Geology of the Hoodoo Mountain Area (NTS 104B/14W)

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KEYWORDS: Hoodoo Mountain, Sphaler Creek, Stikine assemblage, Stuhini Group, copper porphyry, Galore Creek, Dirk prospect, Telena prospect, volcanic-hosted massive sulphide, Rock and Roll, Andrei Icefield, Iskut River

INTRODUCTION

Hoodoo Mountain area is located between the enormous copper-gold resource defined at Galore Creek and the past-producing gold deposits of the Bronson Camp. Reserves at Galore Creek in proven and probable categories are 528 Mt grading 0.58% Cu, 0.32 g/t Au and 6.02 g/t Ag (Gill *et al.*, 2011). In the Bronson Camp, the Snip mine produced 32 million grams of gold, 12 million grams silver and nearly 250 000 kilograms copper from about 1.2 million tonnes between 1991 and 1999; Johnny Mountain produced for less than two years with produced, proven, probable and "possible" categories totalling 0.622 Mt at 19.54 g/t Au (MINFILE, 2011). Bronson Slope is underlain by a low-grade porphyry with a measured and indicated resource estimate stated to meet "CIMM resource standards and classifications" of 225 Mt grading 0.36 g/t Au, 2.22 g/t Ag, 0.13% Cu and 0.008% Mo plus 163 Mt grading 7.28% magnetite (Giroux and Gray, 2010). Despite the region's exceptional mineral endowment, large parts of the Hoodoo Mountain area lacked systematic mapping or were last mapped by Forrest Kerr in the 1920s during International Boundary Commission, which also generated the first topographical maps. To address this geoscience knowledge gap, a program of geological mapping and sampling was initiated in 2010, funded principally by the federal GEM program (Geoscience for Energy and Minerals Strategy) over the eastern half of the Hoodoo map area (NTS 104B/14E, Mihalynuk *et al.*, 2011a, b). Continuation of that mapping in 2011 focused on the western half of the Hoodoo Mountain area (NTS 104B/14W), and is the subject of this report. New or substantially revised information is included herein; see Mihalynuk *et al.* (2010, 2011a) for additional unit descriptions and previous work.

LOCATION AND ACCESS

Hoodoo Mountain area (NTS 104/14W) can be accessed either via the Bronson airstrip to the immediate south, or via the Espaw camp located at kilometre 91 on the incomplete Galore Creek access road, immediately north of the map area. At the time of our field program, both required air transport from Bob Quinn airstrip located on Highway 37, approximately 400 km by road from both Smithers and Terrace (Figure 1). Bob Quinn airstrip is 60 km from both Bronson airstrip and Espaw Camp.

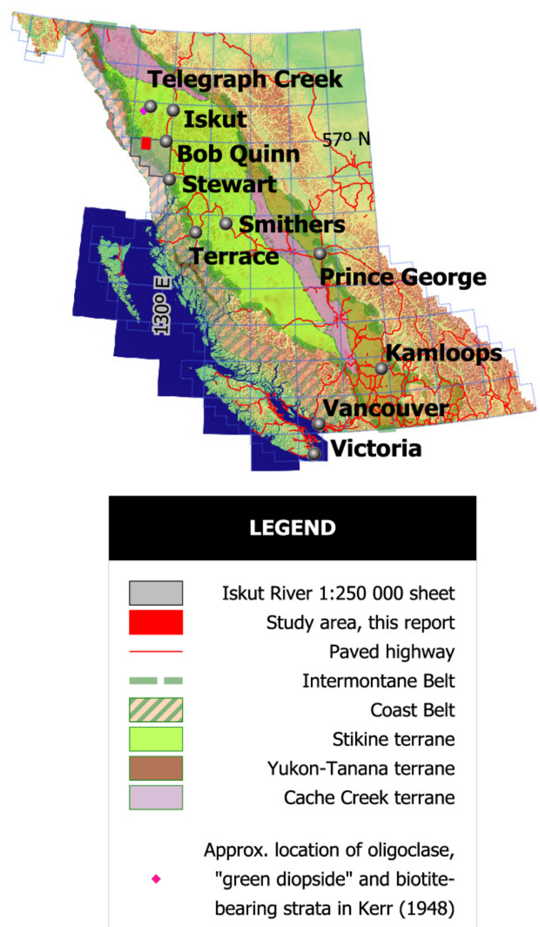

Figure 1. Location of the Iskut study area near the boundary of the Coast Belt and western Stikine terrane.

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Our fieldwork focused on the mountain slopes between the Iskut River and Sphaler Creek. Work in this typically rainy coastal region is commonly curtailed by low cloud and inability to fly, the summer of 2011 was no exception. Our work was facilitated by the comfortable facilities at Espaw camp on Sphaler Creek, established by the Galore Creek Mining Company (GCMC) and operated by Romios Gold Corporation during our tenure. Helicopter services were supplied by Lakelse Air Ltd. Travel by foot out of the Espaw Camp is aided by the GCMC access road, which ends ~2 km west of the camp. In practicality, however, foot travel is limited to valleys south of the turbulent Sphaler Creek.

PREVIOUS WORK AND REGIONAL GEOLOGY

Much of the area within NTS 104B/14 had not been mapped as part of a systematic regional program prior to the start of our program in 2010. Between 1926 and 1929, Forrest Kerr covered the corridor along the Iskut River (Kerr, 1948; Figure 2), but Kerr designated the area between the Iskut River and Sphaler Creek as one "Large ice field with a few peaks rising above the ice level". However, deglaciation during the intervening 80+ years has exposed the terrain considerably. Many striking examples of kilometres of glacial retreat can be seen in the area (*e.g.* see retreat history of Twin Glacier, Figure 4 of Mihalynuk *et al.*, 2011a). Never-before-seen rock exposures are revealed by glacial retreat with each successive year.

Mihalynuk *et al.* (2010, 2011a) provide overviews of previous geological studies in the Iskut region, which are not repeated here. Not part of their overview, and specific to the Hoodoo west map sheet and adjacent area to the north, are exploration programs in the Hoodoo River area (Holbeck, 1983), on the south flank of Pheno Mountain (Doyle and Awmack, 1991), and the Trek property that spans Sphaler Creek (Caulfield, 1989; Awmack and Yamamura, 1988; Simmons, 2006) and extends east to "Quest Creek" (Kasper, 1989; informal names appear within quotation marks). Geological mapping conducted as part of these programs is compiled in Figure 3. Relying on such compilation as well as vantage point, airphoto, LandSAT5 and ASTER satellite imagery interpretation, we have extended our field observations to most parts of 104B/14W. One area that still lacks geological observations of any sort is around the Johnson Glacier (Figures 2, 3).

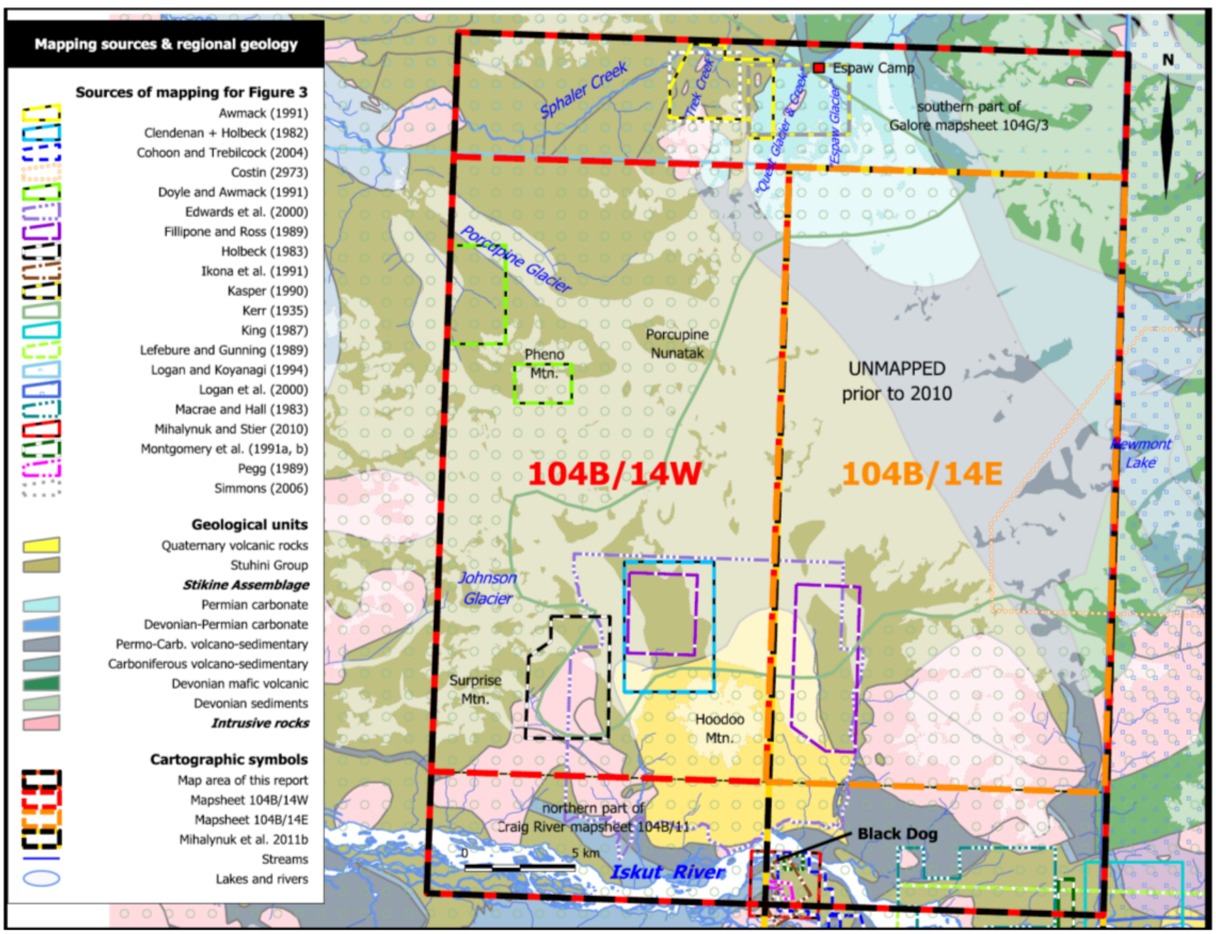


Figure 2. Sources of geological map information within the Hoodoo Mountain mapsheet (NTS 104B/14) and adjacent areas. Geological mapping and sampling in 2011 was focused in areas outlined by the western rectangle The regional geology portrayed within the study area (red rectangle) is largely after Kerr (1935) as compiled by (Massey *et al.*, 2005). Location of the Rock and Roll property (Black Dog surface showing) and important landmarks are also indicated.

Our work in 104B/14W continued to extend the geological relationships outlined by Mihalynuk *et al.* (2011b) and Logan *et al.* (2000) in the adjoining map sheets to the east and north respectively. Stratigraphic relationships between the rock packages indicate that Late Triassic Stuhini Group and Early Jurassic Hazelton Group arc and basinal strata unconformably overly a composite basement of deformed Late Paleozoic Stikine assemblage (Brown *et al.*, 1991). Structural deformation affecting Mesozoic Stuhini and Hazelton group strata include mainly east-northeast-directed thrust faults that interleave them with Paleozoic strata. High angle faults trend mainly north-northwest and northeast dissecting the interleaved strata. Eocene plutons cut the high angle faults with evidence of fault reactivation around the margins of the plutons.

STRATIGRAPHY

Hoodoo Mountain area is underlain by six volcano-stratigraphic packages that range in age from Carboniferous to Quaternary. Stratigraphic assignments in this report build upon those reported in Mihalynuk *et al.* (2011a) which rely extensively on Logan *et al.* (2000).

Paleozoic Stikine assemblage (Monger, 1977) rocks are restricted to: (a) chert, carbonate and volcanic strata in the far northeast of the Hoodoo (west) map sheet, (b) the adjacent "Quest Creek" (informal name on map in Kasper, 1989) valley farther north and (c) one <1 km^2 culmination in the upper Porcupine Glacier area (Figure 3):

1. Carboniferous mafic and felsic volcanic rocks and intercalated carbonate strata characterized by giant crinoid fossils have not yet been confirmed within the western Hoodoo map sheet; although they underlie about half of the northern and eastern margins of the eastern Hoodoo Mountain sheet (and they are mapped immediately north of 104B/14W). Permian carbonate-dominated strata characterized by large horn corals and giant fusulinids.

Three Mesozoic packages dominate the central and western map area:

2. Middle to Late Triassic strata overlying interbedded chert and limestone of presumed Permian age are composed of chert sharpstone conglomerate and turbiditic sandstone/argillite, bedded black chert, minor basalt and micritic carbonate containing *Halobiid* paper clams and ammonites.
3. Triassic arc strata characterized by coarse augite porphyritic basalt of the Stuhini Group (Souther, 1971) and extensive volcanic conglomerate and in eastern Hoodoo Mountain area. These strata are cut by alkaline intrusions that are associated with Cu-Au mineralization at the Dirk, Telena and Trek prospects (Chadwick and Close, 2009).
4. Jurassic strata mainly composed of turbiditic volcanic sandstone, argillite and conglomerate. Pebbles and cobbles are characterized by quartz and hornblende porphyritic volcanic and plutonic rocks.

Two Cenozoic magmatic rock packages span the map area:

5. A north-northwest trending belt of exhumed Eocene plutons cross the centre of the Hoodoo map sheet. These lie east of, and are geochemically distinct from,
6. Rocks of presumed Pliocene to Pleistocene age comprising volcanic strata of Hoodoo Mountain and flanking Pheno Mountains, two of the highest peaks in the Hoodoo area (Figure 3).

