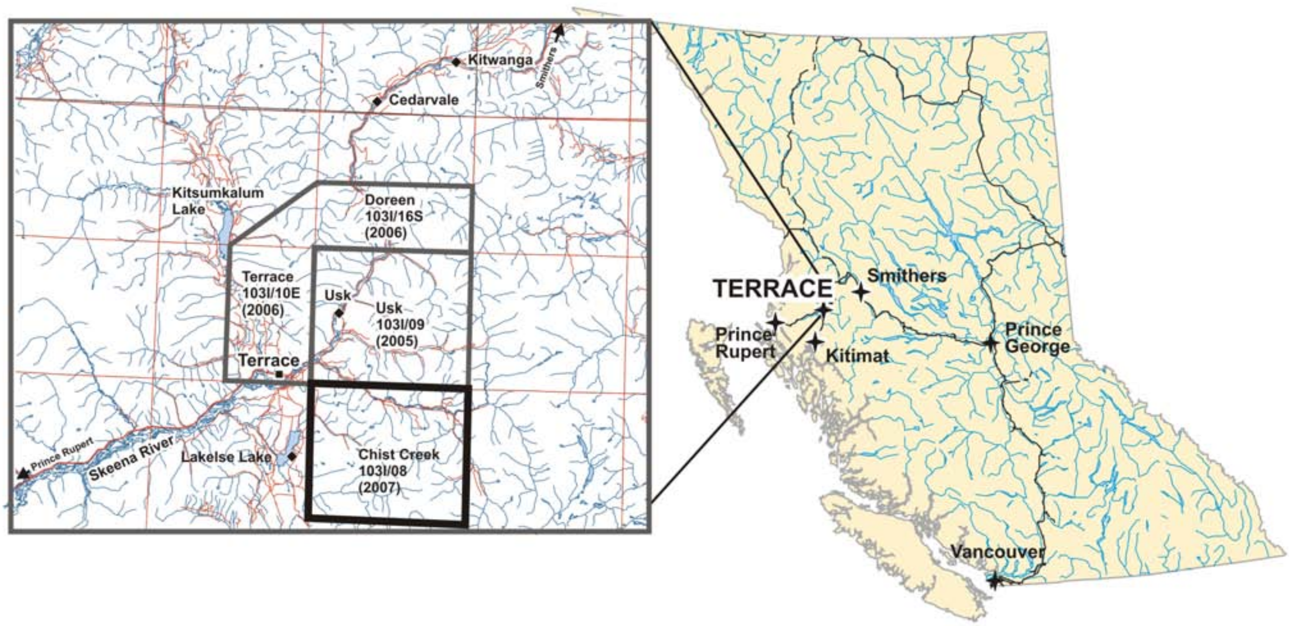


Figure 1. Location of the Chist Creek map area near Terrace, BC.

within and south of the lower Zymoetz River valley in the Usk map area. These strata have now been traced over 25 km to the south in the lower reaches of Chist Creek, and may well extend farther south and west. The Zymoetz Group is divided into two units: a lower, volcanogenic unit named the Mount Attree volcanics, overlain by Lower Permian limestone that is age-equivalent to, and correlative with, the Ambition Formation of Gunning et al. (1994).

Mount Attree Volcanics

This unit is named for Mt Attree, a prominent summit on the ridge between the Zymoetz River and Williams Creek. Its dominant composition is andesitic and it is seen as flows, pyroclastic and epiclastic beds (Fig 4).

On Mt Attree and along the ridge to the east, dark green plagioclase and augite-phyric andesite and basalt flows are interbedded with volcanic breccia and lapilli tuff, with minor marble and calcsilicate layers. At two localities 7 km east of Mt Attree, the upper part of the unit is an unusual succession of rhyolite, quartz-sericite schist, grey cordierite-bearing graphitic phyllite and conglomerate (Fig 2; Nelson et al., 2008). The lower conglomerate beds interfinger with black argillite, phyllite and greywacke; they grade up into fossiliferous calcirudite with siliceous, tuffaceous laminae. Clasts tend to be very well rounded, in contrast to the more subrounded to angular clasts in the basal Telkwa conglomerate rocks. They are dominantly of siliceous composition, a further suggestion of maturity and significant reworking. Clasts include recrystallized chert and argillite, plagioclase-rich dacite, and large, embayed single quartz phenocrysts, enclosed in a variably foliated matrix of sericite, quartz, biotite, actinolite and in some cases, postkinematic andalusite. The high degree of foliation within this sequence contrasts with the limestone above it, and suggests that an episode of deformation affected the unit prior to the deposition of the overlying limestone. North of the present area, tuff within the upper part of the volcanogenic unit have yielded a ca. 285 Ma, Early Permian, U-Pb age (Gareau et al., 1997a).

South of Williams Creek, well-bedded volcaniclastic units — fine-grained andesite, dacite and rhyolite tuff and lesser coarse plagioclase and augite-phyric volcanic breccia — are more abundant than flows. The degree of foliation and metamorphic grade increases towards the south and west. The dark green phyllite that outcrops along Chist Creek was probably the source of its name, as locals pronounce it ‘Schist Creek’. The succession south of Williams Creek contains an upper marker unit composed of thinly bedded epiclastic sandstone, mudstone and tuff; and a lower unit of thin calcsilicate and marble interlayered with tuffaceous phyllite. These units define a gently warped trend (Fig 2). Facing directions along it are to the northeast and southeast, and no structural repetition is indicated. On the ridge between Williams and Chist Creek, a broad area of quartz-sericite schist alteration and strong gossan development occurs within the Mt Attree volcanics (Fig 5).

Although heavily masked by alteration, felsic intrusive and extrusive phases form an integral part of this system, which is described in a separate paper (McKeown et al., 2008). Within the quartz-sericite schist, there are small, widespread areas of base-metal sulphides; and a new showing, the Sub, contains barite as well silica-facies alteration zones that together define a small syngenetic exhalitive system (McKeown et al., 2008).

The Mt Attree volcanics are a newly defined unit that occupies an area assigned to the Jurassic Telkwa Formation on earlier regional maps (cf. Woodsworth et al., 1985). Although some rock types within it, such as plagioclase and augite-phyric andesite breccia, resemble the lower Telkwa, it differs critically from the Telkwa in a number of important respects:

- It is depositionally, probably unconformably, overlain by Permian limestone, which forms a continuous band from the ridge east of Mt Attree, to the ridge west of Flat Top Mountain.
- It contains marble, calcsilicate and black phyllitic units that are incompatible with the terrestrial origin of the Telkwa Formation in this area.

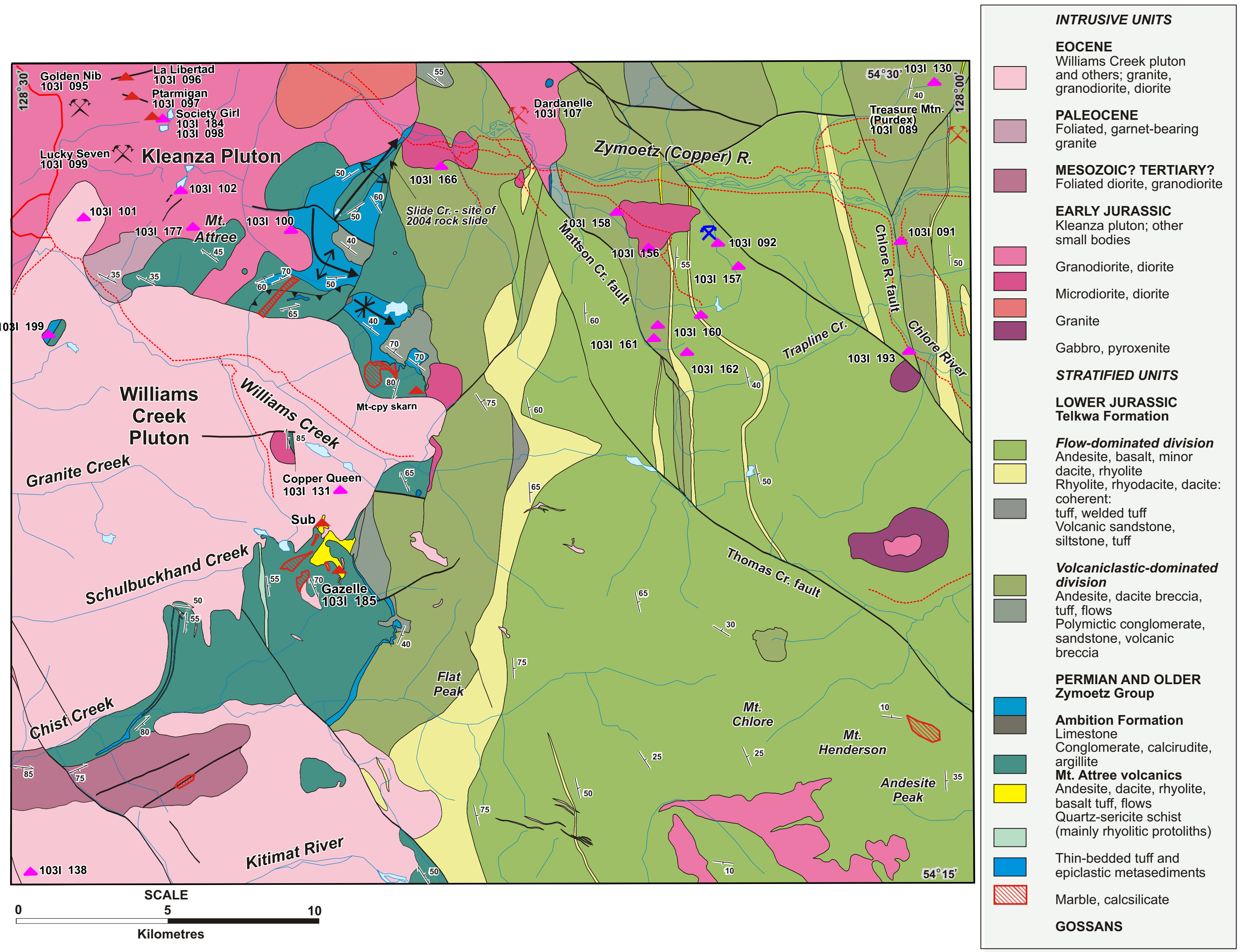


Figure 2. Geology of the Chist Creek map area, compiled *from* 1:20 000 field maps completed in 2007 (Nelson et al., 2008).

