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Stratigraphic and structural setting of mineral deposits in the Brucejack Lake area, northwestern British Columbia (104B/8)

A.G.S. Davies, P.D. Lewis, and A.J. Macdonald
Mineral Deposit Research Unit
Department of Geological Sciences
University of British Columbia
6339 Stores Road
Vancouver, BC, V6T 1Z4, Canada

ABSTRACT

Upper Triassic to Lower Jurassic Stuhini and Hazelton groups in the Brucejack Lake area, northwestern British Columbia host several precious metal vein deposits and showings. Oldest strata in the map area are Upper Triassic(?) heterolithic volcaniclastic conglomerate-breccia and sedimentary rocks, overlain by Lower Jurassic(?) sedimentary rocks. This sedimentary succession is overlain by intermediate volcaniclastic rocks dominated by feldspar-amphibole-bearing volcanic breccia. Uppermost rocks are dacitic and include both flows and volcaniclastic rocks. The stratigraphic succession is intruded successively by (1) plagioclase-hornblende diorite porphyry, (2) plagioclase-hornblende-phyric, potassium-feldspar megacrystic porphyry, (3) flow-layered plagioclase porphyry. Field relationships suggest that precious metal mineralization may be associated with the second of these intrusive suites. Principal folds and associated cleavage overprint precious metal-bearing veins and associated alteration and likely formed during Cretaceous contractional deformation.

Introduction

Widespread alteration and abundant mineral showings near Brucejack Lake in the Iskut River map sheet, northwestern B.C. (Fig. 1) has attracted exploration to the area for over 30 years. Despite this focused interest, efforts to equate stratified host rocks with regionally defined sections elsewhere have been thwarted by alteration and plutonism in the area, and poor chronologic control. Documentation of a 185.6 Ma dacitic flow-dome complex in the east part of the area (Macdonald, 1993) demonstrates that at least some of the area contained rocks coeval with parts of the Hazelton Group, but the rock type distribution and stratigraphic relationships within the area remained poorly known. MDRU 1:5,000 scale mapping completed during the 1993 field season (Fig. 1) identified a stratigraphic succession over 750 m thick which contains the upper part of the Stuhini Group and a thick Hazelton Group section. This report outlines six units defining this stratigraphic succession and three plutonic rock types which intrude these units, discusses new constraints on the structural history of the area, and briefly addresses how these aspects relate to alteration and mineralization near Brucejack Lake.

Previous Geological Work

Earliest mapping in the Brucejack Lake area was completed as part of an M.Sc. thesis by Kirkham (1963). Subsequent exploration of the property by Granduc Mines Ltd. and Esso Resources Canada was reported by, for example, Bridge et al. (1981). Results of British Columbia Geological Survey Branch mapping have been reported by Alldrick and Britton (1988), Britton and Alldrick (1988) and Alldrick and Britton (1991); Geological Survey of Canada open file maps have been published by Kirkham (1991, 1992). Henderson et al. (1992) described stratigraphy and structure to the north of the Brucejack Lake area. Mapping by Newhawk Gold Mines Ltd. has focused on the geology in the vicinity of mineral showings that are the subject of active exploration (e.g. Roach, 1990). Earlier work by MDRU personnel and co-workers include a discussion of mineralization in the West Zone (Roach and Macdonald, 1992) and the stratigraphy south and east of Brucejack Lake (Macdonald, 1993).

Stratigraphy

Strata exposed at Brucejack Lake comprise six mappable sedimentary and volcanic rock units. Moderate to steep eastward regional dips and facing directions, although locally complicated by folds and faults, indicate an eastward younging progression of these units. Contacts between these map units are sharp to gradational over several metres; all non-faulted contacts are parallel to bedding in units both above and below, and no unconformities are identified. Detailed lithostratigraphic descriptions for all rock units are provided in Table 1 and photographs of representative examples are given in Figures 2-8. Lowest rocks, assigned to unit 1, comprise heterolithic mafic to intermediate volcanic breccia and conglomerate. Units 2 through 4 are sedimentary units consisting primarily of interbedded siltstone and sandstone, coarse-grained sandstone to conglomerate, and thinly bedded argillite and mudstone, respectively. Andesitic rocks of unit 5, dominated by plagioclase-hornblende volcanic breccia, mark a transition to more active volcanic environments characterizing the central part of the exposed sequence. Rocks of unit 6 are dacitic (Macdonald, 1992) and include both flow and volcaniclastic rocks, and minor sedimentary rocks.