Paleozoic

Carboniferous volcanic rocks

Indistinctly pillowed, dark green mafic flows (Figure 4a) crop out in a belt that extends from near the mouth of Quest Creek" to the west side of upper "Quest Glacier" (Figure 3). They are strongly chlorite-epidote altered. Fine-grained felted feldspar may be observed in hand specimen with difficulty, otherwise, the unit is relatively featureless. Jasper outlines some pillows.

These pillow basalts are the presumed oldest rocks within the 2011 study area. Infolded with the mafic unit are layers of recrystallized limestone up to 5 m thick, also of presumed Carboniferous age, although giant crinoids typically contained in mid-Carboniferous carbonate are not present. Elsewhere the mafic flow unit is in contact with maroon tuff, and variable thicknesses of maroon tuff (<1 m to >5 m) occur between the mafic volcanic unit and recrystallized carbonate.

Maroon and green epiclastic and tuffaceous strata comprise a mappable unit extending ~1.5 km along Sphaler Creek upstream of "Quest Creek". Beds of dust to lapilli-sized fragments and epiclasts are centimetres to decimetres thick and may display grading (Figure 4b). In places protolith textures are well preserved, but only metres away texturally destructive foliation can be strongly developed and refolded to form a second, less intense fabric. These strata are intercalated with fine siliciclastic strata. Estimates of structural thickness based on our map data are not possible as the base of the volcanic units does not crop out in the mapped area. However, incorporating the mapping of Logan and Koyanagi (1994), a structural thickness of up to 400 m is indicated.

This unit may be correlative with lithologically similar units in eastern Hoodoo map area that occur together with rhyolite units from which a preliminary isotopic age of ~340 Ma was determined (Early Carboniferous (Viséan) age; N. Joyce, unpublished data).

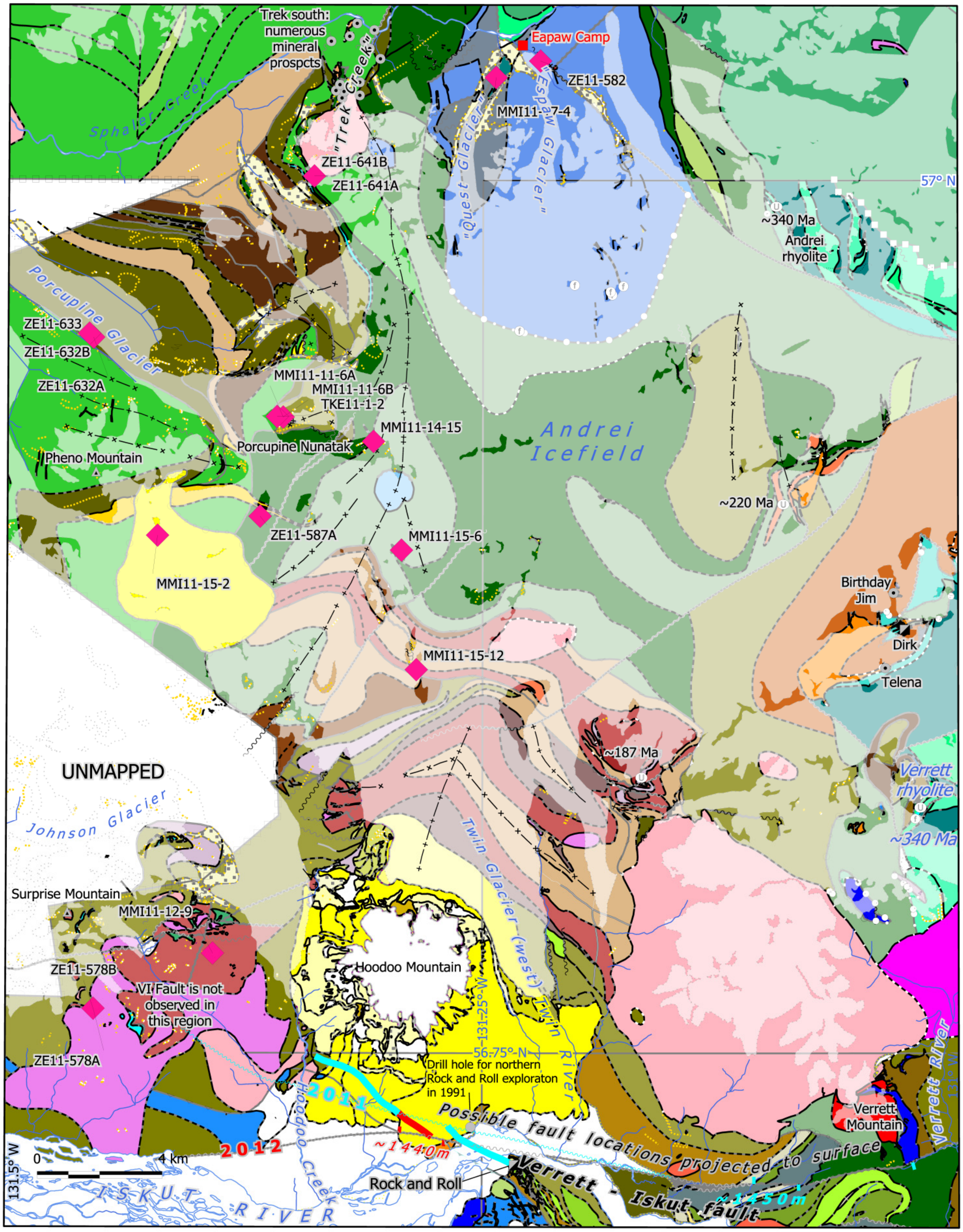


Figure 3. Geology of the Hoodoo Mountain – Iskut River area simplified after Mihalynuk *et al.* (2012). Refer to the detailed map of these authors for a full description of all units represented on Figure 3; not all minor units are included in the legend.

Layered Rocks

(Note colours muted beneath glaciers)

Pliocene to Holocene HPMVC

porphyritic phonolite

Pheno Mtn. "phonolitic rhyolite"

Hoodoo-Pheno Mountain basalt

Hoodoo Mtn. aphyric phonolite

Early Jurassic

turbiditic calcareous wacke

maroon ash tuff/tuffite, also in Late Triassic and Carboniferous

dense breccia > lapilli-ash tuff

hornblende-biotite ash flow ~187Ma

argillaceous turbidite, fine wacke

Late Triassic (to Early Jurassic)

orange wacke ± biotite/K-feldspar

micritic carbonate

well-bedded wacke ± chert clasts

dacite ash flow ~220 Ma

feldspar porphyry breccia, tuff, flow

polymictic conglomerate

feldspar pyroxene breccia ±pillowed

Middle-Late Triassic

rusty graphitic argillite/siltstone

Paleozoic - Jurassic

(South of latitude of Hoodoo Peak)

quartz sandstone

siltstone ±volcanic / laminated

chert (also Carboniferous-Permian)

carbonaceous siltstone

tuffaceousPhyllite/wacke

andesite breccia and lesser ash

mafic volcanic - tuff and minor flow

sericite schist

undivided sediment/volcanic

felsic tuff and minor flows

ash flow in Carboniferous

argillite > volcanic sediment/tuff

turbiditic, also Carboniferous

Early Permian

limestone -massive to well-bedded

Carboniferous

marble (± Permian, Devonian)

fine siliciclastics, chert, limey

tuffite with chert/exhalite

volcanic wacke/conglomerate

limestone, commonly crinoidal

basalt -pillowed and breccia

Intrusive Rocks

Pliocene-Pleistocene

Pheno Mtn. quartz monzonite

Eocene

Early? Eocene granodiorite

Jurassic-Eocene quartz diorite

Early to Middle Jurassic

granodiorite, diorite, undivided

?Triassic - Jurassic

coarse K-feldspar granodiorite

diorite ±quartz diorite

Late Triassic

K-feldspar - biotite syenite ~204 Ma

?Carboniferous

Verrett graphic granite

Symbols

Contacts

contact defined

contact approximate

contact inferred

fault defined

fault approximate

fault inferred

thrust defined

thrust approximate

thrust inferred

unconformity defined

unconformity approximate

unconformity inferred

Other symbols

form lines from imagery

synform / syncline

antiform / anticline

limit of data

moraine

lakes

glacier (transparent overlay)

major streams

U-Pb zircon age locality

conodont fossil locality

developed prospect

mineral showing

Geochemical sample site

Former interpreted northern Verrett-Iskut fault trace

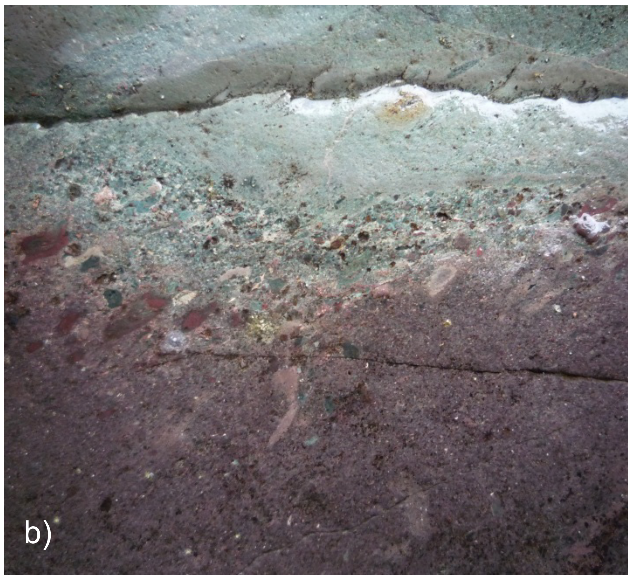


Figure 4. (a) Bright green and maroon epiclastic strata of presumed Carboniferous age are exposed along the banks of Sphaler Creek. (b) Maroon colouration is often incorrectly assumed to indicate subaerial deposition. At this locality, colour is an indicator of local oxidation fronts. Photo shows about 30 cm width of extensive creek exposures.

Fine siliciclastic strata and chert

Black, grey and rust, well bedded to boudinaged chert and siltstone-argillite in 3 to 15 cm thick beds occurs between the Carboniferous strata and mountainsides dominated by limestone (Figure 5). Where highly recrystallized, the chert is white or translucent. In places disrupted layers of sharpstone conglomerate comprises <3 cm diameter aphanitic olive, grey and black fragments in a foliated, calcareous matrix. In some sections volcanic ash appears within the margins of chert beds. Elsewhere, slippery light grey clay layers between chert beds are interpreted to as clay-altered ash tuff. This unit is correlated with a much less variable, bedded chert unit between Carboniferous and Permian carbonate units in east-central 104B/14E. Extensive deformation precludes estimation of stratigraphic thickness; unfaulted panels having a stratigraphic thickness of greater than 10 m thick are uncommon. Structural thickness of the unit is between 200 and 450 m, although it can be removed by faults.

Figure 5. Well-bedded chert and fine grained siliciclastic strata west of the mouth of “Quest Creek”. Open to isoclinal folds plunge north (towards viewer and Sphaler Creek) and most thrust fault-fold relationships suggest a west-side-up vergence, but the opposite vergence is also indicated. Tim Davis for scale.

A sample of chert was collected from this unit east of the top of “Quest Glacier” (northwest corner of 104B/14E; Figure 3). The unit contained a poor to moderately preserved radiolarian assemblage providing a Carboniferous age (Table 1).

Permian

Both well bedded and massive Permian carbonate units track northwards from extensive exposures underlying northern Andrei Icefield in 104B/14E to the toe of the “Espaw Glacier”. Giant fusulinids are common within these units, indicative of a Permian age. For further descriptions of these units see Mihalynuk *et al.* (2011a).

An isolated exposure of interbedded light grey, fossil-poor limestone and irregular tan chert occurs on the north side of upper Porcupine Glacier (Figure 3). Carbonate layers range from 10 to 50 cm with 10 to 20 cm chert interbeds. These strata are interpreted to be Permian in age on the basis of correlation to Permian strata in the eastern Hoodoo Mountain map area. They are overlain by carbonate-rich matrix-supported chert sharpstone conglomerate (Figure 6). Although the contact is not exposed, it is interpreted to be an angular unconformity. Green felted feldspar dikes extensively crosscut and thermally alter the unit. The uncertainty over the degree of structural repetition renders thickness estimates difficult. Given that the base of the section is not observed, and the top may be bevelled by erosion, the

Table 1. Results of chert processing and radiolarian micropaleontology for sample ZE10-333.

SAMPLE No: ZE10-333
LOCALITY and COORDINATES: Nunatak at the top of Quest Glacier; 56.97971 -131.26344

GEOLOGICAL UNIT: Stikine Assemblage
LITHOLOGY: laminated chert, dark grey-black
OCCURRENCE OF RADIOLARIANS: confirmed
PRESERVATION: poor to moderate

RADIOLARIAN TAXA:
abundant spumellarians
- ?Arrectoalatus sp.
-Belowea sp.
- ?Ceratoikiscum sp.
-Entactinia multispinosa Won
-Entactinia sp.
-Entactinosphaera sp.
- ?Pylentonema sp.
OTHER: rare sponge spicules, silica fragments (matrix), pyrite, clays

AGE: CARBONIFEROUS (possibly late Mississippian-Pennsylvanian)
COMMENTS: the Carboniferous age is based on the entire assemblage. A “possible late Mississippian-Pennsylvanian” call is based on the range of Arrectoalatus sp. whose occurrence is not well established.