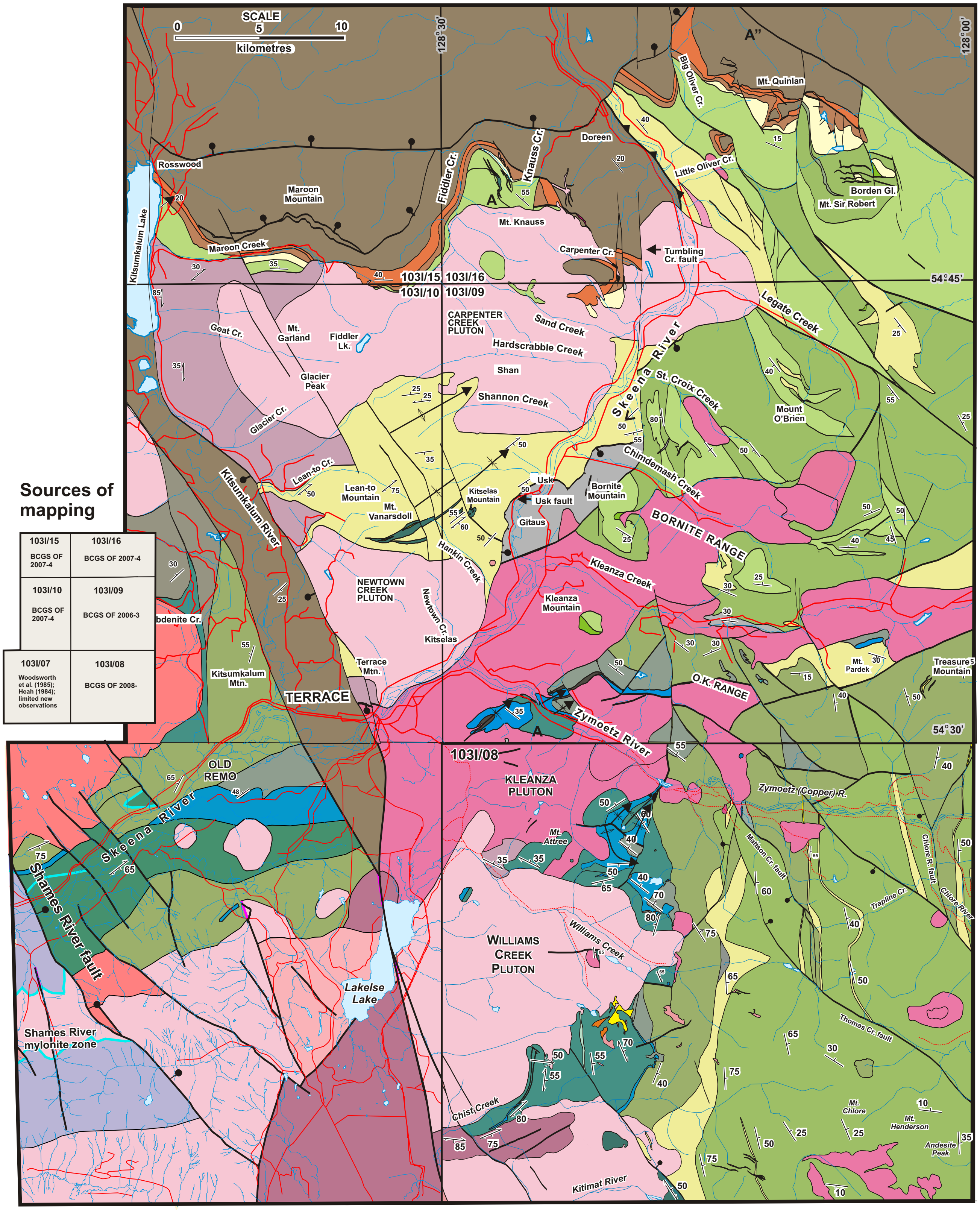
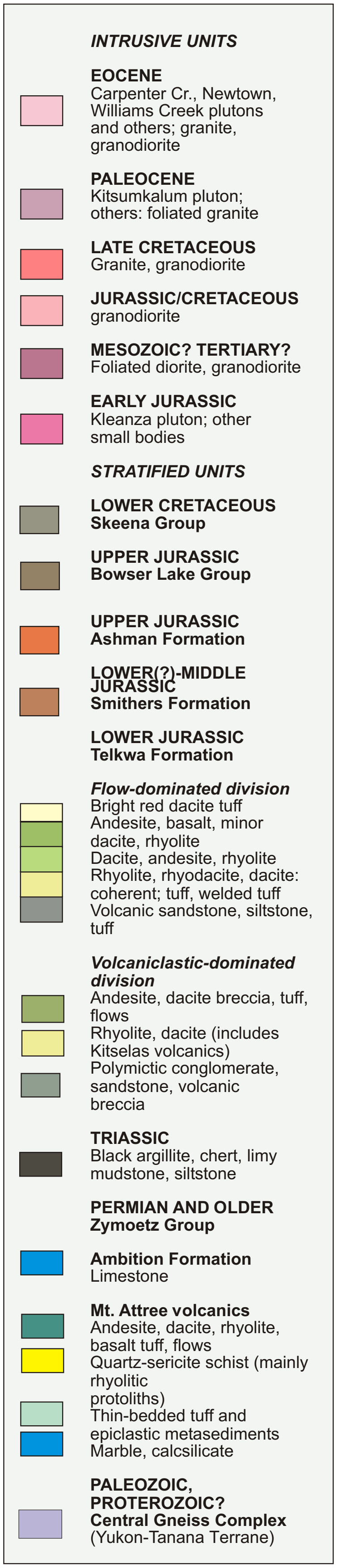


Figure 3. Geology of the Terrace area, compiled *from* field mapping at 1:20 000 scale in 2005 to 2007 (Nelson et al., 2006b; Nelson and Kennedy, 2007b), with additional data *from* Woodsworth et al. (1985) and Heah (1991) via the BC Geological Survey compilation on the MapPlace.



Legend for Figure 3.

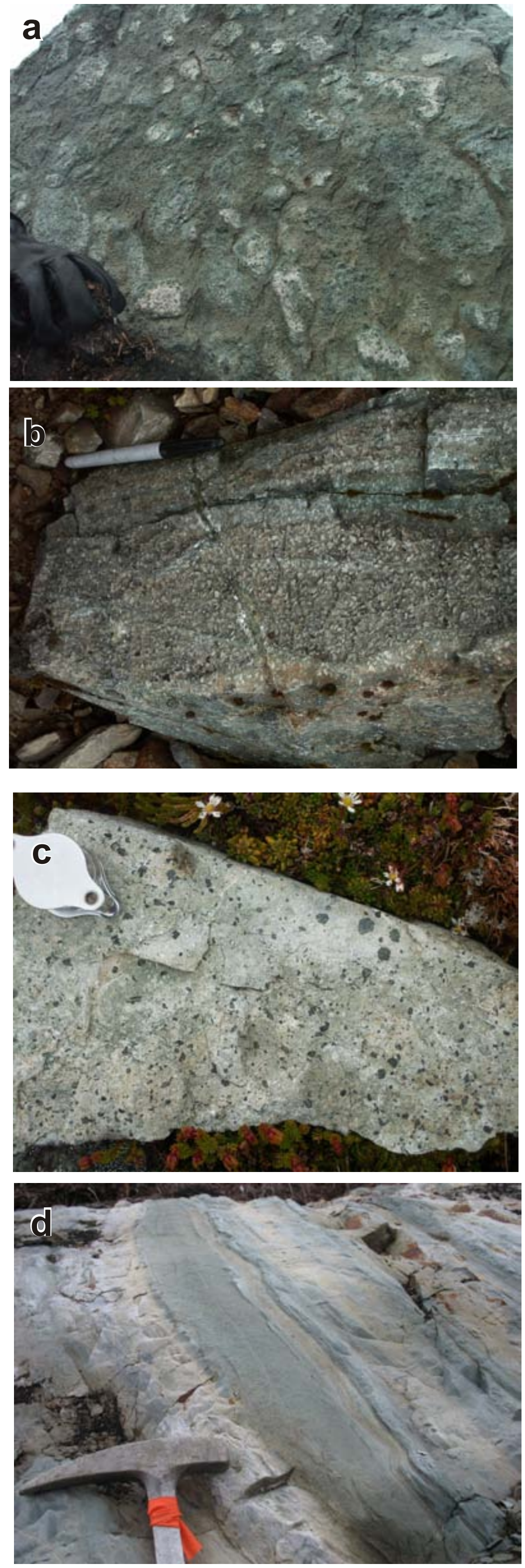


Figure 4. Andesite volcanic variations in the Mt Attree volcanics: a) pyroclastic breccia of augite-plagioclase-phyric andesite clasts, Chist Creek; station 07JK16-1; b) typical plagioclase-phyric coherent andesite, flow on ridge east of Mt Attree; station 07MM18-02; c) augite-plagioclase-phyric coherent andesite, flow on ridge east of Mt Attree; station 07JN17-04; d) bedded andesitic tuff and epiclastic greywacke and mudstone, Chist Creek; station 07JK16-12.

