Geological Maps of the Iskut River Area

by

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REGIONAL GEOLOGICAL MAPS: ADDITIONAL NOTES

1:50,000 scale geological maps are included for map sheets 104 B/8, 104 B/9, and 104 B/10. These maps are compiled from 1:20,000 scale regional mapping completed by the MDRU, and from industry and government mapping of areas not visited by the MDRU. All maps use a single legend included as a separate sheet.

The stratigraphic divisions used on the maps differ from those on previous maps of the Iskut River area, particularly within the Hazelton Group. The Hazelton Group nomenclature used reflects our improved understanding of Hazelton Group stratigraphy, which has evolved significantly over the course of the Iskut River project through the addition of new mapping constraints, geochronology, and biochronology. The revised Hazelton Group nomenclature is outlined below, and will be the subject of a separate upcoming publication.

Revised Hazelton Group Stratigraphy for the Iskut River area

Geological studies completed in the Iskut River area over the last decade have provided an extensive database to draw from in defining new stratigraphic divisions within the Hazelton Group. Critical new data sets include: i) 1:20,000 scale mapping of about half of the Iskut River map sheet (Alldrick and Britton, 1991,1992; Lewis, 1992, 1993) and 1:50,000 scale mapping of the remainder (Anderson, pers. comm., 1993); ii) a U-Pb geochronological data base comprising more than 40 well-constrained stratigraphic and intrusive ages (Macdonald, this volume, a and b; Macdonald et al., 1992; Anderson, pers. comm., 1993; Childe, 1994; Childe et al., 1994; Mortensen, pers. comm.); iii) structural studies documenting the extent and geometry of structural disruption of map units (Lewis, 1992, 1993); and iv) a biostratigraphic database of over 80 paleontological age determinations (Nadaraju, 1993).

These studies define three major stratigraphic divisions within the Hazelton Group. They comprise, from lowest to highest, i) basal, coarse to fine grained, locally fossiliferous siliciclastic rocks, ii) porphyritic andesitic composition flows, breccias, and related epiclastic rocks; dacitic to rhyolitic flows and tuffs; and locally fossiliferous marine sandstone, mudstone, and conglomerate, and iii) bimodal subaerial to submarine volcanic rocks and intercalated mudstone. These three rock-stratigraphic units are the smallest units which fulfill the requirements of formation units as outlined in the Code of Stratigraphic Nomenclature, and we apply the designations Jack Formation, Betty Creek Formation, and Salmon River Formation to them.

Jack Formation: Lower Hazelton Group sedimentary strata:

Basal Hazelton Group typically consists of locally fossiliferous conglomerate, sandstone, and siltstone of the Jack Formation. These rocks are well exposed in the upper Unuk River/Sulphurets area along both limbs of the McTagg Anticlinorium and have been traced at least as far south as the Frank Mackie icefield. Strata of correlative age are also present in the Salmon Glacier area. No exposures of the Jack Formation are known west of Harrymel Creek. The most complete and best exposed sections are located in alpine areas north and south of John Peaks and along the west side of the Jack Glacier. The Jack Formation was first defined (informally) by Henderson et al. (1992), who used the name for distinctive coarse clastic and calcareous fossiliferous rocks occurring at the Stuhini Group/Hazelton Group

contact. Henderson et al. (1992) placed the unit between the two groups; the present inclusion within the Hazelton Group is based on the conformable relationship with overlying rocks and the often unconformably contact with Stuhini Group strata.

Lithology:

The Jack Formation is a lithologically varied sequence of sedimentary rocks which overlies Stuhini Group strata. Best reference sections of the Jack Formation occur at the Bruce Glacier/Jack Glacier area, south of John Peaks, and near Eskay Creek. At Bruce and Jack glaciers, the formation consists of a thin conglomerate containing clasts of subjacent Stuhini Group turbiditic mudstones and siltstone (Henderson et al., 1992). Trough cross stratification and channelized sandstone and conglomerate layers are common. In one location, a 2-3 m thick welded, intermediate composition pyroclastic flow deposit is interstratified with these clastic rocks. Overlying the basal sequence are fossiliferous limy sandstone and siltstone, and thinly to medium bedded, locally phyllitic, turbiditic siltstones and interbedded sandstones, up to several hundred metres thick. There is a general transition southward towards John Peaks towards a thicker basal conglomerate and sandstone, and a thinner calcareous and turbiditic component. At the reference section south of John Peaks and on the ridge extending east from Unuk Finger, the Jack Formation consists entirely of conglomerate and sandstone. Well rounded granitoid cobbles are diagnostic, typically comprising up to 50% of the clasts. West of the Unuk River in the Eskay Creek area, Jack Formation rocks comprise several hundred metres of thickly bedded to massive wackes with local conglomeratic lenses and cross-stratified intervals.