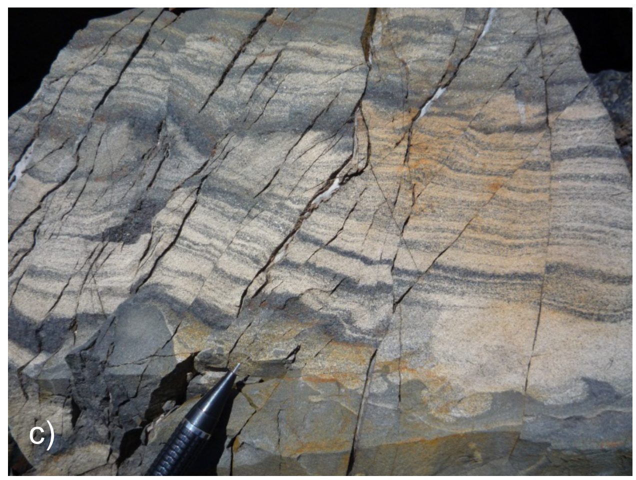


Figure 6. (a) Carbonate with irregular chert interbeds is overlain by (b) chert sharpstone conglomerate with a calcareous matrix. On the next outcropping ridge, chert sharpstone conglomerate is intercalated with feldspathic wacke (c) in which syn-depositional growth faults (some outlined by carbonate veinlets) and water-escape features are beautifully displayed.

layering-normal thickness is roughly estimated to be ~340 m.

Early to Middle Triassic?

Structurally overlying the sharpstone conglomerate–wacke unit is an irregularly bedded chert and fine siliciclastic unit with a structural thickness of no more than 100 m. Superficially like the Carboniferous chert-siliciclastic unit described above, decimetre thick chert beds in this unit range in colour from black and grey to dark green and may contain green volcanic dust and aphanitic angular fragments to coarse ash size. Siliciclastic rocks are interbedded graded sandstone-silty argillite turbidite beds 0.5-2 cm thick with scoured bases. A distinctive conglomerate layer within the unit contains mainly rounded carbonate clasts as well as rounded black chert and rare altered porphyry clasts with equant green crystals, probably pyroxene, in a cream-coloured matrix.

This unit apparently underlies a distinctive micritic *Halobiid* carbonate packstone (*Halobiids* are ribbed, paper-thin bivalves of Carnian to middle Norian age) with sparse ammonites, and this relationship is repeated on both sides of a synform (although the carbonate unit is lost beneath cover). Similar stratigraphic relationships between fine siliciclastic rocks and micritic *Halobiid* packstone are described in Mihalynuk *et al.* (2011a) for an area in eastern 104B/14E (see that paper for further lithologic descriptions).

Late Triassic

Similar to the eastern Hoodoo map area, Late Triassic Stuhini Group strata are dominated by volcaniclastic units. In contrast to the predominance of polymictic boulder conglomerate with abundance of volcanic, carbonate, and intrusive clasts in the east Hoodoo Mountain area, western units predominantly contain volcanic clasts.

The hallmark unit of the Stuhini Group, coarse augite-phyric volcanic breccia, is present in relatively thin (~200-500 m thick) bands (although greater thicknesses could be hidden beneath glaciers). Bands of augite porphyry are overlain (and underlain in places) by more widespread epiclastic layers increasingly dominated by feldspar- rather than augite-phyric clasts. These epiclastic layers (Figure 7; see also "Feldspar-phyric breccia and epiclastic" in Mihalynuk *et al.*, 2011a) and lesser reworked maroon tuff layers ("Maroon tuff" in Mihalynuk *et al.*, 2011a) appear to interfinger with more distal sedimentary rocks (wacke and argillite) to the west (see Mihalynuk *et al.*, 2011a for descriptions).

Coarse biotite and K-feldspar-bearing conglomerate underlying tens of square kilometres in the east, are recognized only locally in the west, and the biotite and K-feldspar-porphyritic hypabyssal rocks from which they were derived have not yet been observed in the west. Interestingly, copper porphyry mineralization at the Trek property does lie along strike to the north of detrital biotite units exposed on the "Porcupine Nunatak" (see Economic Geology).

Late Triassic to Early Jurassic

Demarcation of the Triassic-Jurassic boundary within the volcanosedimentary succession in the western Hoodoo Mountain area has not been confirmed with isotopic or fossil age determinations. We suspect that it corresponds with the change from dark, carbonate-cemented conglomerate with abundant angular clasts of micritic and carbonaceous limestone (Figure 7b), feldspar-phyric and lesser pyroxene-phyric clasts, to deeper-water strata dominated by argillite to coarse wacke beds (Figure 8a). In southwest 104B/14W, fetid grey carbonate with a structural thickness of perhaps 100 m, is isolated within a

Figure 7. (a) Coarse reworked breccia fragments interbedded with coarse arkosic sandstone in northwest 104B/14W. About 1 km south of this locality the conglomerate overlies coarse augite porphyry breccia. (b) Poorly sorted carbonate-cemented conglomerate interpreted to approximately demark the Triassic-Jurassic boundary within the sedimentary-dominated succession in the western Hoodoo Mountain map sheet.

klippe atop well bedded, green tuffaceous wacke/tuffite. Although the base of the carbonate is strongly mylonitic, underlying wackes have an increasing lime interbed content towards the mylonite contact, suggesting that it is a décollement without significant stratigraphic throw. However, our preferred interpretation is that the underlying green tuffaceous wacke/tuffite unit is a distal correlative of a very well bedded green tuff/tuffite that envelopes an Early Jurassic (187.0 ±1.9 Ma, N. Joyce, personal communication, in Mihalynuk *et al.*, 2011b), dacite ash flow unit ~10 km northeast of Hoodoo Mountain (see Mihalynuk *et al.*, 2011a, "Hornblende-feldspar ash flow and breccia"), and that the mylonite represents a thrust fault between the tuffite and structurally overlying carbonate.

Strata of probable Jurassic age contain planar beds of conglomerate with well-rounded clasts (Figure 8b) having a high proportion of intraformational wacke, and quartz-phyric volcanic (Figure 9a) and hypabyssal clasts. Within this succession, tuffaceous rocks with flattened pumice

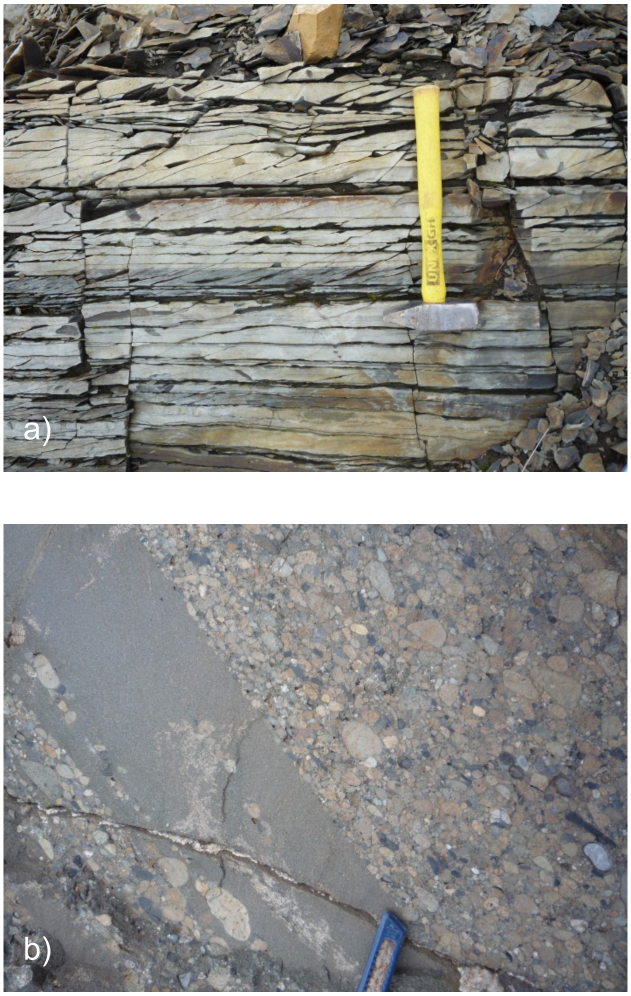


Figure 8. (a) Well-bedded turbiditic silt to sandstone beds with thin argillaceous interbeds. (b) Pebble to cobble conglomerate with medium to coarse-grained wacke interbeds.

blocks (Figure 9b) are broadly correlated with the Early Jurassic felsic volcanic units to the east Ammonites collected from these sections should help with age determination; results are pending.

Triassic-Jurassic stratigraphy records cessation of vigorous Triassic arc volcanism and deepening of the succeeding Triassic-Jurassic sedimentary basin. Abundance of quartz-phyric and intraformational clasts may indicate resumption of arc volcanism outside of the map area, but this volcanism is more evolved than mafic-dominated volcanism in the Triassic. Middle to Late Jurassic strata, typified by chert pebble conglomerate, have not been recognized in the Hoodoo Mountain map area.

Hoodoo - Pheno mountains volcanic complex

Majestic Hoodoo Mountain spans the southern boundary between the 2010 and 2011 map areas. It is an extinct, glacier-capped, Quaternary volcanic edifice (Figure 10a) that has been previously studied by Edwards (1997), Edwards and Russell (2002) and Edwards *et al.* (2000, 2002, and references therein). Unpublished

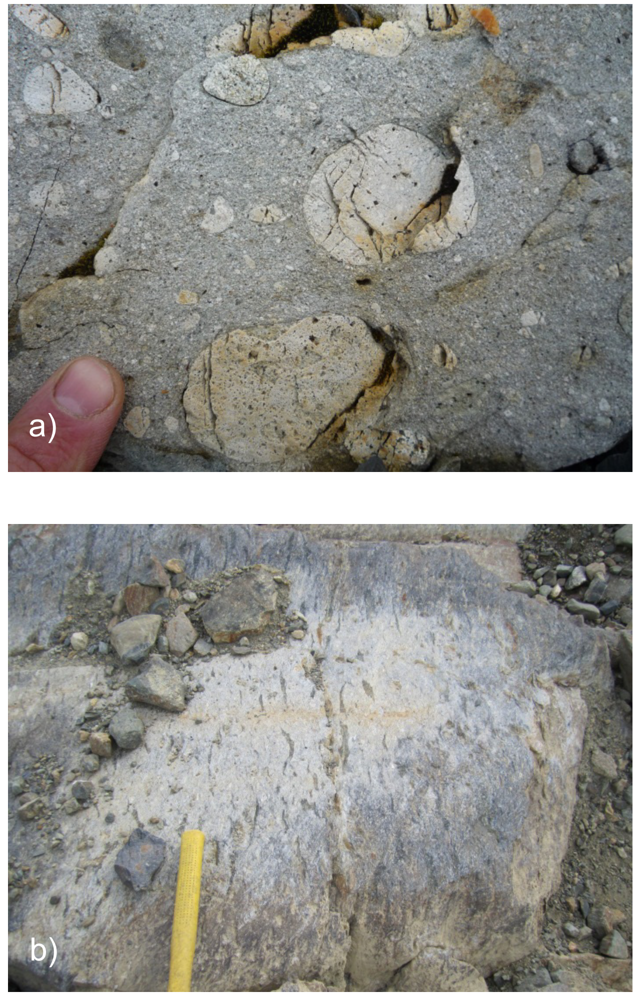


Figure 9. (a) Matrix-supported conglomerate containing mainly quartz-phyric volcanic/hypabyssal clasts of presumed Early Jurassic age. (b) Ignimbritic feldspar porphyritic tuff is part of a volcanic/volcaniclastic section overlain (outside the photo to the north) by disrupted turbiditic strata.

isotopic age determinations indicate an early Quaternary to Recent history ranging from 2.8 to 0.009 Ma ($^{40}Ar/^{39}Ar$ with no error limits on personal communication from M. Villeneuve, 1998 in Edwards *et al.*, 2000; M. Villeneuve, unpublished in Edwards, 1997; and unpublished, but possibly disturbed, K-Ar whole rock age determinations of Souther and Armstrong in Breitsprecher and Mortensen, 2004). Volcanic textures support a history of interaction with glacial ice (Kerr, 1948; Edwards *et al.*, 2002 and references therein).

About 15 km north-northwest of Hoodoo Mountain is Pheno Mountain, one of the highest points in the map area. Its south flank is extensively underlain by volcanic and intrusive equivalents of the Hoodoo Mountain volcanic complex, herein we collectively term these volcanic relicts the Hoodoo-Pheno mountains volcanic complex (HPMVC). Elevations of the basal contacts of the volcanic unit at Pheno Mountain are not highly variable suggesting a Pliocene-Quaternary topography much gentler than today.

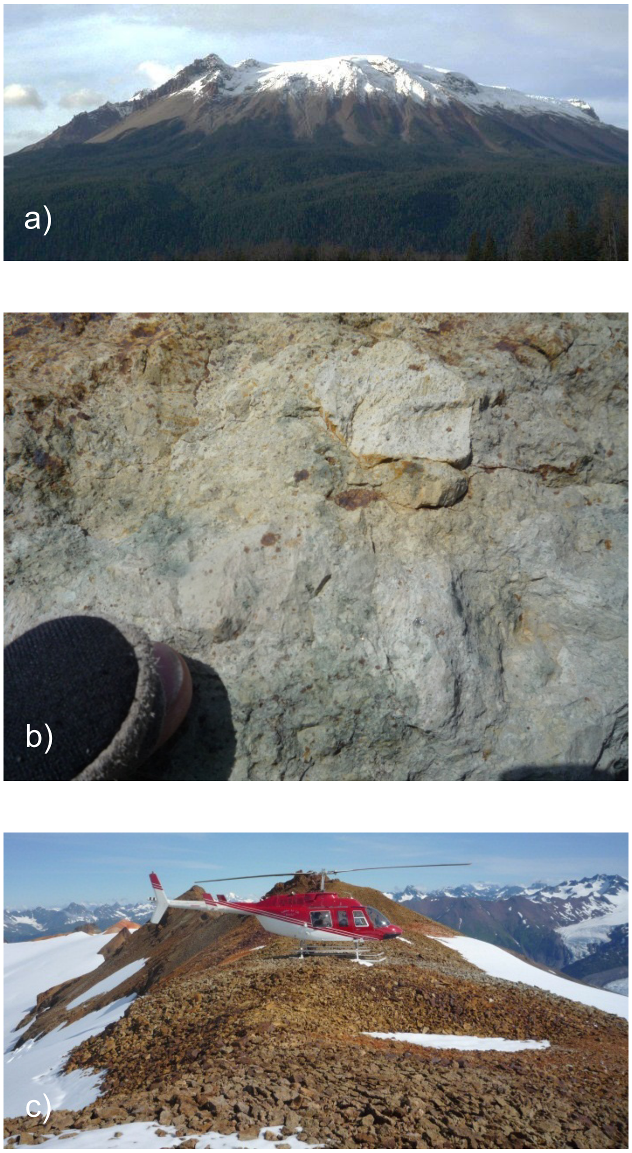


Figure 10. (a) Photo of Hoodoo Mountain looking northwest from the Iskut River. (b) Typical light-weathering lapilli tuff contains quartz-phyric fragments. (c) View to the north of weathering characteristic of Hoodoo peralkaline rhyolite. Note bright orange peak west of the helicopter tail is composed of altered Hoodoo volcanic rocks.