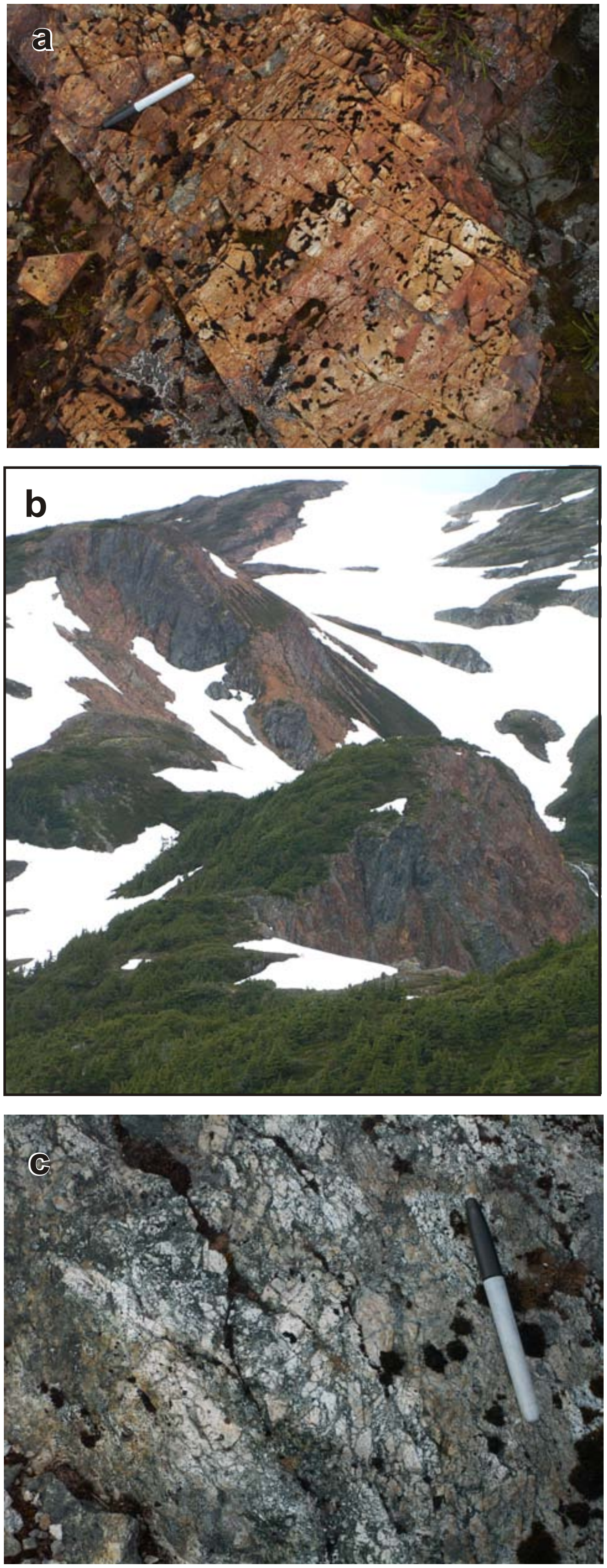


Figure 5. a) Rusty, pyritic quartz-sericite schist in Mt Attree volcanics south of Williams Creek. The protolith is a quartz-phyric rhyolite lapilli tuff. b) Gossanous, pyritic quartz-sericite schist; dark areas are highly silicified. c) Aphanitic rhyolite breccia with chlorite infillings.

- It contains significant areas of quartz-sericite schist, which are absent in the Telkwa.
- It contains rhyolite that is typically quartz-phyric, unlike the dominantly plagioclase-phyric rhyolite of the Telkwa. More siliceous compositions are suggested. The characteristic coarse, polymictic welded tuff of the Telkwa Formation is not present.
- Andesite flows in it contain only small amygdules, if any, in contrast to the large, irregular amygdules that are common in the Telkwa Formation.
- Characteristic stubby, ragged shapes of plagioclase grains in the andesite are unlike the lath-shaped phenocrysts in Telkwa andesite (compare Fig 4b with Fig 7e).
- The degree of foliation within it stands in strong contrast to overlying Telkwa volcanic units, which are completely unfoliated.
- Greenschist to lower-amphibolite grade, synkinematic metamorphic assemblages contrast with the nearby basal Telkwa, which locally contains epidote-actinolite contact-related assemblages but is regionally metamorphosed in zeolite facies (Mihalynuk, 1987).

It should be noted that some conglomeratic units that were included within the Paleozoic section north of the Zymoetz River by Nelson et al. (2006a, b) have been reassigned to the basal Telkwa in current mapping (compare Fig 3, this paper, with Fig 4, Nelson et al., 2006a). Work in 2007 has enhanced our appreciation of the variability within the basal Jurassic conglomerate rocks and reinforced their stratigraphic position above the Permian limestone.

Ambition Formation

A unit of thick, in part richly fossiliferous, limestone outcrops from the Zymoetz River through the ridge east of Mt Attree, across Williams Creek and south to the ridge west of Flat Top Mountain (Fig 6a, b).

Macrofossil identifications by previous workers have identified the limestone as of Permian age (Duffell and Souther, 1964; Woodsworth et al., 1985; Gareau et al., 1997b). It is correlative with the Ambition Formation in the Iskut area of northern Stikinia (Gunning et al., 1994). White and red secondary chert replace beds in some areas and thin tuff beds are present locally, particularly near the base of the unit. North of the Zymoetz River, a mixed carbonate-volcaniclastic facies consists of calcarenite interbedded with limy volcanic sandstone.

The base of the Ambition Formation on top of the Mt Attree volcanics is sharp, with small-scale irregular relief. Pods of limestone within the top few decimetres of the volcanic pile may attest to slumping and the formation of olistostrome deposits, and/or to the deposition of limy material within open spaces in its substrate.

TELKWA FORMATION (HAZELTON GROUP)

Basal Unconformity

The Telkwa Formation lies above an unconformable surface. Bedding-parallel relationships between strata above and below it, for instance between Permian limestone and greywacke in the basal Telkwa, are consistent with a paraconformable contact. Regionally, however, the unconformity bevels through the thin Upper Triassic unit

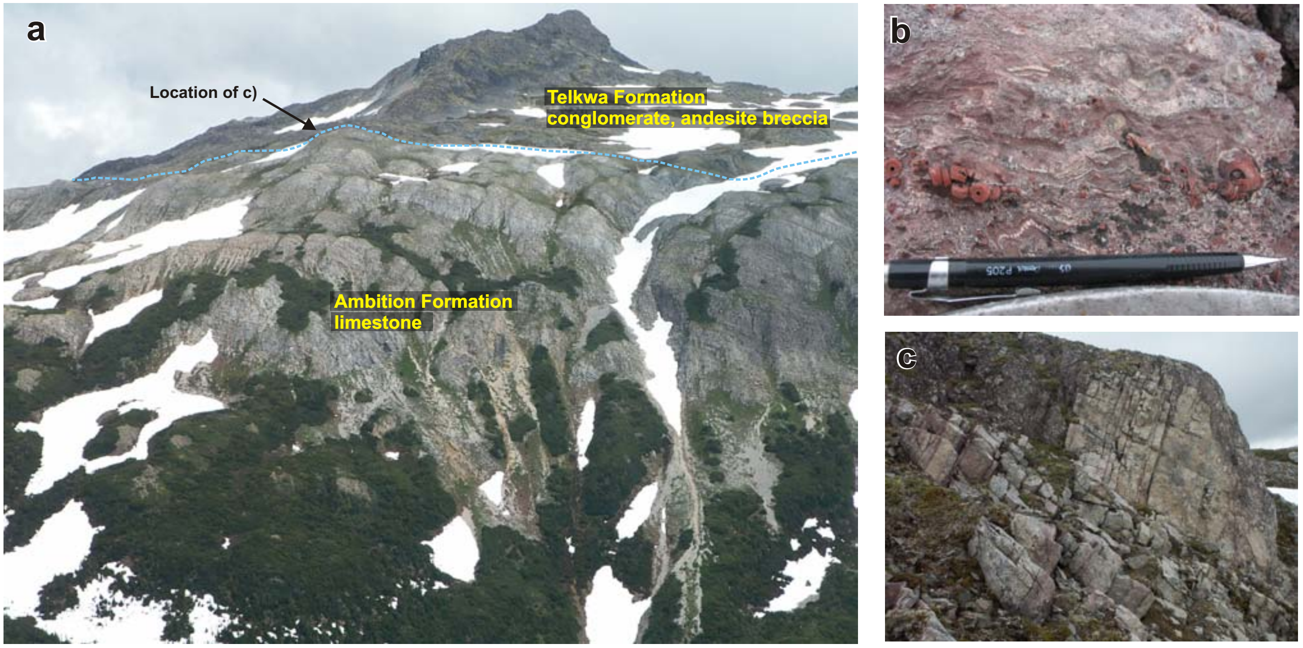


Figure 6. a) Ambition Formation at the headwaters of 8 Mile Creek. Here the well-bedded, fossiliferous limestone is overlain by conglomerate and breccia at the base of the Telkwa Formation. b) Silica-hematite-replaced crinoid segments in limestone. Note the crinoid calyx at the far left; station 07JK24-11. c) Detail of basal Telkwa unconformity. Note the strong relief on contact and the penetration of conglomerate along bedding planes. Overall both limestone and conglomerate dip steeply northeast: this part of the basal contact was originally steep and possibly karst controlled.

north of the Zymoetz River and in part through the Permian limestone. At a number of localities on the ridge east of Mt Attree, Telkwa conglomerate directly overlies the Mt Attree volcanics (Fig 2). In the headwaters of 8 Mile Creek and near Flat Peak, local relief on the unconformity is shown by channels cut into the limestone (Fig 6c).