Although absolute age control is lacking at Brucejack Lake, similarities of units 1 through 6 to strata elsewhere in the Iskut River area (e.g., Alldrick and Britton, 1988; Anderson and Thorkelson, 1990; Anderson, 1993) suggest equivalence to Upper Triassic and Lower Jurassic Stuhini and Hazelton Group rocks. The boundary between Stuhini and Hazelton groups elsewhere in the region is an angular unconformity to disconformity, overlain by coarse clastic sedimentary strata (Henderson et al., 1992) followed by andesitic volcanic breccia. Stratigraphically higher rocks typically include intercalated sedimentary and felsic volcanic rocks, with local basaltic flows. Units 3 through 6 at Brucejack Lake are similar to this regional Jurassic succession, although detailed correlation to specific sections elsewhere are not possible. Rock types present in units 1 and 2 are consistent with Triassic Stuhini Group strata elsewhere in the region (Anderson, 1993).

Intrusive rocks at Brucejack Lake can be grouped into three map units: (1) a plagioclase-hornblende-phyric diorite (Macdonald, 1992), (2) a potassium-feldspar megacrystic plagioclase-hornblende porphyry, and (3) a plagioclase and (rarely) potassium feldspar porphyry of dacitic composition. Minor, fine-grained, green andesitic and felsic (quartz monzonitic composition; Macdonald, 1992) dykes cut these units, and are not differentiated in Figure 1. Lithological similarities and contact relationships suggest that some of the intrusive rocks are cogenetic with upper parts of the volcanic sequence: the plagioclase porphyry exhibits both intrusive and extrusive contacts with supracrustal rocks to the north and south of Brucejack Lake, and forms a flow dome south of the lake (Macdonald, 1993). The potassium-feldspar megacrystic porphyry may be the subvolcanic equivalent of volcanic rocks of unit 6 (Table 1) on Mount John Walker; petrographic and geochronologic analyses to evaluate this proposition are in progress. Intrusive rocks similar to the megacrystic porphyry elsewhere in the Iskut River area have yielded Early Jurassic U-Pb dates ranging from 185-195 Ma (Anderson, 1993).

The rock units presented in Table 1 and diagram shown in Figure 1 include several modifications to previously published geologic maps (e.g., Alldrick and Britton, 1988; Kirkham, 1992) that include the Brucejack Lake area:

(1) Jurassic Hazelton Group strata are divided into four mappable units (Units 3 to 6; Table 1), comprising from the base upwards two distinct sedimentary units (Units 3 and 4), an intermediate volcaniclastic unit (5) and an upper felsic, mixed flow and volcaniclastic unit (6).

(2) A potassium feldspar megacrystic intrusion is recognized west of the major mineralized zones, where previous maps indicate Triassic volcanic strata. An intrusive origin for this unit is supported by exposed contacts which cut across bedding in adjacent sedimentary country rock, narrow (<10 cm) contact aureoles, and the presence of well developed flow layering following irregular intrusive contacts.

Structural Geology

Major structures at Brucejack Lake include several orientations of mappable faults and folds, a regional penetrative foliation, and zones of extensive veining and alteration. The dominant structure in the area is the Brucejack Fault, which forms a northerly-striking lineament extending northward from the Sulphurets-Knipple ice field (Kirkham, 1963). This fault cuts all stratigraphic and intrusive contacts, alteration zones, and vein systems that contact it, indicating that latest motion postdates all rocks and alteration in the area. A vertical to steep westerly fault dip is constrained by outcrop distribution in the northern part of the map area, and is consistent with orientations of both minor adjacent fault surfaces and the exposed Brucejack Fault north of the map area. Previous attempts to estimate movement on the Brucejack Fault have indicated a combination of right lateral and normal (east side down) motion to the north of the map area (e.g., Margolis, personal communication). From our work to the northwest of Brucejack Lake, the fault surface preserves slickenside and clast elongation lineations indicating at least a late period of dip-slip offset. If these linear features represent the net slip direction, displacement of 700-800 m of reverse (west-side-up) motion is constrained from offset faulted and stratigraphic contacts. 1 km northwest of Brucejack Lake, centacts show 200 to 300 m of strike separation, and displacement is likely considerably less.

Other mappable faults in the map area strike northeasterly and northwesterly. Northeast-striking faults dip steeply to the northwest, have steep north-plunging striations, and have tens of metres of normal-dextral oblique displacement. Northwest-striking faults have unknown dips and displacement directions, but displace steep contacts a few tens of metres dextrally.