EXTRUSIVE COMPONENTS

Hoodoo Mountain is composed mainly of phonolitic flows and tuffaceous rocks, with lesser tephrite and trachyandesite volcanic and hypabyssal units (Edwards *et al.*, 2000). The south ridge of Pheno Mountain leads to a gentle snow peak with ribs of rock that are entirely comprised of light coloured, rusty-weathering peralkaline rhyolite (field term) lapilli tuff, lesser breccia and banded flows. Fresh surfaces are pale shades of grey, green and maroon. Medium-grained quartz eyes comprise 3-5% of the rock, together with 0.5 to 10% ghosted tabular to rounded, white to pink feldspar and 1-2% acicular chloritized crystals that were probably amphibole. Vesicles are irregularly developed, comprising up to several percent by volume of the rock. Vesicles up to 2 cm diameter are not filled, while 1-2 mm vesicles are filled with chlorite. Magnetic susceptibilities average ~0.15 x 10^{-3} SI. Rusty weathering is imparted by oxidation of pyrite (locally up to 5%) which is disseminated as cubes and irregular clots throughout all leucocratic units, both intrusive and extrusive. Parts of the unit appear strongly altered, but these parts were not collected for analysis.

HOODOO INTRUSIVE COMPONENTS

Glacier cirques dissect the southeast and southwest sides of Pheno Mountain exposing a west-striking tabular intrusive body about 800 m thick. It is composed of a white to rusty weathering alkali-feldspar porphyritic quartz monzonite to monzonite. Alkali feldspar is tabular up to 1 cm. North of the quartz monzonite, sub-parallel sills up to 3.5 m thick intrude deformed Jurassic tuffaceous country rocks.

Two types of HPMVC dikes are recognized: brown melanocratic white rhomb porphyry and leucocratic quartz-alkali feldspar porphyry. Melanocratic dikes are the most widespread and that apparently radiate from Hoodoo Mountain, especially within a northern corridor, extend at least 15 km. They are brown to black with rhombic alkali feldspar (Figure 11a) ranging from fine-grained in the chilled margin to coarse (up to 2 cm) within the dike interior where they comprise ~20% of the dike volume. Dikes attain thicknesses of 3 m, but most are 0.1 to 0.5 m thick and display sharp, parallel, chilled margins. Some dikes are banded, suggesting pulsed injection. Vesiculation is common, but vesicles rarely comprise more than 5% of the dike volume. Late brittle faults commonly offset the dikes (Figure 11a).

Leucocratic dikes are pale grey with pinkish or greenish casts, and commonly with rusty-weathering zones (Figures 11b). Their phenocryst contents are variable, but a typical dike will contain 25% alkali feldspar as single crystals or glomerocrysts up to 2 cm diameter. Quartz comprises 20% as fine to medium-grained eyes and may also mantle feldspars. A clear mineral that is softer than quartz occurs within the rock matrix. At high levels, chilled dike contacts are distinctive. Outside of the main dike body a frothy and siliceous zone 10-20 cm thick containing fragments of country rocks can envelope parts of the dike locally. Within the dike, chilled margins are flow banded and can be a deep blue colour (Figure 11c). If this colour is imparted by very fine-grained sodic amphibole (*e.g.* arfvedsonite), none have been recognized in hand specimen. Magnetic susceptibilities of both melanocratic and leucocratic dikes are typically higher than the extrusive peralkaline rhyolite, with averages ranging to 20 (x 10^{-3} SI).

HOODOO - PHENO COMPLEX GEOCHEMISTRY

Peralkaline rocks of Hoodoo Mountain are characterized by elevated concentrations of high field strength elements such as Nb, Ta, Hf, Th, U and Zr as

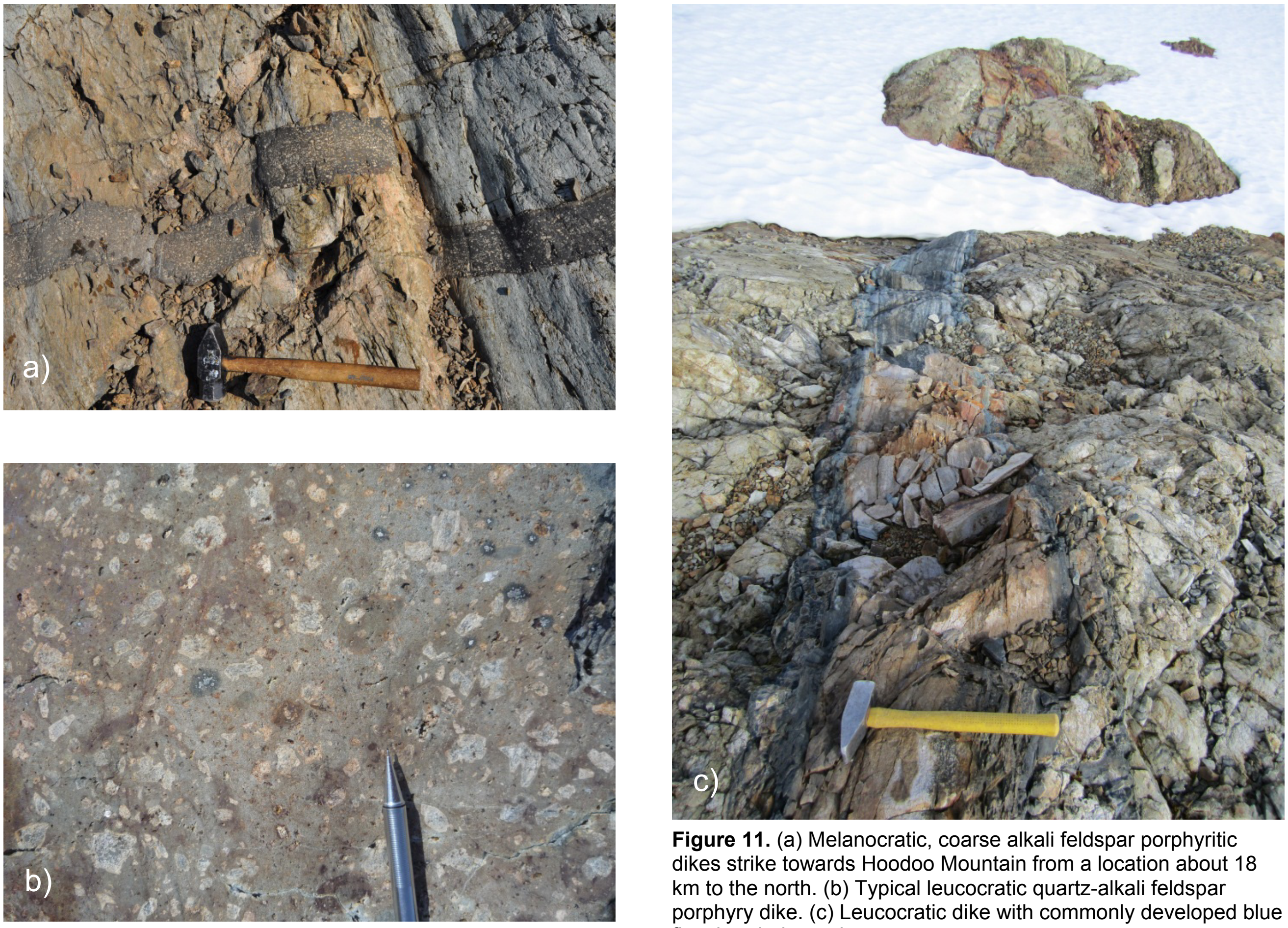


Figure 11. (a) Melanocratic, coarse alkali feldspar porphyritic dikes strike towards Hoodoo Mountain from a location about 18 km to the north. (b) Typical leucocratic quartz-alkali feldspar porphyry dike. (c) Leucocratic dike with commonly developed blue flow-banded margins.

well as most rare earth elements (Figure 12). Semiquantitative analyses of the Pheno Mountain volcanic and intrusive rocks were conducted in the field using a handheld XRF. These analyses demonstrate very strong Zr enrichment characteristic of peralkaline complexes. In addition, INAA analyses of these rocks acquired following the field season show elevated high field strength elements (HFSE) and rare earth elements (REE), (Table 2). Considering the serendipitous nature of this REE discovery, exploration for higher grade REE zones may be warranted (see Economic Geology).

Source of peralkaline magmas can vary from anatectic crustal melts to melting of metasomatized subcontinental mantle lithosphere (*e.g.* Schmitt *et al.*, 2000). Edwards *et al.* (2002) suggest that compositions of phonolitic volcanic rocks at Hoodoo Mountain may have been modified from primary, mantle-derived alkali-olivine basalt through a process of fractional crystallization and crustal assimilation. Petrogenesis of the Hoodoo-Pheno mountains volcanic complex (HPMVC) is beyond the scope of the current study; however, elevated U and Th within the Pheno Mountain suite of rocks analyzed show a U/Th ratio of 0.27, equivalent, within error, to average upper crustal values of 0.26 (Figure 13; Taylor and McLennan, 1985). REE abundances of rocks near Pheno Mountain as determined by Instrumental Neutron Activation Analysis (INAA) are compared with those from Hoodoo Mountain reported by Edwards (1997) as determined by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS; Figure 12). Elemental abundances are comparable, except for europium, but it is not known if this discrepancy is due, at least in part, to comparison of results by two different geochemical techniques.

INTRUSIVE ROCKS

Western Hoodoo Mountain area is extensively cut by plutons, stocks and dikes that range in composition from gabbroic to granodioritic with minor intrusions as felsic as quartzolite. Most significant are a continuation of the Twin River granodiorite (Mihalynuk *et al.*, 2011b) belt across the northeast map area, as well as satellites of the Coast Plutonic Complex which are particularly prevalent in the southwest.

Eocene Twin River granodiorite belt

Twin River pluton (Mihalynuk *et al.*, 2011a, b) is a ~50 km^2, northwest-elongated pluton that underlies the eastern headwaters of the Twin River. Much smaller bodies crop out in a belt extending to the northwest, parallel with the dominant structural grain. A ~6 km^2 stock straddles the boundary between 104B/14E and W

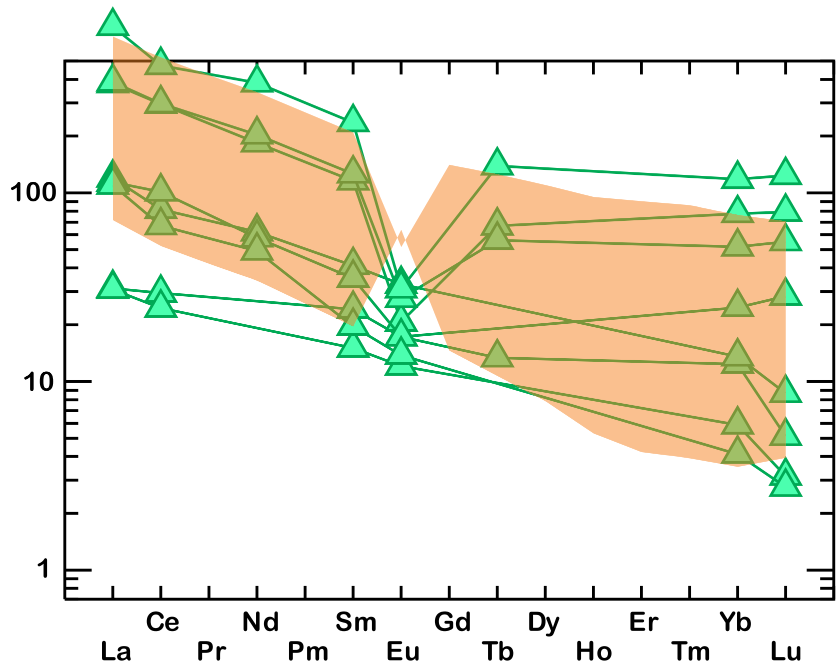
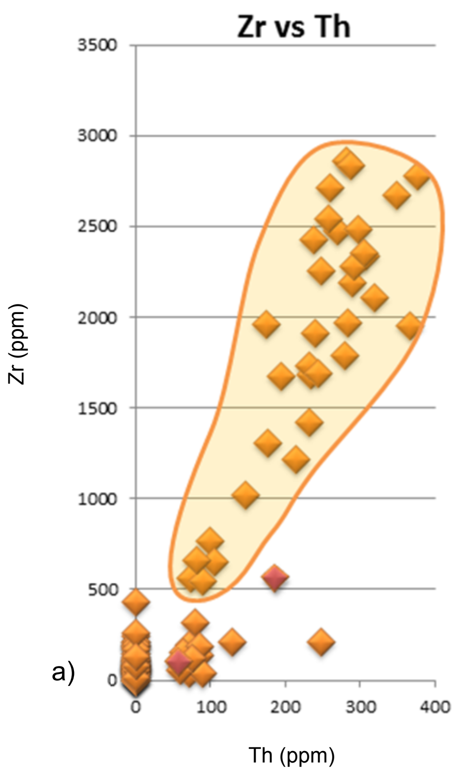


Figure 12. INAA geochemical analyses of HPMVC volcanic rocks from near Pheno Mountain. Rare Earth Elements are normalized with respect to chondrite using factors of Sun and Mcdonough (1989). The orange field are a comparison with ICP-MS sample analyses reported by Edwards *et al.* (2000).