Lower Telkwa Formation

The lowest unit of the Telkwa Formation, directly above the unconformity, includes both polymictic conglomerate and breccia with sparse thin interbeds of greywacke and, in a few areas, pyroclastic breccia. It grades up into, and interfingers with, polymictic and monolithic volcanic breccia sourced wholly from within the lower Telkwa. The conglomerate is overall polymictic, but in many exposures tends to be dominated by one or a few clast types that reflect local sources. For instance, limestone clasts concentrate directly above the Ambition Formation (Fig 7a), whereas augite and plagioclase-phyric andesite clasts concentrate above the Mt Attree volcanics.

In some clasts, volcanic textures are identical to those in the immediately underlying Paleozoic unit, which identifies them as externally rather than internally derived. Volcanic centres within the lower Telkwa also strongly influence the clastic composition of the conglomerate and breccia, with concentrations of felsic clasts in some areas (Fig 7b), and plagioclase-phyric or plagioclase-hornblende-augite-phyric clasts in others. The breccia in Figure 7c is related to a small dioritic centre at the base of the Telkwa Formation near Williams Creek. Early Telkwa volcanism seems to have been sourced from a series of small, explosive centres, the products of which mixed with clastic deposits.

North of the Zymoetz River and west of Dardanelle Creek, limestone olistrostromes occur, containing blocks up to several metres across. Also present in these conglomerate rocks are black argillite clasts, probably derived from the Triassic beds, and densely plagioclase-phyric andesite clasts with textures similar to those seen in volcanic breccia throughout the lower Telkwa. These exposures are continuous with rocks that were interpreted as Paleozoic (Nelson et al., 2006a, b); however, the conglomerate passes transitionally upwards into typical lower Telkwa pyroclastic units, so they are redefined here as basal Telkwa.

Felsic Marker Units and the Upper Telkwa Formation

As in the Usk map area to the north, the mainly clastic and volcaniclastic lower Telkwa Formation is overlain by an upper, flow-dominated unit. In the Usk map area, the contact is marked by a discontinuous, thinly bedded sedimentary unit of volcanic greywacke and mudstone (Nelson et al., 2006a, b). Here, it is marked instead by a dacite-rhyolite unit of regional extent, the 'lower felsic marker'. There is a higher rhyolite unit within the upper flow sequence, the 'intraflow felsic marker'.

The lower felsic marker is exposed as part of continuous sections along the Mattson Creek logging road and on the road to the repeater tower east of Mattson Creek, on Treasure Mountain, and on remote ridges in the eastern part of the map area. It varies from a few hundred metres to nearly 1 km in thickness. Highly variable volcanic textures (Fig 8a–c) document a widespread felsic volcanic event. There are coherent rhyolite and dacite units with local strong flow banding and even folded flow bands; welded rhyolite tuff; bedded rhyolite and dacite lapilli tuff; and interbedded polymictic andesitic breccia, possibly derived from uplifted parts of the underlying section or from more distant penecontemporaneous volcanic centres.

In the far southern part of the map area, between Chist Creek and the Kitimat River, the lower volcaniclastic Telkwa thins, and andesite flows occupy the section below the lower felsic marker.

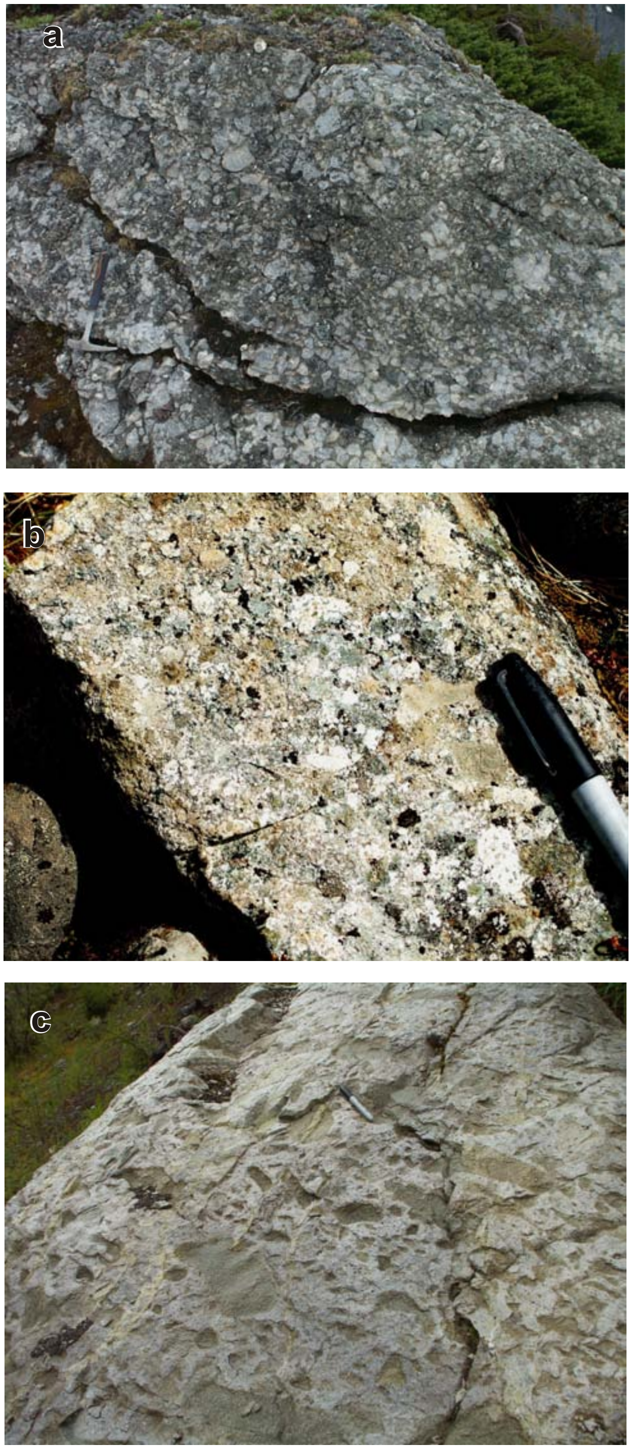


Figure 7. Compositional variations in the lowermost Telkwa conglomerate and breccia: a) limestone breccia, 10 m above Permian limestone, headwaters of 8 Mile Creek; b) breccia dominated by Telkwa felsic fragments, 20 m above Permian limestone, from a ridge northeast of Mt Attree; station 07JN20-3; c) plagioclase-augite-phyric pyroclastic breccia in the lowermost Telkwa Formation south of Williams Creek; note the flattened bombs.

Although a few andesite flows occur within the lower Telkwa, above the lower felsic marker, andesite and lesser dacite flows are dominant. These subaerial flows typify the terrestrial Howson facies of the Telkwa Formation, which extends from this area eastwards into the Howson Range to Smithers (*see* Tipper and Richards, 1976). They are generally plagioclase-phyric, with phenocrysts ranging from millimetre to centimetre scale (Fig 8e). They are also characteristically amygdaloidal (Fig 8d). Amygdules tend to be large and irregular, filled with quartz, calcite, epidote, chlorite, zeolite and rarely piedmontite. In places, zones of them define flow centres and flow tops. Flow breccia is also present, and minor maroon polymictic volcanic breccia is identical to those in the lower Telkwa.

The remote massif of Mt Clore, Mt Henderson and Andesite Peak was unmapped prior to this project (*see* Woodsworth et al., 1985). Through work in 2007, we now assign it to the upper Telkwa Formation. It is underlain by a thick section of moderately to gently dipping andesite, dacite, basalt and rhyolite flows and rhyolitic ash flow deposits, with minor maroon polymictic andesitic breccia and tuff (Fig 8f), intruded by probably comagmatic intermediate plutons (*see* Intrusive Rocks, below). It is a likely candidate for the remains of a major volcanic centre.

Intraflow Felsic Marker

A second felsic unit of regional extent occurs within the upper, flow-dominated part of the Telkwa Formation, between a few hundred metres to 2 km stratigraphically above its base. It outcrops along strike from the repeater tower road in the north, to near the Kitimat River in the south. Its maximum stratigraphic separation from the lower felsic marker is near the Kitimat River, leading to the inference that a volcanic centre was located near there, perhaps in the Clore-Henderson-Andesite massif. This intraflow felsic marker is distinguished from the lower felsic marker only by its position above and below identical, mainly andesite flows. It comprises coherent rhyolite and dacite flows, welded tuff with strong eutaxitic fabrics, and rhyolite and dacite tuff and breccia.

The upper flow-dominated unit of the Telkwa Formation is the highest stratigraphic unit exposed in the Chist Creek map area. Younger units, such as the brick-red tuff of the uppermost Telkwa or Nilkitkwa formations, or the overlying 'pyjama beds' and Bowser Lake Group, are only seen far to the north (Nelson and Kennedy, 2007a, b) near Mt Quinlan, and to the east in the Smithers map area.