Folds in the map area are best developed in thinly- to medium-bedded sedimentary strata of units 1 and 2, exposed in Brucejack Creek west of the potassium-feldspar megacrystic porphyry. Axial trends in this region vary from northerly to northwesterly. Folds are tight to open, have subangular to rounded hinges, and wavelengths of several tens of metres. Limb thrusts are common, prohibiting estimates of shortening represented by the folds. Facing directions and stratigraphic distribution patterns north of Brucejack Creek outline two larger-scale, northwest-trending open synforms (Fig. 1). These two folds have rounded hinges and wavelengths of 700 to 1000 m, and are separated by the Brucejack Fault.

West- to northwest-striking penetrative foliation is present to varying degrees in most map units, but is most strongly developed in areas of sericitic alteration associated with vein-style mineralization, and in unit 2 argillites. Foliation is defined by parallel preferred orientation of fine-grained phyllosilicates, and by flattened clast shapes in fragmental rocks. Flattened clasts are most apparent in units 1 and 5 and have oblate to moderately prolate shapes indicative of dominantly flattening strain. In much of the area, the regional cleavage is subparallel to fold axial surfaces and likely formed during the same deformation event.

Shortening directions implied by folds and cleavage at Brucejack Lake are consistent with formation during the Cretaceous development of the Skeena Fold and Thrust Belt (Evenchick, 1991), and are similar to those in the westerly adjacent Kerr Deposit (Bridge, personal communication, 1993). Large competency contrasts between intrusive rocks, bedded sedimentary rocks, and altered volcanic and intrusive rocks led to heterogeneous strain partitioning and irregular trends of structural features. The Brucejack Fault and other mappable faults are younger, local features with relatively small offsets, and are probably not formed during a regional deformation event.

Alteration and Mineralization

This study did not include a detailed analysis of mineralization and alteration, but several general observations suggest stratigraphic control on the present geometry and distribution of alteration/mineralization:

(1) Extensive alteration at the West Zone, the Shore Zone, Galena Hill, Old Yeller, and Quartz Hill overprints rocks belonging to units 2, 3, and 4, and the hornblende-plagioclase porphyry (JrD), but is most prevalent in the porphyry and the base of unit 5.

(2) Quartz + carbonate sheeted veins, massive veins, stockwork veins, and breccia veins within and stratigraphically below this alteration have variable orientations, but on average have steep dips and southwesterly to northwesterly strikes, at moderate to high angles to regional stratigraphic contacts. These veins and localized alteration extend westward as far as, and locally into, the potassium feldspar megacrystic porphyry.

(3) Most veins and alteration are deformed by both folds and foliation. Deformation within altered and mineralized zones is characterized by buckle folds of veins with axial surfaces parallel to regional foliation, and locally intense foliation devolopment. However, cleavage is locally folded (e.g., West Zone and Old Yeller Zone; Roach and Macdonald, 1992) and quartz±carbonate veins cut the folded cleavages suggesting more complex timing relationships between veins and the development of penetrative fabrics in the Brucejack Lake area.

The postulated equivalence between the potassium feldspar porphyry and unit 6, the style and orientation of veins, and the stratigraphic localization of veins and alteration all imply that alteration and mineralization at Brucejack Lake resulted from a shallow hydrothermal system associated wlth the megacrystic porphyry. Stratigraphic distribution and interpreted thicknesses suggest a depth of porphyry emplacement of not more than a kilometre or two, with most extensive mineralization and alteration (West Zone, Galena Hill, etc.) focused approximately 500 m above the intrusion in lower parts of the mixed volcanic-sedimentary sequence.

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Table 1: Map units identified in the Brucejack Lake area

Stratified Rocks:

Unit	*Thickness*	*Lithology*
Jurassic		
6	250-450 m	Flow and volcaniclastic rocks, minor sedimentary rocks. Flows: dominantly plagioclase phyric, laterally discontinuous plagioclase and potassium feldspar phyric; Volcaniclastic rocks: range from plagioclase ash and crystal tuffs to felsic breccias - clast size may attain several metres. Conglomerate: similar to felsic volcaniclastic breccias with rounded clasts of flow-layered plagioclase porphyry but with matrix component of hematitically altered mud, locally stratified; also includes volumetrically insignificant argillaceous and limy sedimentary rocks at top of exposed section, not differentiated in Figure 1.
5	200-300 m	Massive, green, monolithologic andesitic volcanic breccia to block and ash tuff and minor polylithic volcaniclastic conglomerate. Moderately porphyritic with abundant plagioclase and hornblende phenocrysts up to 2-3 mm long in both clasts and matrix. Clasts are very angular and range in longest dimension from less than 1 cm to almost 1 m. Lowest rocks in section are completely clast supported, and in highest rocks irregularly shaped clasts are supported by a fine- to medium-grained tuffaceous matrix.
4	approx. 75 m	Thin- to medium-bedded dark grey to black mudstone and argillite. Typicallly highly altered; mudstone is typically highly siliceous or cherty in appearance.
3	50-100 m	Medium- to thick-bedded, medium- to coarse-grained sandstone and pebble to cobble conglomerate. Sandstone is medium- to coarse- grained, moderately to well-sorted. Conspicuous internal planar laminations and rare cross-stratification. Conglomeratic portions are clast-supported by rounded to subangular pebbles to cobbles. Clasts are dominantly intermediate composition porphyritic rocks and subordinate argillite and mudstone clasts. Rare, cross-stratified approximately mud chip conglomerate near middle of unit.
Triassic (?)		
2	uncertain, > 200 m?	Thin- to medium- bedded black argillite, siltstone, and fine-grained sandstone. Minor medium-bedded dark grey limestone, tuffaceous mudstone, feldspathic sandstone, and tuffaceous pebble conglomerate.
1	> 150 m	Heterolithic volcanic conglomerate. Massive outcrops, stratification and sorting not visible. Subangular to rounded clasts are dominantly porphyritic (plag, hb, cpx) mafic to intermediate composition volcanic rocks. Clast-supported. Matrix consists of feldspathic wacke.