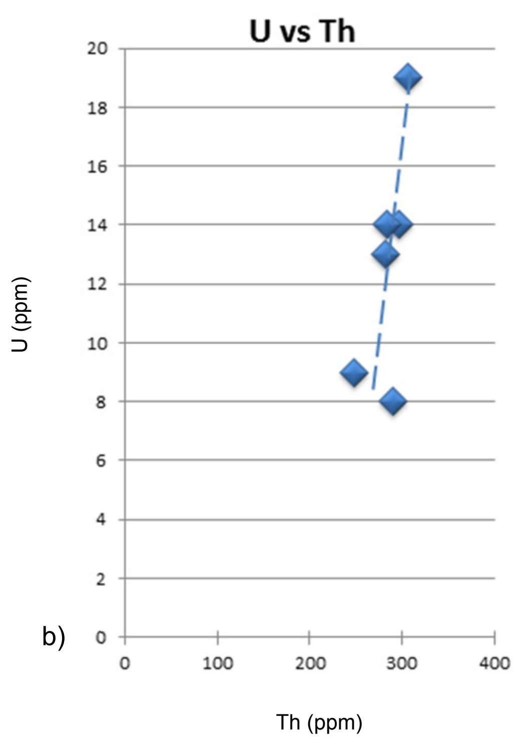


Figure 13. (a) Plot of Zr versus Th from 123 semiquantitative analyses of units within the Hoodoo west map area. All of the samples with Zr >500 ppm (N=31, shaded field) are part of the Hoodoo-Pheno mountains volcanic complex (HPMVC), and were collected mainly from volcanic and subvolcanic units in the Pheno Mountain area. One exception is a pyrite vein (red sample point) of unknown parentage. Detection limits for the handheld XRF vary on a per analysis basis, but averages for this dataset are Th=±40 ppm and Zr=±14 ppm. (b) Uranium versus thorium for HPMVC displays average crustal values of 0.27 (*cf.* 0.26 from Taylor and McLennan, 1985), suggesting derivation from a crustal source.

Table 2. Instrumental Neutron Activation Analysis (INAA) results from samples collected at sites shown on Figure 3. See Table 3 for grid coordinates.

		Analyte >	Au	Ag	As	Ba	Br	Ca	Co	Cr	Cs	Fe	Hf	Mo	Na	Rb	Sb	Sc	Se	Sn	Ta	Th	U	W	Zn	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Mass
		Unit >	ppb	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	g
		MDL >	2	5	0.5	50	0.5	1	1	5	1	0.01	1	1	0.01	15	0.1	0.1	3	0.02	0.5	0.2	0.5	1	50	0.5	3	5	0.1	0.2	0.5	0.2	0.05	
Sample No.	**Lab No.**	**Type**																																	
MMI11-11-6A	62286	Rock Pulp	9	< 5	4.1	240	< 0.5	< 1	< 1	132	< 1	2.78	31	< 1	3.65	41	1.8	1	< 3	< 0.02	9.4	22.4	9.4	< 1	< 50	81.3	158	73	18.3	1.2	3	15.2	2.35	29.4
MMI11-11-6B	62287	Rock Pulp	< 2	< 5	6	90	< 0.5	< 1	4	245	< 1	1.83	< 1	< 1	0.05	< 15	2	1.4	< 3	< 0.02	< 0.5	< 0.2	< 0.5	< 1	< 50	24.8	31	15	2.4	0.6	< 0.5	0.3	< 0.05	32.9
MMI11-12-9	62288	Rock Pulp	56	18	83.9	510	< 0.5	< 1	62	124	< 1	6.53	< 1	< 1	2.08	< 15	0.5	13.1	< 3	< 0.02	< 0.5	1.9	1.4	< 1	500	7.3	15	< 5	2.3	0.7	< 0.5	1	0.08	31.6
MMI11-14-15	62289	Rock Pulp	4	< 5	10.3	210	< 0.5	< 1	2	226	< 1	0.6	< 1	< 1	0.05	< 15	12.7	1	< 3	< 0.02	< 0.5	0.5	< 0.5	< 1	60	1.8	5	< 5	0.4	< 0.2	< 0.5	< 0.2	< 0.05	32.6
MMI11-15-2	62290	Rock Pulp	7	< 5	126	260	< 0.5	< 1	< 1	104	< 1	0.94	35	13	0.05	81	3.7	0.5	4	< 0.02	13.1	30.9	21.4	< 1	< 50	74.6	151	91	23.5	1.5	4.5	18.8	3	28.4
MMI11-15-6	62291	Rock Pulp	< 2	< 5	8.3	160	0.8	< 1	5	230	< 1	1.01	< 1	< 1	0.04	< 15	18.7	3	< 3	< 0.02	< 0.5	< 0.2	< 0.5	< 1	< 50	2.5	5	< 5	0.6	< 0.2	< 0.5	< 0.2	< 0.05	33.5
MMI11-15-12	62292	Rock Pulp	< 2	< 5	2.1	< 50	< 0.5	< 1	3	171	< 1	1.16	< 1	< 1	0.2	< 15	< 0.1	5.3	< 3	< 0.02	< 0.5	< 0.2	< 0.5	< 1	< 50	0.5	< 3	< 5	< 0.1	< 0.2	< 0.5	< 0.2	< 0.05	32.7
MMI11-17-4	62293	Rock Pulp	< 2	< 5	81.2	810	< 0.5	< 1	32	77	< 1	20.6	5	24	0.3	30	12.5	1.6	< 3	0.02	3.8	7.3	8.3	< 1	< 50	50.1	86	26	3.2	0.8	< 0.5	0.4	< 0.05	37.6
TKE11-1-2	62294	Rock Pulp	< 2	< 5	8.8	1350	< 0.5	2	11	74	3	3.64	< 1	< 1	2.98	57	2.9	14.6	< 3	< 0.02	< 0.5	3.3	1.8	< 1	< 50	9.7	20	9	1.9	0.4	< 0.5	0.9	0.15	29.8
ZE11-578A	62296	Rock Pulp	7	< 5	2.6	100	< 0.5	< 1	3	288	< 1	1.96	< 1	42	0.03	< 15	1.7	0.4	10	< 0.02	< 0.5	< 0.2	< 0.5	41	< 50	< 0.5	< 3	< 5	< 0.1	< 0.2	< 0.5	< 0.2	< 0.05	31.7
ZE11-578B	62297	Rock Pulp	< 2	< 5	1.5	< 50	< 0.5	< 1	< 1	309	< 1	0.88	< 1	7	0.02	< 15	0.7	< 0.1	< 3	< 0.02	< 0.5	< 0.2	< 0.5	252	< 50	< 0.5	< 3	< 5	< 0.1	< 0.2	< 0.5	< 0.2	< 0.05	33.4
ZE11-582	62298	Rock Pulp	4960	< 5	32600	< 50	< 0.5	< 1	31	130	< 1	18.1	< 1	< 1	0.08	< 15	489	0.8	22	< 0.02	< 0.5	< 0.2	3.6	154	< 50	< 0.5	< 3	< 5	< 0.1	< 0.2	< 0.5	< 0.2	< 0.05	44.2
ZE11-587A	62299	Rock Pulp	< 2	< 5	179	< 50	< 0.5	< 1	2	132	4	3.27	26	57	0.37	146	7.9	0.4	6	< 0.02	9.5	22.4	15.5	< 1	190	90	181	86	17.7	1.2	2.5	13.2	2.01	31.5
ZE11-632A	62300	Rock Pulp	18	< 5	144	1100	< 0.5	< 1	3	97	< 1	3.09	8	9	2.43	86	6.4	6.5	< 3	< 0.02	1.9	7.9	3.2	5	180	27	62	27	5.4	1	< 0.5	4.2	0.72	32.1
ZE11-632B	62301	Rock Pulp	4	< 5	20.4	< 50	< 0.5	< 1	< 1	43	2	3.39	16	19	0.18	244	2.4	1.2	< 3	0.05	6.9	13	3.7	3	200	91.8	182	95	19.3	1.6	2.1	8.8	1.4	30.2
ZE11-633	62302	Rock Pulp	< 2	< 5	546	< 50	< 0.5	< 1	< 1	114	< 1	3.33	35	7	2.53	77	8.8	0.4	< 3	< 0.02	11.3	26.4	5.9	< 1	410	181	290	179	36.1	1.8	5.2	20.1	3.14	34.3
ZE11-641A	62303	Rock Pulp	4	< 5	4.3	2210	< 0.5	3	6	109	3	2.07	3	24	2.9	114	1.9	4.5	< 3	< 0.02	< 0.5	11.6	4.5	18	70	26.1	41	23	3	0.8	< 0.5	0.7	0.07	29.9
ZE11-641B	62304	Rock Pulp	< 2	< 5	4.4	1750	< 0.5	< 1	8	157	3	4.11	3	27	2.38	67	0.9	3.7	< 3	0.05	< 0.5	8.8	4	< 1	< 50	17.6	31	15	2.5	0.6	< 0.5	0.7	0.06	33.7
Reference Materials																																			
MMI11-QUARTZ	62276	Rock Pulp	< 2	< 5	2.3	< 50	< 0.5	< 1	< 1	345	< 1	0.31	< 1	< 1	0.02	< 15	0.2	0.2	< 3	< 0.02	< 0.5	< 0.2	< 0.5	< 1	< 50	< 0.5	< 3	< 5	< 0.1	< 0.2	< 0.5	< 0.2	< 0.05	32.2
GSB-till	62295	Rock Pulp	47	< 5	75.7	1170	< 0.5	< 1	50	374	3	7.97	3	< 1	1.91	< 15	17.5	28	< 3	< 0.02	2.7	6.1	2.6	< 1	420	28.4	50	29	6.3	1.9	< 0.5	2.3	0.22	26.8
DMMAS 114 Measured			2250		1760	1710			40	91		3.34			1.98		9.7	6.8					17.2			16.9	27		2.4					
DMMAS 114 Certified value			2199		1624	1561			42	84		3.31			1.78		11.2	6.5					17.4			15.1	23.7		2.4					
Blank			< 2	< 5	< 0.5	< 50	< 0.5	< 1	< 1	< 5	< 1	< 0.01	< 1	< 1	< 0.01	< 15	< 0.1	< 0.1	< 3	< 0.02	< 0.5	< 0.2	< 0.5	< 1	< 50	< 0.5	< 3	< 5	< 0.1	< 0.2	< 0.5	< 0.2	< 0.05	

Analyses performed by Activation Laboratories Ltd., Ancaster

Method INAA 1D, 30g

and a stock of similar size extends less than a kilometre within 104B/14W, mainly contained by map sheet 104G/03 where it underlies the headwaters of "Trek Creek" (Figure 3). These bodies are composed mainly of hornblende-biotite granodiorite. They are blocky, and light grey to white-weathering. At "Trek Creek", medium-grained biotite>>hornblende granodiorite with ~10% chloritized mafic minerals comprises a pluton with a diameter ~3 km across its slightly elongated northeast axis. Border phases commonly contain mafic xenoliths. A strong thermo-metamorphic halo can affect country rocks more than 0.5 km from the surface contact. Proximal wacke is hornfelsed while distal intermediate breccia is epidote-chlorite altered.

Logan and Koyanagi (1994) report a K/Ar biotite age for the "Trek Creek" body of 47.3 ±1.7 Ma. Age determinations from the two bodies to the southeast within the belt are pending.

Quartzolite

Approximately 4 km east of Surprise Mountain, shallow to moderately dipping quartz veins coalesce downwards to form the continuous roof of a "flow-banded" felsic intrusion estimated to be comprised of >90% banded quartz with ~10% fine grained aplite bands. Only 200 m in its exposed, north-elongate dimension, this body is an oddity. It is orange and white weathering, and contains no visible sulphide mineralization. Age of the quartzolite body is unknown, but lack of any deformation suggest that it is Eocene or younger.

Blue-grey feldspar porphyry-gabbro complex

In the same area as the quartzolite body is a complex of blue-grey feldspar porphyry and gabbro. Intrusive contacts meander and it is not known if the intrusive phases comingle or are of entirely separate magmagenesis. Locally the gabbro does appear to cut the porphyry. In places the porphyry appears brecciated and may be volcanic in origin. Feldspar comprises ~10-15% of the porphyry, is medium grained and too turbid to permit identification of twin planes.

Gabbro is green to black weathering with medium to coarse equant crystals, probably uralitized pyroxene in an approximately equal volume of epidote-chlorite altered feldspathic matrix (Figure 14). Gabbro may be interlayered or contain screens to several metres thick of cherty argillite. Magnetic susceptibility of the gabbro is surprisingly low, averaging 0.75 (x10-3 SI). Age of these units is not known, but they are suspected to be Triassic or Jurassic. However, they may be younger, related to "Mesozoic to Tertiary" intrusions (below).

Mesozoic to Tertiary gabbro to granodiorite

Between Hoodoo and Surprise mountains is an irregular bimodal intrusion that cuts and thermally metamorphoses the well-bedded Triassic section. This body may be equivalent to the "Mesozoic to Tertiary varitextured melano-granodiorite" of Mihalynuk *et al.* (2011a).