Intrusive Rocks

Within the Chist Creek map area, there are at least four inferred generations of plutonic rocks. As there are no modern U-Pb dates from the area, correlations are based on relationships to supracrustal units, and continuity with or similarity to well-dated bodies farther to the north (*see* Gareau et al., 1997a). Representative samples have been collected for U-Pb dating. In order of inferred geological age, the plutonic suites are

- small hypabyssal intrusions related to the Paleozoic Mt Attree volcanics;
- Early Jurassic intrusions, including the large Kleanza pluton and scattered smaller bodies that are probably comagmatic with the Telkwa Formation;

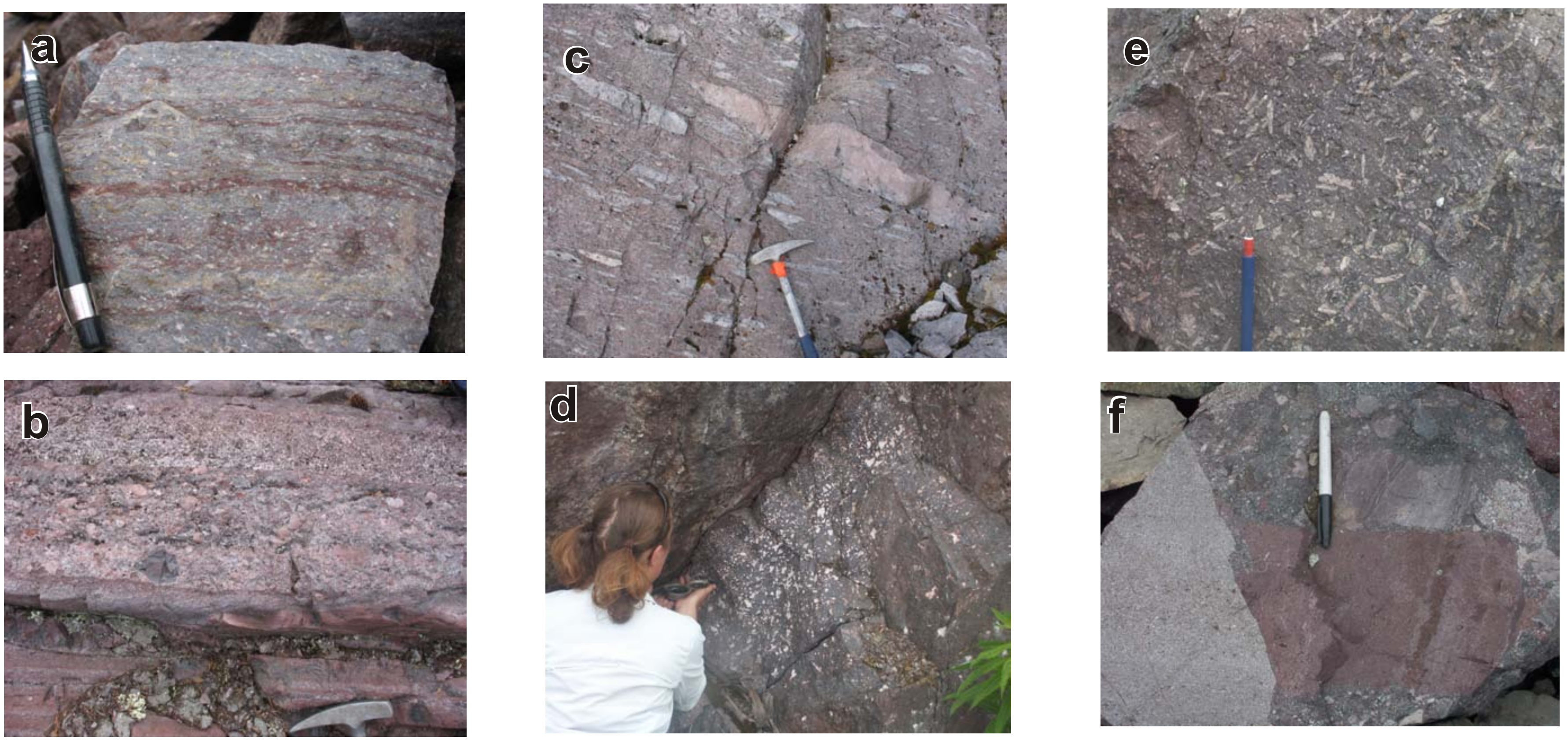


Figure 8. a) Flow-banded plagioclase-phyric dacite, near the base of upper Telkwa Formation, west of Mattson Creek; station 07JK03-04. b) Rhyolite-dacite polymictic lapilli tuff with fine-grained tuff interbeds, lower felsic marker at the base of the upper Telkwa Formation, Mattson Creek repeater road; station 07JK08-07. c) Eutaxitic texture in a welded rhyolite lapilli tuff, in the intraflow felsic marker unit, upper Telkwa Formation; station 07JK44-3. d) Zone of large, irregular amygdules in andesite flow, upper Telkwa Formation; station 07MM05-07. e) Plagioclase megacrystic andesite flow, upper Telkwa Formation; station 07MM05-07. f) Polymictic breccia with second-cycle clasts, upper Telkwa Formation near Mt Clore; station 07JN24-04.

- Cretaceous to Paleocene (?), ductilely deformed, mainly granitic bodies that outcrop at low elevations in the valleys of Williams Creek, Chist Creek and the Kitimat River;
- a large bulbous granitic to granodioritic body of probable Eocene age, the Williams Creek pluton.

PALEOZOIC INTRUSIONS

These are of limited extent, but of an importance that is disproportionate to their size. The rhyolitic volcanic centre that is associated with syngenetic quartz-sericite alteration and base-metal sulphide mineralization in the Mt Attree volcanics south of Williams Creek is partly defined by the presence of white, aphanitic rhyolite dikes and sills, and small, apparently cross-cutting bodies of foliated quartz-feldspar porphyry. One of the latter has been collected for U-Pb dating, and results are anticipated within the next few months.

EARLY JURASSIC INTRUSIVE SUITE

The largest intrusion of this suite is the southern extension of the Kleanza pluton, dated by Gareau et al. (1997a) as ca. 200 Ma, which sprawls along the Zymoetz River and Kleanza Creek to the north (Fig 3). It extends onto Mt Thornhill and the area around 8 Mile Creek. Its southern boundary lies on the slopes north of Williams Creek, where it is cut off by the Williams Creek pluton. As elsewhere, this pluton consists of a variety of phases that range from microdiorite, gabbro and minor clinopyroxene-bearing ultramafite, through coarse-grained tonalite and granodiorite, to quartz-rich granite. Hypabyssal phases that form part of the Kleanza pluton and exhibit transitional relationships to upper Telkwa andesite flows have been documented farther north (Nelson et al., 2006). In the present map area, deeper levels of the Kleanza pluton are exposed.

A number of smaller plutons show more direct ties to Early Jurassic arc-related volcanism in the Telkwa Formation. A small mafic pluton intrudes the base of the formation on the ridge east of Mt Attree. It is texturally highly variable, ranging from gabbro to microdiorite. Intrusive breccia is well developed near its margins (Fig 7c). It is surrounded by andesitic breccia, which grades outwards from monolithic bomb and pyroclastic breccia to more heterolithic breccia with andesite and diorite clasts, and lastly, an uppermost unit of thinly bedded andesitic turbidite overlain by welded tuff of the lower felsic marker. Clearly depicted here is a high-level intrusion and its apron of pyroclastic to reworked epiclastic products. Similar relationships are shown between a small body of microdiorite and porphyritic andesite east of 'Slide Creek', and nearby andesite breccia that contains clasts with identical igneous textures.

There are two small ultramafic to mafic intrusions that intrude the upper Telkwa flow-dominated unit in the eastern part of the map area. The best exposed of the two, located southeast of Moraine Creek, is roughly 1.5 km in diameter. It consists of a thick outer rim of gabbro, diorite and clinopyroxene-rich ultramafite, and a core of plagioclase-rich leucogabbro. The other intrusion is a body of clinopyroxenite and gabbro exposed over a few hundred metres west of the Clore River.

Irregular intrusive bodies outcrop extensively within the Clore-Henderson-Andesite massif (Fig 2). They are generally intermediate to felsic, of dioritic, tonalitic and dacitic compositions. Textures vary from fairly coarse grained equigranular to porphyritic with a very fine grained matrix. They are accompanied by swarms of andesite and dacite dikes, such that the boundary between intrusive and extrusive regimes is difficult to pinpoint. Their outcrop pattern suggests the gently undulating roof of a magma chamber, with gently dipping andesite and dacite flows in its cupola. This massif is interpreted as a volcanic centre, based on its thick accumulation of flows; the presence of an inferred subjacent intrusion strengthens that supposition.

LATE CRETACEOUS-PALEOCENE (?) INTRUSIONS

These are limited in extent, occurring along one logging road on the north side of Williams Creek, near the mouth of Chist Creek and at one locality north of the Kitimat River. They are defined primarily by the presence of strong ductile fabrics. They intrude highly foliated Paleozoic metavolcanic rocks, and both are cut by unfoliated granite of probable Eocene age.

The body in Williams Creek is composed of granite and lesser granodiorite. In a small quarry along the main logging road, it shows strong foliation and metamorphic recrystallization under amphibolite conditions, and transposed igneous layering (Fig 9a). Higher above the valley, the intensity of foliation decreases, but the body is still characterized by clumps of dynamically recrystallized biotite. One phase also contains tiny pink garnets, both single grains and clusters that outline pelitic xenoliths that are now completely resorbed except for these delicate pseudomorphs.

Highly foliated tonalite near the mouth of Chist Creek is more mafic than the Williams Creek granite, but shows a similar texture of wispy, recrystallized biotite aggregates. A metamorphic complex exposed on a logging branch north of the Kitimat River comprises green phyllite allied with the Mt Attree volcanics and also fine-grained metadiorite with pegmatite and aplite dikes and sills.

The occurrence of these strongly foliated intrusive bodies associated with other deformed rocks in topographically low areas is reminiscent of the character and external relations of the ca. 58 Ma Kitsumkalum granite suite within the Kitselas complex (Gareau et al., 1997a, b; Nelson and Kennedy, 2007a). This Paleocene body is interpreted as being emplaced during tectonic unroofing of the complex during early Tertiary detachment faulting. A similar interpretation of these granitoid bodies is explored later in this paper (*see* Structure, below).