Intrusive Rocks:

Unit	*Lithology*
Jurassic (?)	
JrP	Plagioclase porphyry, typically flow layered and flow folded intrudes unit 5 north of Brucejack Lake and flows and volcaniclastic rocks of unit 6; plagioclase phenocrysts (30-40%) to 4 mm exhibiting minor sericite alteration along fractures, and local epidote and hematite alteration; rare potassium feldspar megacrysts; conspicuous, trace apatite (<0.2%) needles to 400 microns; groundmass (60-70%) of quartz ± feldspar ± clay ± sericite ± carbonate.
JrK	Megacrystic potassium feldspar, hornblende+plagioclase porphyry, probably intrudes the hornblende-plagioclase diorite. Potassium feldspar megacrysts up to 4 cm long, less common megacrystic hornblende up to 2 cm, and widespread smaller (<5 cm) plagioclase+hornblende phenocrysts, all set in a fine-grained groundmass. Conspicuous flow layering defined by crystal size, composition is subparallel to intrusive contacts. Intrusive contacts with unit 1 argillites have only thin (<10 cm) chilled margins and wall rock hornfels zones.
JrD	Plagioclase-hornblende diorite, fine grained, massive; plagioclase and hornblende phenocrysts up to 4 mm in longest dimension. Extensively altered and veined west of Galena Hill and the West Zone, but in some exposures relic feldspar phenocryst obtlines allow positive identification.

Figure Captions

Figure 1: Geology of the Brucejack Lake area, northwestern British Columbia, based upon and simplified from 1:5000 mapping by the authors in 1993. Inset shows regional location.

Figure 2: Pebble to cobble conglomerate within medium to coarse-grained feldspathic wacke, 1 km west-northwest of Brucejack Lake. Matrix is coarse and well-sorted lithic sand, Unit 3.

Figure 3: Trough cross-stratified quartz-feldspar arenite, interbedded with mud-chip conglomerate beds, west of Catear mine site, Unit 3.