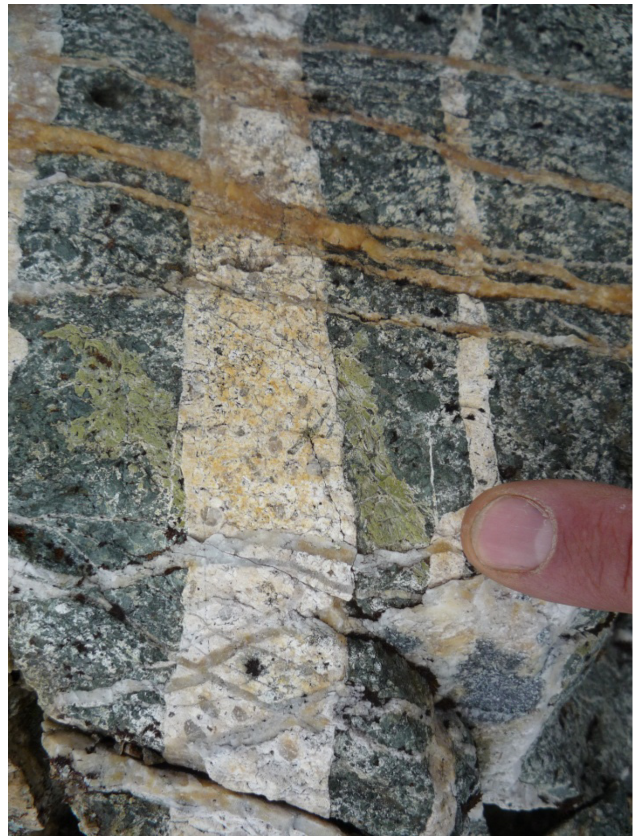


Figure 14. Epidote altered, dark green gabbro in Surprise Mountain area is cut by quartz-eye porphyritic granitoid, which is cut by white and rust sheeted quartz veins.

Away from the main intrusive mass, dikes and tongues of gabbro-quartz diorite are common within the overlying sedimentary rocks. At its eastern end the intrusion is variegated, but mainly composed of altered, medium to coarse grained pyroxene gabbro and quartz diorite. In this area, it weathers light grey-green and may display an orangish rind. Locally it is porphyritic with euhedral, green to black subidiomorphic pyroxene (probably largely replaced by amphibole) floating in a white feldspathic matrix in which turbid altered plagioclase (probably now albite) is locally replaced by epidote. Pyrite is finely disseminated (~0.25%) together with traces of chalcopyrite. More quartz dioritic compositions contain chloritized hornblende (25%) and platy biotite (<10%). Fresh biotite occurs locally within a ~1 m thick chilled contact. This has been sampled for $^{40}Ar/^{39}Ar$ age determination; results are pending. Intrusion of this body post-dates mylonitic fabrics in presumed Triassic limestone and foliated augite-phyric tuff. A Cretaceous or Eocene age is expected.

To the west, the body is dominated by chloritized, medium grained, acicular hornblende diorite. In places the western body is foliated. It is cut by quartz-eye feldspar porphyry dikes that may attain thicknesses of more than 3 m, and sheeted sets of rusty quartz veins containing centimetre knots of pyrite as well as centimetre-long prismatic bismuthinite (see Economic Geology).

ECONOMIC GEOLOGY

Previous Exploration

A brief history of mineral exploration within the Hoodoo and adjacent areas dating to the 1900s is presented in Mihalynuk *et al.* (2011a) and is amply documented elsewhere (*e.g.* ARIS reports and MINFILE, 2011). Mineralization recognized in the eastern Hoodoo sheet includes volcanogenic massive sulphide-style mineralization of probable Late Triassic age (Bernales *et al.*, 2008) and Carboniferous age (Logan, 2004; Mihalynuk *et al.*, 2011a), and Late Triassic intrusion-related vein, skarn and disseminated mineralization (Chadwick and Close, 2009). We have recognized no VMS-style mineralization in the western Hoodoo sheet, however, we report on other new mineralization and pathfinders. In addition, 2011 was a busy year for exploration at the Trek copper porphyry property.

Trek Creek copper porphyry mineralization and regional potential

Trek

Currently, the most active mineral exploration project in the area is the Trek prospect. Mineralization was discovered at the Trek prospect in 1957 (Holtby, 1989). Successive exploration programs have led to discovery of numerous zones of mineralization including a swarm of breccia pipes with diameters between 3 and 15 m (Desautels, 2011). Drilling at the north Trek in 2011 returned a 22.1 metre intersection grading 1.25% Cu and 22.43 g/t Ag (Skimmer, 2011) as well as longer, lower grade intersections. We did not map or sample the mineralized zones on the Trek property, but they are reported to be related to a porphyry system of Late Triassic age (Skimmer, 2011; for up-to-date exploration results at the Trek and alkalic porphyry copper-gold targets at the Dirk-Telena in the eastern Hoodoo Mountain sheet, see Romios Gold Resources Inc. web site http://www.romios.com).

Regional alkalic porphyry potential

Mapping in the Porcupine nunatak area south of "Trek Creek" reveals detrital biotite-rich wacke in faulted sections. This same lithology forms an apron around the mineralizing eruptive centre at the Dirk prospect in east central 104B/14E (Mihalynuk *et al.*, 2011a), and close to the intrusive centre, coarse K-feldspar and chrome diopside are found. Near the Galore Creek deposit too, strata containing clasts of coarse K-feldspar crystals and biotite mark the time of mineralizing intrusions. Thus, these strata may be a vector for alkaline magmatism related to alkalic copper-gold porphyry mineralization, and therefore, a useful regional exploration tool.

A possible test of this exploration tool is the area southwest of Telegraph Creek (Figure 1) where Forest Kerr (1948) describes sediments overlying or nearly overlying the Triassic volcanic rocks: "…a unique coarse tuff is commonly found, andesitic in composition, with large crystals of acid oligoclase, unusually dark green diopside, and, rarely, a crystal of biotite. It is well displayed on Brewery Creek mountains and in Prichard Creek area" (page 29). It may be that these strata are related to an alkalic intrusive-extrusive centre. Exploration in the areas noted by Kerr is warranted to test this possibility.

Mineralization in 104B/14W

Mineralization encountered during our mapping within 104B/14W and adjacent to its northern boundary is located in three areas. From north to south these are: "Trek Creek"-"Espaw Glacier" area, south flank of Pheno Mountain, and the Hoodoo-Surprise mountains area.

Mineralized "Espaw Glacier" moraine

At the east side of the toe of "Espaw Glacier" a subrounded rusty, arsenopyrite-rich boulder was sampled (sample ZE11-582, Table 3: 29.9% Fe, >10% S and >1% As). Analysis of the boulder shows it to contain 6.1 g/t Au, 29 g/t Ag and 0.16% Cu. We are uncertain of the source of the boulder, but presume that it was carried by the glacier from some point up the east side of the "Espaw Glacier" valley.

Hoodoo Glacier – Surprise Mountain area mineralization and indicators

In the area between Hoodoo and Surprise mountains, persistently west dipping, volcanic tuff and derived sedimentary rocks and minor flows and sills are cut by diorite to granodiorite intrusions of Mesozoic or Eocene age. Near its western contact, the intrusion is cut by sheeted sets of rusty quartz veins (Figure 15a). A feldspar porphyritic unit within the sedimentary succession contains a series of quartz-chalcopyrite veins rarely up to 20 cm thick.

Rusty sheeted quartz veins

Thickness of the sheeted veins ranges from millimetres to a decimetre (Figure 15a). They are vuggy owing to removal by weathering of disseminations of cubes and knots of pyrite up to 1 cm diameter. Insoluble prisms and crystal clusters of bismuthinite, once intergrown with the pyrite, are more than 1 cm long (Figure 15b; confirmed by handheld XRF).

We analyzed two samples: one from the vein shown in Figure 15b and one from a nearby vein (sample ZE11-578A and B). Neither sample returned appreciable Au (5 ppb, Table 3, 7 ppb Table 2). However, elements known to be pathfinders for intrusive-related gold deposits (*cf.* Lefebure and Hart, 2005) are elevated beyond the limit of accurate measurement by the ICP-MS method (Table 3):

Table 3. Inductively Coupled Plasma Mass Spectrometry results for samples collected at sites shown on Figure 3. Grid coordinates are UTM zone 9, NAD83 (mean for CONUS).

		Analyte >	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	Au	Th	Sr	Cd	Sb	Bi	V	Ca	P	La	Cr	Mg	Ba	Ti	B	Al	Na	K	W	Hg	Sc	Tl	S	Ga	Se	Te
		Unit >	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	PPB	ppm	ppm	ppm	ppm	ppm	ppm	%	%	ppm	ppm	%	ppm	%	ppm	%	%	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
		MDL >	0.1	0.1	0.1	1	0.1	0.1	0.1	1	0.01	0.5	0.5	0.1	1	0.1	0.1	0.1	2	0.01	0.001	1	1	0.01	1	0.001	20	0.01	0.001	0.01	0.1	0.01	0.1	0.1	0.05	1	0.5	0.2
Sample No.	**Lab No.**	**Type**																																				
MMI11-11-6A	62286	Rock Pulp	1.7	20.5	34.3	33	<0.1	2	0.8	62	3.07	2	1.8	6.5	3	<0.1	1	0.1	4	<0.01	0.009	35	77	0.01	12	0.006	<20	0.17	0.111	0.04	<0.1	<0.01	0.1	<0.1	0.61	3	1.3	<0.2
MMI11-11-6B	62287	Rock Pulp	0.2	67.6	2.8	18	<0.1	5.4	4.3	998	1.81	3.8	2.6	0.3	22	<0.1	0.2	<0.1	36	0.75	0.02	21	125	0.73	25	0.004	<20	0.66	0.003	0.01	<0.1	<0.01	1.4	<0.1	0.05	3	<0.5	<0.2
MMI11-12-9	62288	Rock Pulp	0.7	>10000.0	12.1	394	15.4	13.7	60.2	718	6.04	75.9	37.5	0.3	17	3.3	0.4	0.2	107	0.7	0.072	3	55	1.16	13	0.147	<20	1.87	0.046	0.03	0.1	0.05	4.8	<0.1	1.6	7	7.7	1
MMI11-14-15	62289	Rock Pulp	0.6	21.8	0.7	61	0.1	5.5	1.5	104	0.53	6.8	1	0.1	2	0.5	1.1	<0.1	8	0.03	0.013	<1	115	0.02	32	0.003	<20	0.13	0.002	0.04	<0.1	<0.01	0.5	<0.1	0.05	<1	0.6	<0.2
MMI11-15-2	62290	Rock Pulp	12.5	29.3	16.5	12	0.3	1.5	0.3	61	0.67	133.8	1.2	2.6	1	<0.1	0.6	0.1	<2	0.08	0.001	51	62	<0.01	4	0.005	<20	0.43	0.004	0.31	<0.1	<0.01	<0.1	0.1	0.18	7	<0.5	<0.2
MMI11-15-6	62291	Rock Pulp	0.2	1117.2	1.6	7	0.6	5.6	5	346	0.91	5.9	3.9	0.1	10	0.2	0.5	<0.1	11	0.94	0.02	2	126	0.14	30	0.001	<20	0.33	0.004	0.08	<0.1	<0.01	1	<0.1	0.07	<1	0.5	<0.2
MMI11-15-12	62292	Rock Pulp	<0.1	19.4	0.4	4	<0.1	3.5	1.6	142	0.36	0.6	0.9	<0.1	12	<0.1	<0.1	<0.1	6	0.36	0.001	<1	140	0.08	7	0.001	59	0.1	0.006	0.01	<0.1	<0.01	0.7	<0.1	<0.05	<1	<0.5	<0.2
MMI11-17-4	62293	Rock Pulp	26.2	13.9	35.1	48	0.3	116.2	39.2	152	25.97	99.7	0.6	0.4	45	0.5	1.4	<0.1	8	0.88	0.01	5	41	0.64	7	0.003	<20	1.32	0.04	0.13	<0.1	0.21	0.4	0.7	>10.00	7	<0.5	<0.2
TKE11-1-2	62294	Rock Pulp	0.1	77.5	9.7	45	<0.1	5.8	10.3	645	3.51	6	<0.5	1	84	<0.1	1.1	<0.1	80	1.84	0.076	6	33	0.95	211	0.041	<20	1.6	0.051	0.37	<0.1	<0.01	9.2	<0.1	0.41	5	<0.5	<0.2
ZE11-578A	62296	Rock Pulp	46.2	28.3	46	4	2.9	3.4	2	12	2.01	<0.5	5.5	0.1	1	<0.1	1.5	>2000.0	4	<0.01	0.002	<1	138	<0.01	15	0.002	<20	0.03	0.002	0.02	41.3	<0.01	0.1	<0.1	1.14	<1	10.1	3.9
ZE11-578B	62297	Rock Pulp	8	9.7	22.6	2	0.3	3.8	0.6	11	0.89	<0.5	0.6	<0.1	2	<0.1	0.5	766.6	<2	<0.01	<0.001	<1	145	<0.01	42	<0.001	<20	0.02	0.003	0.01	>100.0	<0.01	<0.1	<0.1	0.49	<1	4.6	1.5
ZE11-582	62298	Rock Pulp	2	1605.3	54.1	127	29.2	2.8	52.8	1657	29.94	>10000.0	6133	<0.1	70	3.1	551.6	32	6	1.86	0.003	<1	58	0.15	8	<0.001	<20	0.03	<0.001	<0.01	>100.0	<0.01	<0.1	<0.1	>10.00	<1	28.7	8.4
ZE11-587A	62299	Rock Pulp	46.6	10.6	24.5	218	0.1	1.5	0.7	190	2.91	177.6	<0.5	2.4	4	0.3	5.9	2.7	2	0.89	0.003	67	64	<0.01	10	0.056	<20	1.1	0.062	1.12	0.6	<0.01	<0.1	0.7	1.22	9	1.1	<0.2
ZE11-632A	62300	Rock Pulp	4.2	15.6	10.1	173	0.4	1.8	3	276	3.19	152.2	8.5	0.9	5	0.3	3	2	<2	0.18	0.03	15	57	0.02	58	0.003	<20	0.58	0.044	0.26	1	<0.01	1.2	<0.1	2	3	0.8	<0.2
ZE11-632B	62301	Rock Pulp	22.2	6	9.7	219	0.2	0.8	0.7	555	3.47	17.1	2.5	1.9	2	0.6	1.7	0.7	<2	0.33	0.008	86	26	0.02	2	0.005	<20	0.8	0.004	0.25	<0.1	<0.01	0.5	0.3	1.04	19	0.8	<0.2
ZE11-633	62302	Rock Pulp	2.9	13.4	32.8	428	0.3	1.7	0.7	746	3.53	550.4	3.9	3.7	1	0.8	7	1.3	<2	0.27	<0.001	182	63	0.01	1	0.005	<20	0.48	0.089	0.08	0.5	<0.01	<0.1	<0.1	2.2	6	<0.5	<0.2
ZE11-641A	62303	Rock Pulp	19.4	29	1.8	45	0.1	3.5	5.6	415	1.89	1.3	4.6	7.9	38	<0.1	0.1	1.6	30	1.26	0.053	13	55	0.46	396	0.07	<20	0.74	0.072	0.4	3.7	<0.01	2.9	0.1	0.83	4	0.6	<0.2
ZE11-641B	62304	Rock Pulp	25.1	59.1	2.7	44	0.3	3.4	9.7	329	4.02	1.6	10.4	7.1	20	<0.1	0.3	46.2	34	0.22	0.044	8	71	0.41	82	0.094	<20	0.77	0.085	0.41	0.5	<0.01	2.7	0.1	2.77	4	1.8	0.2
Pulp Duplicates																																						
MMI11-15-2	62290	Rock Pulp	12.5	29.3	16.5	12	0.3	1.5	0.3	61	0.67	133.8	1.2	2.6	1	<0.1	0.6	0.1	<2	0.08	0.001	51	62	<0.01	4	0.005	<20	0.43	0.004	0.31	<0.1	<0.01	<0.1	0.1	0.18	7	<0.5	<0.2
MMI11-15-2	62290	REP	13	29.7	17.5	13	0.3	1.7	0.3	65	0.68	135.7	1.6	2.9	1	<0.1	0.7	0.1	<2	0.09	0.001	52	65	<0.01	4	0.006	<20	0.44	0.004	0.32	<0.1	<0.01	<0.1	0.1	0.19	7	<0.5	<0.2
Reference Materials																																						
MMI11-QUARTZ	62276	Rock Pulp	0.3	4.8	<0.1	<1	<0.1	4.1	0.6	14	0.26	<0.5	1.2	<0.1	<1	<0.1	<0.1	<0.1	<2	<0.01	<0.001	<1	163	<0.01	2	<0.001	<20	<0.01	<0.001	<0.01	0.2	<0.01	<0.1	<0.1	<0.05	<1	<0.5	<0.2
GSB-till	62295	Rock Pulp	0.9	193.1	240	359	1.8	227.3	48.7	1685	7.25	67.9	20.5	3.9	19	0.9	8.4	0.4	107	0.35	0.114	15	235	2.94	298	0.083	<20	3.11	0.002	0.05	<0.1	0.33	15.8	<0.1	<0.05	9	0.7	0.3
	STD DS8		15.2	120.9	126.7	329	1.8	39.6	8.2	631	2.51	26.9	140.8	7.3	69	2.8	5	7.3	43	0.73	0.081	15	119	0.64	319	0.121	<20	0.99	0.101	0.44	2.6	0.18	2.4	5.4	0.21	5	5.5	5.1
	STD OREAS45CA		0.9	528.1	20.7	66	0.3	258.8	92.2	959	15.37	4.6	41.9	7.1	17	<0.1	<0.1	0.2	223	0.46	0.037	17	674	0.16	179	0.144	<20	3.7	0.004	0.07	<0.1	0.03	43	<0.1	0.07	20	0.9	<0.2
	BLANK		<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<1	<0.01	<0.5	<0.5	<0.1	<1	<0.1	<0.1	<0.1	<2	<0.01	<0.001	<1	<1	<0.01	<1	<0.001	<20	<0.01	<0.001	<0.01	<0.1	<0.01	<0.1	<0.1	<0.05	<1	<0.5	<0.2