EOCENE INTRUSIONS

A large, bulbous undeformed body, mainly of granite and granodiorite, underlies the valley of Williams Creek and the western ridges to the south of it, including the drainage of the eponymous Granite Creek. South of a re-entrant near the mouth of Chist Creek, another salient extends along the valley of the Kitimat River. This body is named the Williams Creek pluton for its extensive exposures there. Its roof is exposed at middle elevations on the ridges north and south of the creek; overall, its geometry is the classic 'balloon' shape typical of granite emplaced into the upper crust.

Compared to the Jurassic Kleanza pluton, the Williams Creek body is compositionally more homogeneous and tends towards more felsic compositions. Most abundant are granite and granodiorite. Textures range from equigranular to inequigranular with euhedral, blocky white plagioclase and/or K-feldspar phenocrysts up to 1 cm in length. Planar pink pegmatite and aplite dikes are common (Fig 9b). Unlike Kleanza granite, biotite in the Williams Creek pluton is more abundant than hornblende, and both are unaltered and fresh. A key identifying characteristic is the presence of small, clear, euhedral, amber-coloured titanite grains.

The Williams Creek body strongly resembles the ca. 53 Ma Carpenter Creek pluton west of the Skeena River (Gareau et al., 1997a; Nelson and Kennedy, 2007a, b). Both are predominantly felsic, both are large, bulbous bodies and both are postkinematic to ductile deformation events. Titanite also occurs in the slightly older Kitsumkalum intrusive suite (Gareau et al., 1997a; Nelson and Kennedy, 2007a). Pending ongoing U-Pb dating, the Williams Creek pluton is assigned a probable Eocene age.

Granitic and granodioritic dikes related to the Williams Creek pluton are widespread, but concentrate near the pluton margins. They crosscut all older units and all fabrics.

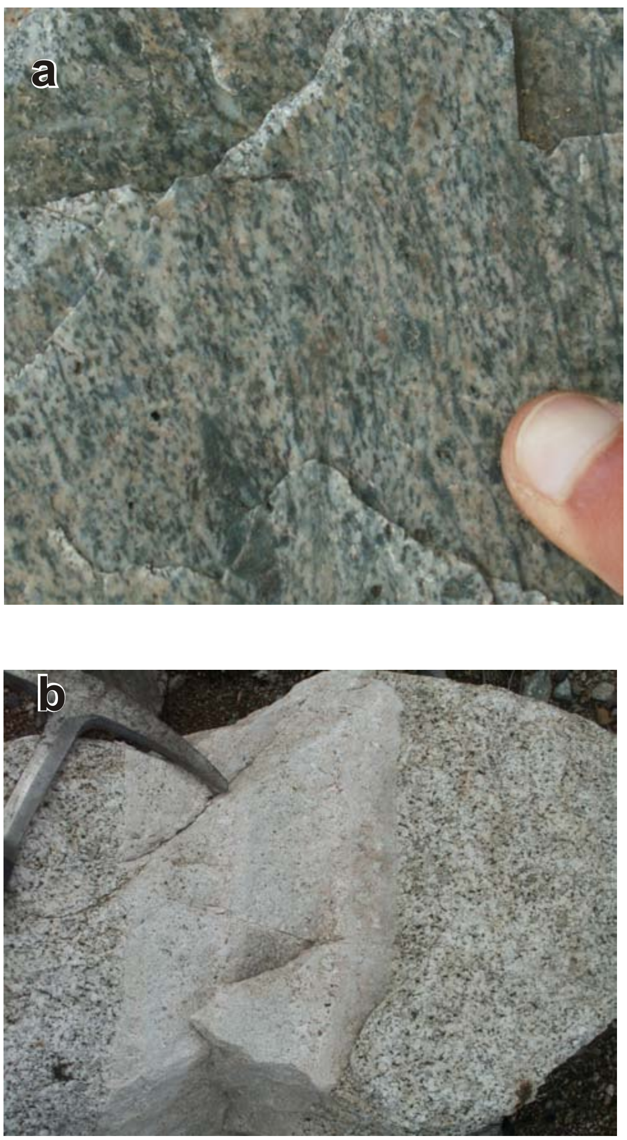


Figure 9. Contrasting Paleocene (?) and Eocene intrusions: a) strongly deformed granite in Williams Creek; station 07JA05-01; b) undeformed, inequigranular granite with a pegmatite dike, Williams Creek pluton; station 07JN11-06.

In addition to felsic plutonic rocks, medium-grained equigranular diorite is abundant south of Chist Creek and near the Kitimat River. Because they are fresh and postkinematic, and are associated with the more typical granite, they are also assigned to the Eocene suite.

Structure and Metamorphism

MAJOR STRUCTURES

The Paleozoic to Jurassic stratigraphic sequence in the Chist Creek map area is deformed into a northeast-trending, regional-scale anticline. Its shape is outlined by the curvilinear outcrop pattern of the Ambition Formation limestone, which strikes north-northeast near Chist Creek, changing to north-northwest on the ridge south of Williams Creek, west-northwest on the ridge east of Mt Attree, and is then deformed into a series of northeasterly plunging folds in the hinge area from 'Slide Creek' into the Zymoetz River valley and on Copper Mountain (Fig 2, 3). The Mt Attree volcanics occupy its core.

An east to east-northeast-striking band of Permian limestone, overlain by Triassic radiolarian chert and limy shale, and then fragmental volcanic rocks of the Telkwa Formation, extends west towards Old Remo (Fig 3). A similar northeasterly striking succession is recognized near the Shames River, although there it may be complicated by thrust faulting (Heah, 1991). However, it is plausible that the northeasterly trending anticline outlined in the Chist Creek area extends west as far as the Shames River fault. Heah (1991) reports a U-Pb age of 331 to 317 Ma from a quartz diorite body east of the Shames River, and G. Woodsworth has obtained a Mississippian age from an intrusion in the eastern Coast Mountains near Kitimat (pers comm, 2006).

Regional attitudes in the Telkwa Formation reflect the east limb and hinge of the anticline. Predominant strikes in most of the Chist Creek map area are northerly, with moderate dips and facings to the east (Fig 3). To the north, across a series of east-west faults, the prevailing strike changes to west-northwesterly, with shallow dips to the northeast; these attitudes are seen over a broad region from near Kleanza Creek in the south to Mt Quinlan and Maroon Creek to the north, with the exception of rotated fault blocks near Mt O'Brien (Fig 2, 3).

A set of northwest-striking faults in the Chist Creek map area repeat the Telkwa stratigraphy. Displacement across them was southwest-side-down and/or dextral, based on offsets of the two felsic markers within the section. Although these faults have strong topographic expressions and significant offsets within the Chist Creek area, they are more or less truncated by westerly faults and elongate apophyses of the Kleanza pluton between the Zymoetz River and Chimdemash Creek (Fig 3).

Doubt has been cast on the imbricated thrust faults shown near the Zymoetz River (Nelson et al., 2006a, b). Detailed remapping of this area has redefined coarse volcanic-derived clastic strata as Telkwa rather than Paleozoic volcanogenic units. It has also shown that structural repeats of Ambition Formation and basal Telkwa conglomerate are separated by the Triassic sedimentary unit, in normal stratigraphic order: they are northeasterly trending folds, not older-over-younger thrust faults. Contrary to Nelson et al.

(2006a), there is no longer a case for post-Triassic, pre-Jurassic thrusting in this area. Deposition of the basal Telkwa was preceded by strong uplift, but not necessarily crustal compression.

North of Terrace, a major low-angle fault system is recognized along the valley of the Skeena River, separating a footwall of metamorphosed Telkwa-equivalent rocks and ductilely deformed Paleocene granitoid rocks to the west from a hangingwall composed of northeast-younging Paleozoic to Upper Jurassic stratified rocks, intruded at lower stratigraphic levels by the Jurassic Kleanza pluton, to the east (Gareau et al., 1997a, b; Nelson and Kennedy, 2007a, b). This, the Skeena River fault system, is expressed as zones of strong ductile deformation and shearing, with superimposed high-angle normal faults. It probably was the locus first of late Mesozoic thrust motion, followed by Eocene down-to-the-east detachment (Nelson and Kennedy, 2007a). Prior to 2007 mapping, its southernmost known extent was near the base of Terrace Mountain, where it separates granitoid rocks with strong ductile fabrics from unfoliated K-feldspar-megacrystic granite that is the western extension of the Kleanza pluton on Copper Mountain.

In the Chist Creek map area, zones of strong ductile deformation occur at low topographic elevations near the mouths of Williams and Chist creeks, and on the north side of the Kitimat River. Strong foliations, and in some cases shears, are developed both in metavolcanic rocks and in granitoid rocks. The postkinematic Williams Creek pluton crosscuts all of them. The zone in west Williams Creek involves garnet-bearing biotite granite of probable Paleocene age that intrudes, and is deformed with, mafic metavolcanic rocks of the Mt Attree volcanics. At the elevation of Williams Creek, the granite is a streaky protomylonite cut by top-to-the-northeast shear bands. Farther up the north slope, it is foliated but not mylonitic. Foliated andesite breccia that it intrudes is identical, except in its higher metamorphic grade and degree of deformation, to the sporadically foliated Mt Attree volcanics on the ridge above. At 400 m elevation above the creek, foliation is weak in the meta-andesite, and undeformed gabbro of the Kleanza pluton occurs. This upward decrease in intensity of deformation and metamorphism is consistent with a position in the immediate hangingwall of a low-angle detachment fault. The fault itself would lie below the lowest outcrop in the valley. Similarly, the biotite schist and metaplutonic rocks at low elevations in western Chist Creek, although at higher metamorphic grade and degree of ductile deformation compared to higher and more easterly outcrops, show continuity with them and are interpreted as the base of the hangingwall of a subjacent shear zone. The metavolcanic-metaplutonic exposure in the Kitimat River valley is isolated from undeformed ridge-top exposures, so its position above or below the major detachment is unknown.