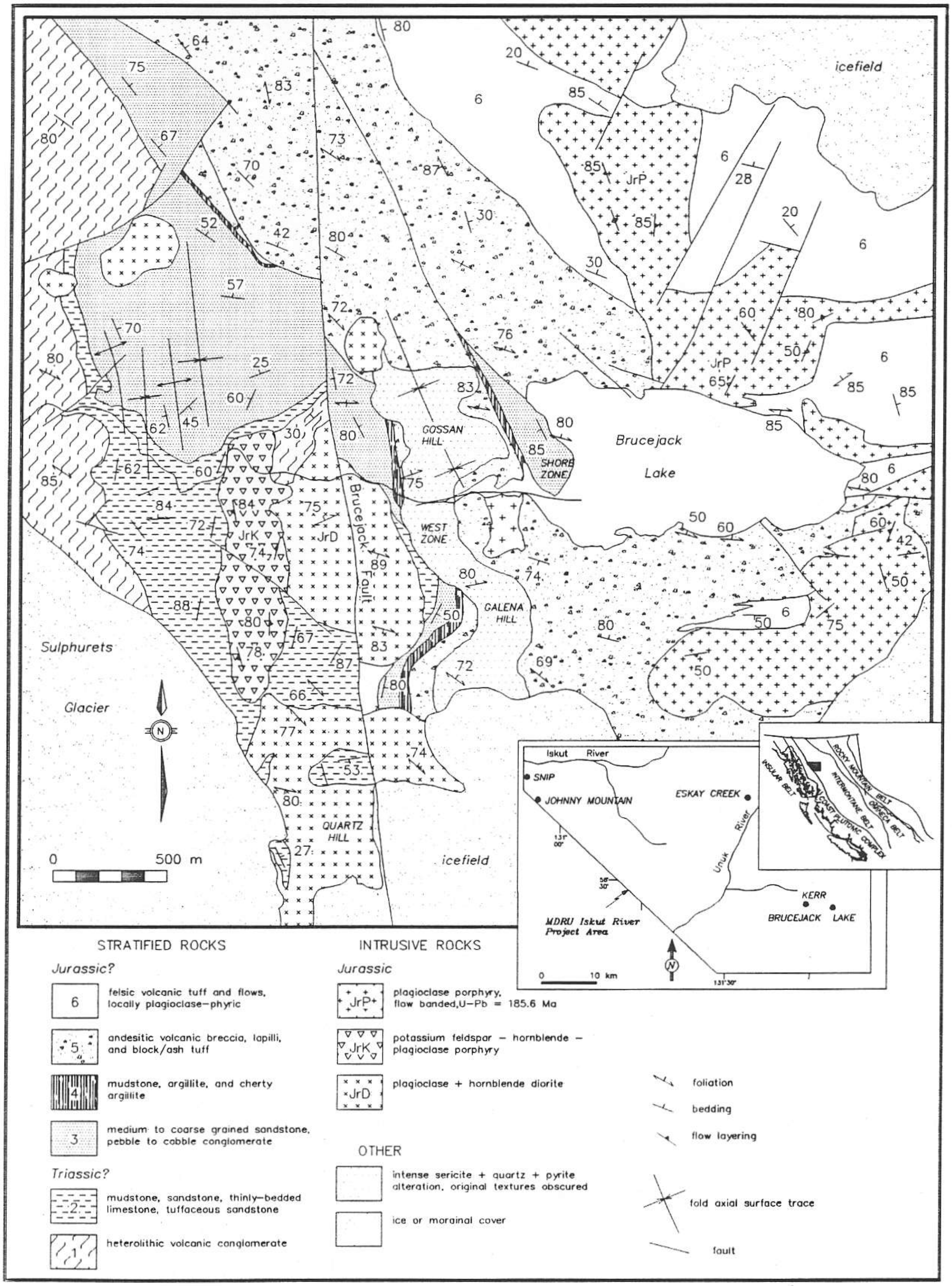
Figure 4: Intermediate lapilli tuff and block tuff, 1 km northwest of Brucejack Lake, Unit 5.

Figure 5: Potassium feldspar-megacrystic, plagioclase phyric flow, 400 m south of Brucejack Lake, Unit 6.

Figure 6: Flow fold in flow-layered dacitic intrusion, 750 m north of Brucejack Lake, JrP.

Figure 7: Breccia of flow-layered dacitic flow (extrusive equivalent of rock in Figure 6) in hematitic mud matrix, 1.35 km north-northwest of Brucejack Lake, Unit 6.

Figure 8: Medium- to coarse-grained ash tuff and lapilli tuff, 550 m south of Brucejack Lake, Unit 6.


icefield
Brucejack Lake
GOSSAN HILL
SHORE ZONE
WEST ZONE
GALENA HILL
QUARTZ HILL
Brucejack Fault
Sulphurets Glacier
JrP
JrK
JrD
0 500 m
Iskut River
SNIP
JOHNNY MOUNTAIN
ESKAY CREEK
Unuk River
KERR
BRUCEJACK LAKE
MDRU Iskut River Project Area
0 10 km
INSULAR BELT
COAST PLUTONIC COMPLEX
INTERMONTANE BELT
OMINECA BELT
ROCKY MOUNTAIN BELT
STRATIFIED ROCKS
Jurassic?
6 felsic volcanic tuff and flows, locally plagioclase-phyric
5 andesitic volcanic breccia, lapilli, and block/ash tuff
4 mudstone, argillite, and cherty argillite
3 medium to coarse grained sandstone, pebble to cobble conglomerate
Triassic?
2 mudstone, sandstone, thinly-bedded limestone, tuffaceous sandstone
1 heterolithic volcanic conglomerate
INTRUSIVE ROCKS
Jurassic
JrP plagioclase porphyry, flow banded, U-Pb = 185.6 Ma
JrK potassium feldspar – hornblende – plagioclase porphyry
JrD plagioclase + hornblende diorite
OTHER
intense sericite + quartz + pyrite alteration, original textures obscured
ice or morainal cover
foliation
bedding
flow layering
fold axial surface trace
fault