Analyses performed by ACME Analytical Laboratories Ltd., Vancouver

Method 1DX

Sample No.	Latitude	Longitude	Easting	Northing	Sample No.	Latitude	Longitude	Easting	Northing
MMI11-11-6A	56.93211	-131.35517	356684	6312298	ZE11-582	57.03419	-131.21987	365285	6323382
MMI11-11-6B	56.93211	-131.35517	356684	6312298	ZE11-587A	56.90371	-131.36714	355847	6309162
MMI11-12-9	56.77849	-131.39136	353885	6295280	ZE11-632A	56.95478	-131.45514	350693	6315034
MMI11-14-15	56.92501	-131.30577	359663	6311405	ZE11-632B	56.95478	-131.45514	350693	6315034
MMI11-15-2	56.89816	-131.42105	352542	6308660	ZE11-633	56.95589	-131.45731	350566	6315163
MMI11-15-6	56.89408	-131.29274	360341	6307937	ZE11-641A	57.00116	-131.33908	357926	6319948
MMI11-15-12	56.85986	-131.28482	360696	6304113	ZE11-641B	57.00116	-131.33908	357926	6319948
MMI11-17-4	57.02946	-131.24331	363846	6322902					
TKE11-1-2	56.93225	-131.35835	356491	6312320	MMI11-15-2	56.89816	-131.42105	352542	6308660
ZE11-578A	56.76251	-131.45384	350004	6293638	MMI11-15-2	56.89816	-131.42105	352542	6308660
ZE11-578B	56.76251	-131.45384	350004	6293638					

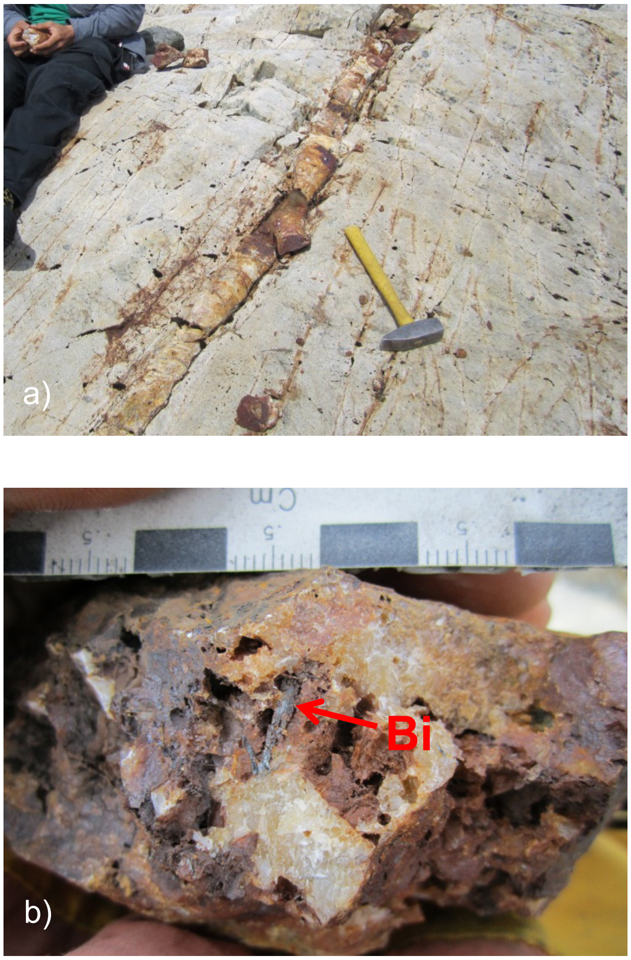


Figure 15. (a) Sheeted, rusty quartz veining in bleached granodiorite. Centimetre-thick veins are typical (beneath hammer). A close-up of the ~10 cm thick vein to the left of the hammer is shown in (b). (b) Vuggy, rusty quartz vein shows angular void outlines of pyrite cubes removed by weathering, and residual bismuthinite crystals (Bi).

Bi to >2000 ppm and W to >100 ppm. One of the samples contains 2.9 ppm Ag (ZE11-587A, Table 3).

In consideration of the small number of samples analyzed, the typical nugget effect in gold mineralization, the persistence of the sheeted veins, and the high concentration of pathfinder elements Bi and W as well as Ag, this area deserves further attention. It is, after all, within site of the Snip and Johnny Mountain gold mines, and considerable gold resources at the Bronson Slope (Figure 2).

Quartz-chalcopyrite veins

In one 5-10 m high cliff section, a ~6 m thickness of flow-banded, medium grained, crowded (30-50%) feldspar porphyry dips shallowly west with underlying strata conforming to its irregular lower surface (Figure 16a). A lithologically similar feldspar crystal tuff forms a 1-2 m thick unit a few metres up section from the porphyry. Intervening strata are tuffaceous siltstone and wacke (Figure 16b) and are locally strongly contorted with bedding ripped up by soft sediment deformation.

Within the feldspar porphyry are subparallel cockscomb quartz-carbonate-chalcopyrite veins. Some of the veins are conspicuous because of malachite staining (Figure 16c); others lack staining. One of the veins is 20 cm thick, but the most are <2 cm thick and are spaced 20 cm to 2 m along about 10 m of outcrop strike. We failed to find more of the vein material either further along or across strike. The mineralization appears mainly restricted to the porphyry; however, our search was far from exhaustive.

One aggregate sample was collected from all easily sampled veins and the adjacent porphyry hostrock. Analysis of this sample is shown in Table 3, sample MMI11-12-9. It yielded the following results: Cu >10 000 ppm, Zn 394 ppm, Ag 15.4 ppm, Au 37.5 ppb (56 ppb in Table 2). Given the cursory nature of our field observations and the interesting metal content of the veins, further work might be warranted.

Pheno Mountain REE – Zr content

Surprisingly strong enrichments in most trace elements within the volcanic and hypabyssal rocks at Pheno Mountain are shown in Table 2. Analyses for an incomplete suite of REE presented in Table 2 yields total REE (not REO) of between 0.035% and 0.072%. Comparisons can be made between the geochemistry of other peralkaline complexes such as Bokan Mountain ring dike complex, Alaska; Clay-Howells syeno-monzonite-carbonatite complex, northern Ontario; Dubbo trachyte intrusion, NSW, Australia; Kutessay, granophyre metasomatism, Kyrgyzstan; Kvanefjeld nepheline syenite, Greenland; and Thor Lake peralkaline intrusion, NWT, Canada (Table 4).

REE contents of peralkaline rhyolite tuff, dikes and monzonite and in the Pheno Mountain area are not comparable to world REE deposits. Yet for random samples collected over a ~20 km^2 area, with no expectation of elevated REEs, the analyses are encouraging and further sampling is warranted.

STRUCTURAL GEOLOGY

Structural styles observed in the western Hoodoo Mountain map area are like those described by Mihalynuk *et al.* (2011a) in the eastern map area. Folding, foliation, and faulting affect domains to varying degrees and penetrative fabrics are not regionally developed. For example, penetrative foliation developed within 15 km northeast and 5 km north of Hoodoo Mountain appears to die out farther afield. Beyond 5 km west of the peak, penetrative fabrics are no longer developed, but another few kilometers farther west, they are re-established. Pre-Neogene strata west of Pheno Mountain also display well-developed penetrative foliation. Such fabric development may be related to proximity of plutons and their extensions in the shallow crust. However, northeast of Hoodoo Mountain, the most likely candidate plutons, those of the Twin River pluton belt, apparently hornfels