Based on these three exposures, we hypothesize that the Skeena River fault zone extends at depth below the Chist Creek area, with the folded section of Mt Attree volcanics, Ambition Formation limestone and overlying Telkwa Formation in its hangingwall.

West of Terrace, the low-angle Shames River mylonite zone and the northwest-striking Shames River fault (Fig 3) both show top-to-the-northeast, normal sense of displacement. Both mylonitic deformation and north faulting are constrained as Eocene, ca. 54 to 47 Ma (Heah, 1991; Andronicos et al., 2003), approximately coeval with unroofing of the Kitselas complex along the Skeena River fault zone. These structures make up a set of crustal-scale detachments along which the eastern Coast Belt was exhumed in transtensional conditions.

FABRICS, STRUCTURES AND REGIONAL METAMORPHISM WITHIN THE ZYMOETZ GROUP

Penetrative cleavage in the Mt Attree volcanics increases from sporadic development in favourable rock types north of Williams Creek, to weakly pervasive south of it, to strong and prevalent in the Chist Creek drainage. One of the northernmost indicators of penetrative deformation is a small marble body that forms an isoclinal fold in a headwall south of 8 Mile Creek, within metavolcanic strata that are otherwise only locally foliated. By contrast, south of Williams Creek, layering in the metavolcanic units has been completely transposed into the foliation, although measured facings are consistently to the east, in the overall direction of stratigraphic younging. Foliation attitudes in general are generally parallel to bedding; they are folded in the same manner around the major anticline (Fig 2).

The conglomerate-phyllite unit at the top of the Mt Attree volcanics north of Williams Creek is affected by two generations of cleavage. One is parallel to layering and a second is axial planar to a minor syncline that affects both metavolcanic rocks and overlying limestone, but apparently not the basal Telkwa conglomerate. On Mt Attree, zones of cleavage in the metavolcanic rocks are crosscut by a dioritic phase of the Kleanza pluton, a demonstration of pre-Early Jurassic penetrative deformation.

A top-to-the-north thrust fault is mapped in the headwaters of 8 Mile Creek, where sheared Mt Attree andesite rests structurally above the Ambition Formation. No other thrust faults were documented in the Paleozoic section. The Mt Attree volcanics show an increase in metamorphic grade from greenschist on the Mt Attree ridge and the Gazelle area south of Williams Creek, to amphibolite on the ridge between Chist Creek and Schulbuckhand Creek. Amphibolite-grade metamorphism is also seen at low topographic elevations in western Williams Creek, near the mouth of Schist Creek and in the valley of the Kitimat River. Greenschist facies assemblages in mafic rocks consist of pale-green to medium-green feathery and acicular actinolite, chlorite, epidote and albite after primary plagioclase. Felsic rocks contain albite, K-feldspar, sericite, biotite and chlorite. In mafic assemblages transitional to amphibolite, chlorite disappears followed by epidote, plagioclase becomes calcic, amphibole becomes more equant and darker in colour, and biotite becomes more abundant. The highest observed metamorphic grades are near the mouth of Chist Creek, where knotted green biotite schist contains cordierite grains with relict garnet in their cores.

Hornfelsic overprinting affects rocks near the Williams Creek pluton. Spongy metamorphic clinopyroxene occurs in amphibolite; and postkinematic cordierite and andalusite occur in the aluminum-rich altered metasedimentary rocks — biotite phyllite and conglomerate — north of Williams Creek. In this area, garnet and diopside are widespread in Ambition Formation limestone, filling fractures and in some cases delicately replacing silica-hematite-replaced fossils.

MINERAL OCCURRENCES AND MINERAL POTENTIAL

Traditionally, the mineral potential of the Chist Creek area was linked mainly to gold in polymetallic veins and redbed-style copper in the upper Telkwa, with lesser emphasis on small skarns. We have visited and sampled a number of known occurrences in the course of this project. Further, the identification of the Paleozoic Mt Attree volcanics and recognition of indicators of significant volcanogenic massive sulphide potential within them adds a new and promising development to the area (McKeown et al., 2008).

Precious metal-bearing polymetallic veins are associated with the Kleanza pluton. Of the many veins on Mt Thornhill, two, the Golden Nib and Lucky Seven, produced on a small scale in the early years of the 20th century. Grab samples collected in 2007 from vein occurrences, the Society Girl and Ptarmigan on Mt Thornhill, show variably high contents of copper and lead, and anomalous silver and gold (Table 1). Veins on Mt Thornhill were observed to contain pyrite, chalcopyrite, sphalerite, galena and arsenopyrite. They occur within northeasterly and west-northwesterly shears.

Regional prospecting along an abandoned logging road north of Williams Creek in 2007 located a sulphide+sulphosalt – bearing quartz vein with high geochemically determined contents of Ag and Au. Sample 07JK17-5, shown on Table 1, contains >10 000 ppb Ag and 14 098 ppb Au. It is exposed in a ditch, cutting metamorphosed Mt Attree andesite. Further extensions are possible.

The most significant vein-type occurrence in the area, also mined in the period of 1910 to 1935, is the Dardanelle (MINFILE 103I 107). In 1983, S. Reamsbottom reported that the property may contain reserves of approximately 181 440 t grading about 7.5 g/t Au and 17.1 g/t Ag (this estimate does not conform to NI43-101 requirements; MINFILE, 2007). The most recent drill program was by Trade Winds Ventures Inc. in 2005 (Burton, 2005). The main vein at Dardanelle lies within a steep, east-northeasterly (250°/80°) shear zone within granodiorite, immediately east of its strongly sheared and faulted western contact with the lower Telkwa Formation (Fig 2). The vein has been traced on the surface and in part underground for 2 km (Burton, 2005). A pink aplite dike occupies the same structure. The width of the vein is highly variable, and its gold grades range from trace amounts to over 33 g/t (Burton, 2005). The vein shows regular dark grey carbonaceous bands typical of orogenic gold-quartz deposits (Fig 10a).

Throughout the region, maroon to red andesite and dacite of the upper Telkwa Formation are host to numerous occurrences of fracture and shear-controlled copper mineralization, typically of high-oxidation assemblages of bornite and chalcocite with hematite, calcite and epidote. Showings on Treasure Mountain, in the northeast corner of the map area, are of particular note. Although most are shear-controlled (Nelson et al., 2006a), the Purdex showing (Snow, MINFILE 103I 090) also exhibits matrix replacement textures over significant widths (Fig 10b). A 26 m surface chip sample from this showing assayed 2.44% Cu and 0.4 g/t Ag (BC Ministry of Energy, Mines and Petroleum Resources, 1965); this is confirmed by our grab sample, which contained 6.21% Cu (Table 1, 07JK47-01). Recently, exploration of this property has been reactivated, with re-opening of surface roads and a limited diamond drill program (Burton, 2006).

In the course of field mapping in 2007, we sampled a number of copper showings within Telkwa volcanic rocks. The most interesting analysis is of sample 07MM07-10 from a shear zone east of the Clore River, which contains 1.35% Cu, 16 ppm Ag and 295 ppb Au.

A series of magnetite-garnet-chalcopyrite+sulphosalt+galena skarn showings are located at and near the base of the Ambition Formation north of the Williams Creek pluton. Some of these show evidence of historic workings, including a well-preserved set of hand tools; but they are not listed in the MINFILE database. Two of our samples from these returned high Cu-Ag values (Table 1). Sample 07MM17-01 contains 13.09% Cu, >100 000 ppb Ag; and 07MM17-04, from a hand-dug pit, contains 7.62% Cu and 70 247 ppb Ag.

The Paleozoic Mt Attree volcanics host several broad zones of quartz-sericite schist, most notably around the Gazelle and Sub showings but also north of Williams Creek (Fig 2). Particularly in the Gazelle-Sub area, the quartz-sericite schist is associated with zones of strong silicifica-

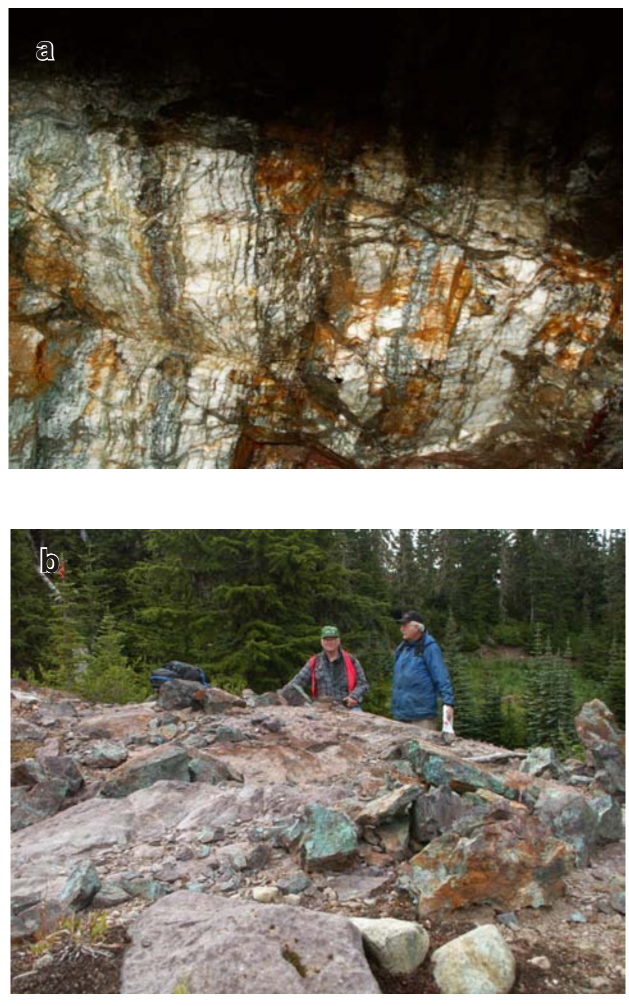


Figure 10. a) Underground exposure of the Dardanelle vein, approximately 200 m from the portal. Width is over 1 m at this point. b) A. Burton and G. Chinn at the Purdex showing on Treasure Mountain, where matrix replacement by copper minerals is shown by malachite staining over a broad area.

TABLE 1. GEOCHEMICAL AND ASSAY RESULTS FOR THE NTS 103I/08 MAP AREA, 2007.ABBREVIATIONS: ALT, ALTERATION; AZ, AZURITE; BO, BORNITE; BX, BRECCIA; CPY, CHALCOPYRITE; DISSEM, DISSEMINATED; GL, GLAUCOPHANE; GN, GARNET; L.JUR., LOWER JURASSIC; MAL, MALACHITE; MB, MOLYBDENITE; MIN, MINERALIZATION; MT, MAGNETITE; PLAG, PLAGIOCLASE; PO, PYRRHOTITE; PY, PYRITE; PZ, PALEOZOIC; QTZ, QUARTZ. ANOMALOUS VALUES ARE HIGHLIGHTED IN YELLOW.

							Element	Mo	Cu	Pb	Zn	Ag	As	Au	Cd	Sb	Bi	W
							Units	(ppm)	(ppm)	(ppm)	(ppm)	(ppb)	(ppm)	(ppb)	(ppm)	(ppm)	(ppm)	(ppm)
							Method	ARMS	ARMS	ARMS	ARMS	ARMS	ARMS	ARMS	ARMS	ARMS	ARMS	ARMS
							Detection Limit	0.01	0.01	0.01	0.1	2	0.1	0.1	0.01	0.02	0.02	0.2
Station number	Easting	Northing	Location	MINFILE	Sample Type	Minerals noted	Description		% if listed	% if listed								
07JA01-03	536737	6016764	Chist Creek	none	2 m cont chip	py	Phyllite with dissem py	4.62	39.96	4.87	240.3	129	0.6	7.5	0.09	<0.02	0.34	0.1
07JA10-10	569870	6047786	Many Bear Creek (093L/12)	93L 323	grab	py	pyritic-silicified rhyollite bx (adv. argillic alt.)	1.77	24.78	4.62	3.4	40	16.7	0.3	0.04	0.52	0.24	<0.1
07JK03-05	562345	6032779	Clore R.	103I 091	2 m disc chip	bo, cpy, po	Amygdaloidal andesite/dacite with min. in amygdales	0.43	3801	9.24	295.3	14200	3.1	0.5	0.15	0.09	0.03	0.3
07JK05-02	548992	6036878	Clore R.	none	5 m disc chip	py, cpy	Vein hosted within andesite lapilli tuff	3.71	105.5	3.1	40.9	873	8.4	79.9	0.11	0.34	0.24	<0.1
07JK15-04	550803	6034687	Mattson Creek W.	none	grab	py	Highly silicified plag phyric andesite with up to 15% dissem py.	1.27	29.65	8.36	64.7	69	5.7	0.6	0.08	0.35	0.02	0.1
07JK16-02	543404	6021282	Chist Creek spur	none	grab	py	L.Jur. sericite schist, up to 15% pyrite within quartz veins	63.46	3620	195.9	7496	4847	8.6	82.3	95.24	0.21	1.14	0.1
07JK17-5	535839	6031689	West Williams Creek	none	grab	py, mb?, sulphosalts?	quartz vein exposed over 1 X 4 metres minimum	18.21	3843	165.4	114.8	>100000	1	14098	3.12	0.3	48.53	0.9
07JK17-13	536358	6033218	West Williams Creek	none	grab	py	pyritic qtz-(sericite?) also diorite with blue opal beads - epithermal? Abundant sulphide alteration	2.03	79.98	14.99	3.1	394	2.1	8.2	<0.01	0.11	0.19	<0.1
07JK27-01	536824	6037770	Mt. Thornhill	near Society Girl 103I 184	grab	py, gn	Smoky qtz vein hosting dissem. pyrite and minor galena	3.32	751.2	1.12%	55.8	45655	80.3	275.3	2.74	13.13	1.56	<0.1
07JK27-02	536633	6038304	Mt. Thornhill	Ptarmigan 103I 097	grab	py, cpy, mal	Qtz vein w dissem and blebby sulphides	1	2.15%	8.47	77.3	11126	2.4	53.2	1.74	0.21	0.16	<0.1
07JK28-03	537977	6034609	Mt. Thornhill south	none	grab	py	Shear with silica/pyritic alteration up to 30% dissem pyrite some massive	2.2	60.61	2.68	42.3	156	11.2	5.9	0.04	0.04	0.7	<0.1
07JK33-02	551598	6030194	Ridge SW of Mattson Cr.	none	grab	mal, minor mt	Amygdaloidal plag phyric andesite with mt, jasper	0.19	9122	9.53	364.5	3056	0.4	474.5	1.3	0.31	<0.02	<0.1
07JK44-03	551409	6014982	Ridge NW of Hunter Creek	none	grab	py >cpy	Highly silicified volcanics with up to 15% fine dissem py	0.75	32.04	7.03	48.5	155	2.9	3.4	0.03	0.11	0.41	0.1
07JK44-04	563863	6016810	Ridge NW of Hunter Creek	none	grab	py	Intense gossan within andesite, pyritic + jarosite	4.37	103.3	6.15	23.9	57	34.2	0.6	0.09	0.3	3.31	<0.1
07JK47-01	563945	6037713	Treasure Mountain	Purdex 103I 090	grab	cpy,po,mal,az	Dacite with fine dissem sulphides	0.44	6.21%	537.7	161.6	35650	1.9	3	0.4	0.39	0.14	0.3
07JN01-03	544844	6039018	N. Zymoetz	none	grab	mt, cpy, gn	Skarn - lenses of calcsilicate metaseds. Mt rich zone with garnet, epidote, diopside	0.32	20.37	2.57	55.2	33	1.5	0.4	0.09	0.18	0.18	0.3
07JN01-06	546451	6039356	N. Zymoetz	none	grab	mal, cpy	Sulphide rich zone within Lower Telkwa, limestone dominated bx.	6.37	7.21%	15.68	97.9	5279	17.1	5.5	0.77	0.42	0.23	0.3
07JN08-05	560476	6034700	W. of Clore	none	grab	zeolite?	Rotten dacite bx silicified (possibly some pink zeolite?)	9.61	60.56	338.3	36	4624	182.8	60.5	0.49	3.48	11.14	>100
07JN17-01	541737	6031336	Camp 2	none	grab	py	Gossan within Pz lapilli tuff, patchy, intense silicified-pyritic zone	0.34	41.74	10.71	72.9	517	8.5	2.3	0.67	0.77	0.64	0.2
07JN24-05	563735	6016931	Clore-Henderson-Andesite Peak	none	grab	py>>cpy	Gossanous diorite with up to 15% py intruding Telkwa rhyolite	1.86	100.3	9.74	15.4	102	10.1	0.8	0.03	0.41	12.92	<0.1
07MM07-10	563650	6033284	E. Clore	none	2m cont chip	mal, cpy, bo	Hosted in porphyritic andesite (Telkwa), likely shear controlled, min over 15 ft	0.38	1.35%	4.43	298.3	15847	2.5	295.5	0.27	0.07	0.34	0.4
07MM17-01	546260	6028880	Summit E. of Mt. Attree	none	grab over 20 m	mt, cpy, gl	Skarn - base of Permian limestone over andesite flow, massive galena and trace grey sulphosalts	1.07	13.09%	248.7	1457	>100000	8.2	72.8	44.48	0.25	124.4	34.3
07MM17-04	546379	6028416	Summit E. of Mt. Attree	none	grab	cpy, mt, gn?	Magnetite skarn within Pz andesite, plag phyric flow	208.3	7.62%	36.6	367.6	70247	2.7	27.1	30.6	0.08	67.99	>100
07MM18-06	545017	6029157	Summit E. of Mt. Attree	none	2 m chip	py	silic-pyritic zone overlying highly foliated quartz-sericite schist	1.28	198.8	5.94	166.5	308	5.4	0.5	0.38	0.04	0.28	2.7

tion and local base-metal sulphide concentrations; massive barite is present at the Sub showing (McKeown et al., 2008). The alteration and mineralization are prekinematic, and are interpreted as syngenetic. This suggests that the Mt. Attree volcanics have the potential for hosting volcanogenic massive sulphide deposits similar to Tulsequah Chief, which is associated with Late Mississippian rhyolite in northern Stikinia.

SUMMARY AND CONCLUSIONS

Field mapping in 2007 of the Chist Creek map area southeast of Terrace has clarified regional geological understanding as well as pointing to volcanogenic massive sulphide potential in newly defined Paleozoic hosts. The western half of the Chist Creek area is underlain in part by Paleozoic volcanic and related strata of the Mt Attree volcanics, which are separated from overlying lower Mesozoic strata by the Permian Ambition Formation limestone. Together the Paleozoic volcanic strata and the limestone form the core of a regional, northeasterly trending anticline. Correlatives of the Zymoetz Group may extend westwards into the eastern Coast Mountains.

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