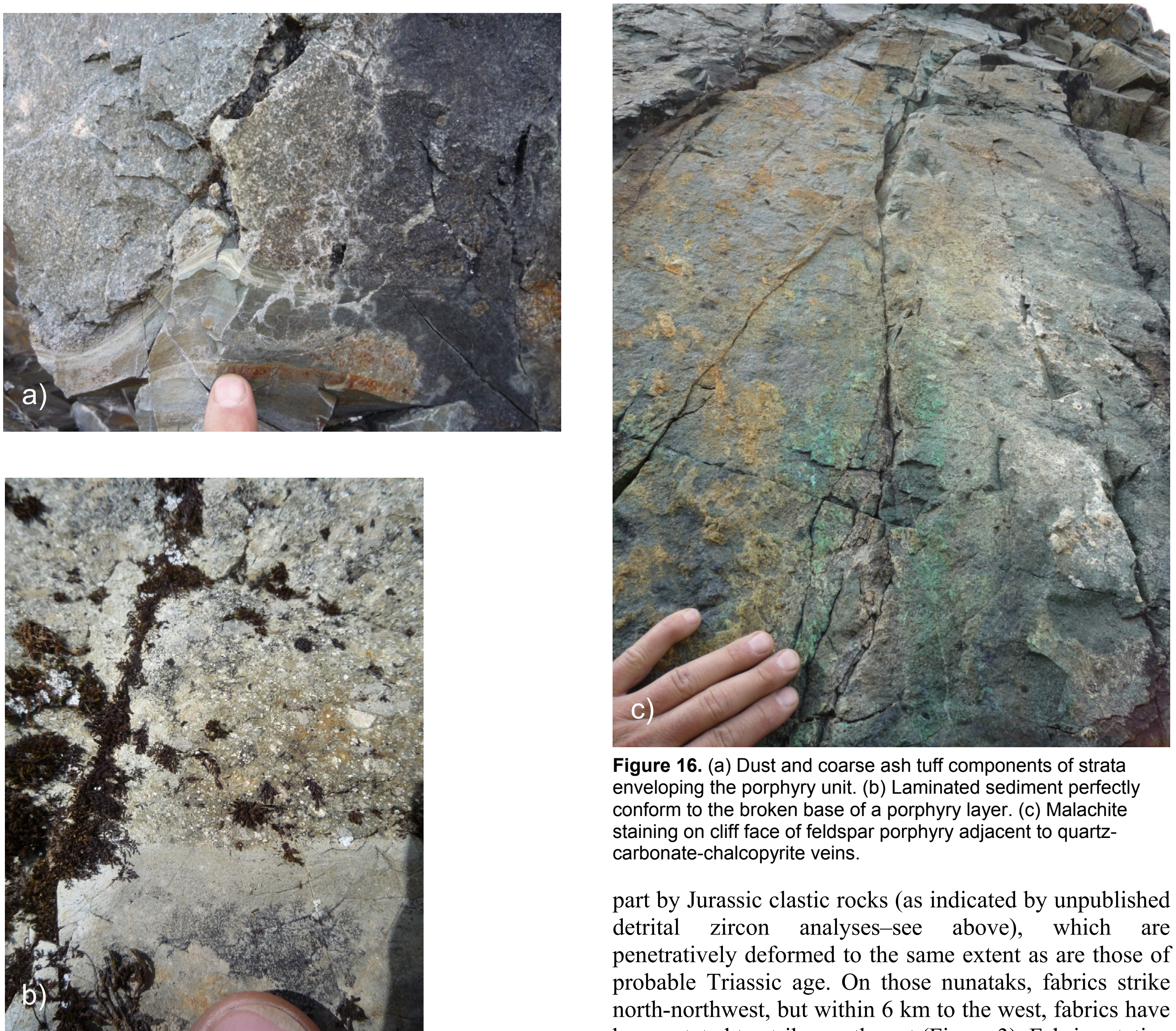


Figure 16. (a) Dust and coarse ash tuff components of strata enveloping the porphyry unit. (b) Laminated sediment perfectly conform to the broken base of a porphyry layer. (c) Malachite staining on cliff face of feldspar porphyry adjacent to quartz-carbonate-chalcopyrite veins.

the fabrics and, therefore, must postdate them. Fabric development appears equally unrelated to a specific stratigraphic interval or structural level. For example, the Twin Glacier nunataks located about 6 km north-northeast and 9 km northeast of Hoodoo Mountain are underlain in part by Jurassic clastic rocks (as indicated by unpublished detrital zircon analyses–see above), which are penetratively deformed to the same extent as are those of probable Triassic age. On those nunataks, fabrics strike north-northwest, but within 6 km to the west, fabrics have been rotated to strike southwest (Figure 3). Fabric rotation appears related to major, north-trending fold with Hoodoo Mountain located in the hinge. This fold is important because if real, it would also fold a pre-existing Verrett-Iskut fault and impact the location of offset portions the Rock and Roll deposit stratigraphy (see below).

Table 4. Representative grades and tonnages of advanced projects or past-producing peralkaline REE complexes worldwide.

Name	Location	Tonnes / class	Total REO	Cut-off	Source*
Bokan Mountain	Southeast Alaska	6.7 Mt inferred	0.580%	0.20%	Robinson *et al.*, 2011
Clay-Howells	Northern Ontario	8.5 Mt inferred	0.73%	0.60%	Daigle, 2011
Kutessay (past producer)	Kyrgyzstan	16.8 Mt measured + indicated	0.22 – 0.27%	0.07%	State Reserve Committee (1996) ***
Kvanefjeld	Greenland	619 Mt indicated + inferred	1.06% + NaF + 0.22% Zn	defined by 0.015% U_3O_8	McIllree, 2010

*Where NI 43-101 compliance in resource calculation is stated as lacking, it is denoted by: ***

Folds and thrust belts

Fold and thrust-style deformation that is best displayed in the belt of Mesozoic strata extending northwest from Twin River pluton, flanks the west side of the Twin River pluton belt (Mihalynuk *et al.*, 2011a,b) at least as far north as Sphaler Creek where it is well exposed. Faults and folds mainly verge northeast, but vergence reversals are not uncommon, and regions of high fault and fold complexity arise (Figure 17).

Fold and thrust-style deformation also affects well-bedded, relatively incompetent chert and siliciclastic strata in the "Quest Creek" valley which are correlated with the "chert-claystone" unit of Mihalynuk *et al.* (2011a) of presumed late Carboniferous age. Faulting focused in this unit accommodates overthrusting of Permian atop Carboniferous strata north of Sphaler Creek (Logan and Koyanagi, 1994).

Late faults

Major steep discrete brittle-ductile faults crop out throughout the map area. Three regional-scale faults that juxtapose units of different character. Two are exposed in "Espaw Glacier" valley and "Quest Creek" valley. A third steep fault, the Verrett-Iskut (V-I) fault is well-exposed in the eastern Hoodoo Mountain area, but runs under cover and has not yet been observed within the western Hoodoo map area.

"Espaw Glacier" fault is very well exposed as a planar, steeply east-dipping fault surface (Figure 18) that projects south-southeastwards to link with the Andrei Glacier fault. Apparent offsets of >1 km on these Andrei Glacier fault segments (Mihalynuk *et al.*, 2011a) do not seem to affect stratigraphy in the Sphaler Creek valley north its confluence with "Espaw Creek".

"Quest Creek" fault is interpreted to extend along the axis of "Quest Creek" where it is exposed. Conglomerate and fault breccia fragments are strongly lineated in a subhorizontal direction within the fault (Figure 19). This fault may accommodate the competence contrast between well-bedded chert-siliciclastic (and argillite) unit and relatively massive greenstone.

Verrett-Iskut fault

Verrett-Iskut fault (V-I fault) is a discrete, high angle fault with 1450 to 1700 m of sinistral offset in the vicinity of Mount Verrett (Mihalynuk *et al.*, 2011a). Within map sheet 104B/14E Mihalynuk *et al.* (2011b) mapped the fault as trending west-southwest from Verrett Creek,

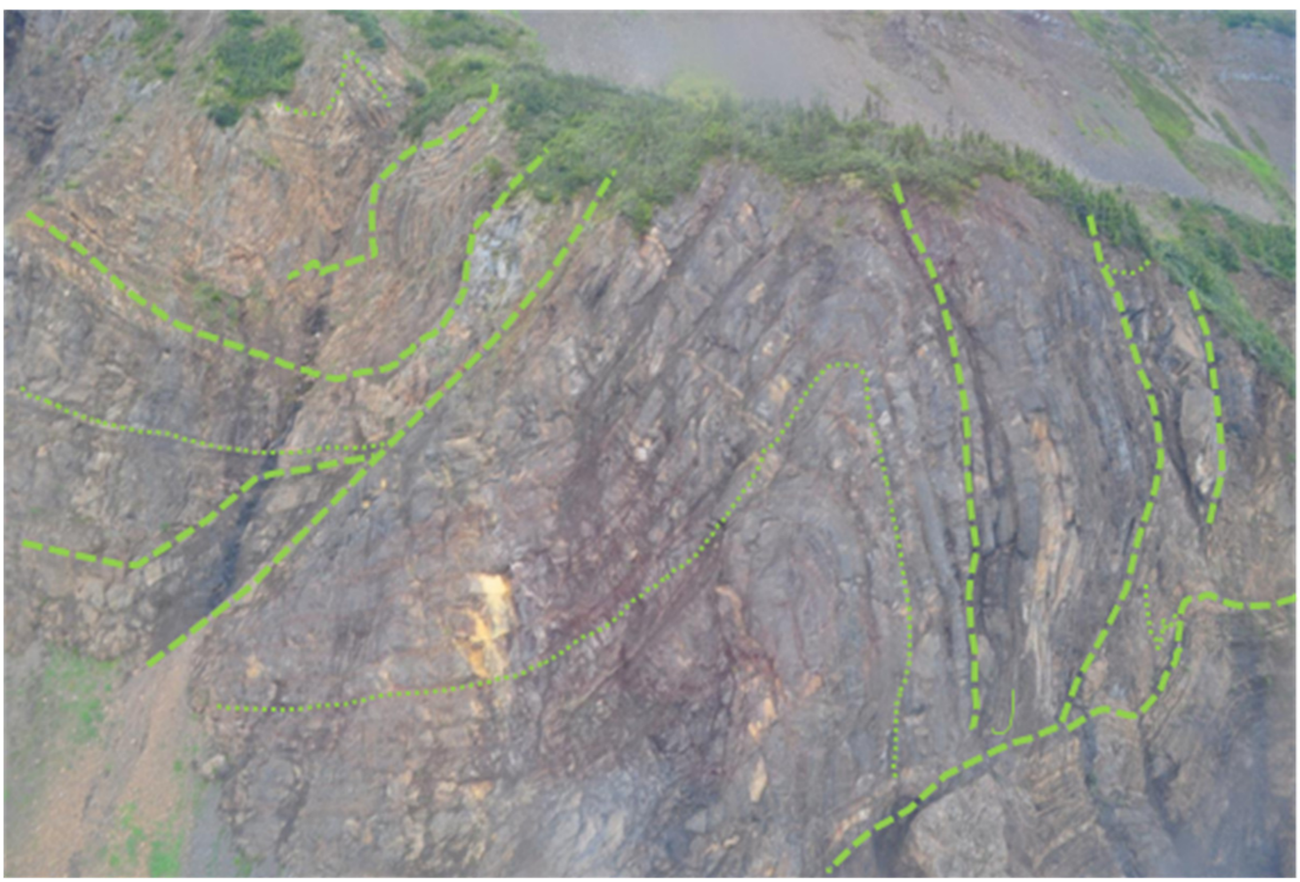


Figure 17. Zone of complex folding and thrust faults. View is of the Sphaler Creek south valley wall, looking towards the south. Most of these low angle faults ramp up section to the west and axial surfaces dip steeply east and west. Note low angle, coherent strata along the top edge of the photo above the talus slope (they persist outside of the photo to the east), presumably a significant décollement is hidden beneath the talus.

Figure 18. Trace of the “Espaw Glacier” fault here juxtaposes highly contorted graphitic and cherty argillite with massive carbonate. View is to the north-northwest. An along strike projection of the fault to the south-southeast links it with the Andrei Glacier fault (Figure 3).

Figure 19. Outcrop exposure of highly lineated fragments of broken country rock in the “Quest Creek” fault, along lower “Quest Creek”. This fault accommodates ductility contrast between Upper Carboniferous chert-siliciclastic unit and Lower Carboniferous metabasite.

across the southeast flank of Mount Verrett, following a well defined, glacially scoured lineament until it is lost at elevations below 1200 m in the forest and below Iskut River gravels. Mihalynuk *et al.* (2011a) speculated on the trace of the fault and proposed two options for the location of its western continuation. Mapping in southwest 104B/14W shows that neither of these western options can be correct (especially the northern option, which is shown on Figure 3), and that the fault must track farther to the south. The new proposed fault trace (under cover) is shown on Figure 3. Accurate location of the fault and determination of offset is important because it bears on prediction of the location of offset portions of stratigraphy that may host continuation of the precious metal-rich Rock and Roll massive sulphide deposit. Location of the new fault trace takes into account revision of the mapping west of Hoodoo Mountain by Edwards *et al.* (2000), and a major north-trending fold with an axis located beneath Hoodoo Mountain. Such a fold would bend the V-I fault to the south, and offset by ~1500 m a belt of carbonate originally mapped by Kerr (1935). The resultant offset would place the potential continuation of Rock and Roll stratigraphy beneath the toes of phonolite lava flows low on the south flank of Hoodoo Mountain.

SUMMARY

More than eighty years after Forest Kerr conducted the first systematic geological mapping around the margins of the Hoodoo Mountain area, we attempted to complete mapping across the interior of the quadrangle. Despite conveniences unimagined by Kerr: helicopters, global positioning systems, satellite imagery, water repellent membranes, geographic information systems, isotopic age dating, and duct tape, we were faced with the same insurmountable obstacle, weather. Generally poor weather during the field season of 2011 ensured that part of the Hoodoo map area, the western edge between Surprise Mountain and upper Choquette Glacier, remained unmapped. Nevertheless, geoscientific knowledge of the area, much of it a clean slate before we arrived, has improved greatly. Fundamental geological information is particularly important in this part of the province given its very high mineral potential. It aids predictive metallogeny and the future design of mineral exploration programs in the area. Some key advancements are:

- Recognition of a westward fining of Late Triassic and Early Jurassic strata, with an arc axis that lay to the east in 104B/14E.
- Continuation of a thrust belt that shortened the sedimentary basin, generally, but not always placing western facies over more easterly facies.
- North trending regional folds that deform the thrust belt as well as metamorphic fabrics.
- North trending regional folds that may also affect Verrett-Iskut fault and location of potentially offset continuation of the hostrocks for the precious metal rich massive sulphide mineralization at the Rock and Roll deposit.
- Northern continuation of the Hoodoo Mountain phonolitic volcanic rocks at Pheno Mountain, together comprising the Hoodoo-Pheno mountains volcanic complex (HPMVC).
- Recognition extreme enrichment of Zr and many REEs within the HPMVC, with possibilities for REE exploration targets.

Laboratory components of our work on the Hoodoo Mountain area is on-going.

ACKNOWLEDGMENTS

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