At Brucejack Lake, thick sequences of sandstones to cobble conglomerates have been assigned to the Jack Formation, although age data are lacking and contacts are ambiguous. In the southern Iskut River area near the Salmon Glacier, Alldrick (1991) describes thick siltstone intervals which may be finer-grained equivalents to Jack Formation to the north. These siltstones, classified as part of the Unuk River Formation by Alldrick, contain faunal assemblages of similar age to assemblages collected near Eskay Creek from the Jack Formation (Anderson, 1993).

Contact relationships:

The basal contact of the Jack Formation is well exposed at the Jack Glacier and south of John Peaks as a sharp, angular unconformity. Along strike from these localities, the contact is less distinct and bedding is concordant with underlying rocks. However, the unit can usually be recognized on the basis of the cobble conglomerate beds at its base. In the Treaty Glacier area to the east, the contact occurs at a concordant transition from Stuhini Group volcanic conglomerates to Jack Formation interstratified coarse sandstone and conglomerate.

No rocks correlative to the Jack Formation have been identified in the Johnny Mountain area, although the Stuhini Group/Hazelton Group contact is clearly defined as a sharp angular unconformity. In this area, lowest Hazelton Group rocks consist of volcanic and epiclastic strata correlated with the Betty Creek Formation.

Age:

Fossil assemblages collected from the Jack Formation in the Unuk River indicate a Lower Jurassic age. Well-preserved ammonites *Paracalocerous* and *Badouxia Canadensis* occur in the Eskay Creek reference section and also near Treaty Glacier, and are diagnostic of an Upper Hettangian to Lower Sinemurian age. Unconformably underlying Stuhini Group turbiditic siltstone to mudstone in this area contain Upper Norian *Monotis cf subcicularis* bivalves, providing a maximum age constraint. Upper biostratigraphic age limits are provided by Upper Pliensbachian ammonite collections from the Betty Creek Formation near Eskay Creek and near John Peaks.

Isotopic age constraints from bounding units corroborate an Early Jurassic age. Dacitic crystal tuff in the underlying Stuhini Group at John Peaks yields a U-Pb zircon date of 215-220 Ma (V. McNicoll reported in Anderson, 1993), and a granitoid clast from the Jack Formation in this same section is dated at about 225 Ma. U-Pb zircon dates from the overlying Betty Creek Formation are as old as 193 ± 1 Ma (M.L. Bevier, pers. comm., 1994).

Betty Creek Formation

Lower Jurassic volcanic and volcaniclastic strata have been problematic for workers in the Iskut River area, and stratigraphic nomenclature has been unevenly applied (see Lewis et al., this volume). Most studies in the area assign intermediate composition rocks in this interval to either the Betty Creek Formation or the Unuk River Formation as defined

by Grove (1986), and felsic rocks to the Mount Dilworth Formation. Much of the difficulty in working with this part of the section stems from the poor stratigraphic continuity of lithofacies, and the lack of regional definitions of the formations. For example, the age of the Mount Dilworth Formation in its type area is largely unconstrained, and the type "area" for the Unuk River Formation is now known to contain a wide variety of rock types representing several formations.

We assign the entire volcanic and volcaniclastic sequence from the Jack Formation to a distinct shift in style of volcanism in the lower Middle Jurassic to the Betty Creek Formation. This formation encompasses most of the rocks previously assigned to the Betty Creek and Unuk River formations, as well as some rocks previously assigned to the Mount Dilworth formation. Use of the Unuk River Formation is discontinued due to its poorly constrained definition. Within the Betty Creek Formation, three members are defined. The Unuk River Member comprises andesitic composition volcanic and volcaniclastic strata, similar to the rock types included within the original definition of the Unuk River Formation by Grove (1986). The Brucejack Lake Member of the Betty Creek Formation consists of andesitic to dacitic pyroclastic, epiclastic, and flow rocks which stratigraphically succeed and may be in part laterally equivalent to parts of the Unuk River Member. The Unuk River and Brucejack Lake Members are overlain by marine sedimentary rocks of the Treaty Ridge Member.

Unuk River Member: Andesitic flows. breccias, and volcaniclastic rocks

Andesitic composition flows, volcanic breccias, and related epiclastic rocks overlying the Jack Formation are included within the Unuk River Member of the Betty Creek Formation. The Unuk River Member is well exposed throughout the eastern Iskut River area, with thickest, best exposed sections at Eskay Creek, Johnny Mountain, Treaty Creek, and Salmon Glacier. The thickness of the Unuk River Member varies substantially: coarse volcanic breccias locally form accumulations up to 2 km thick; these localized deposits may pinch out completely in distances of less than 5 km.

Lithology:

The thickest and best preserved sections of the Unuk River Member are near Treaty Creek and in the Sulphurets area. In these locations, hornblende + plagioclase-phyric andesitic to dacitic flows and dark green volcanic breccias are intercalated with lapilli to block tuff, and lesser amounts of epiclastic sandstone and wacke. Volcanic breccias are monolithologic to slightly polylithic, commonly contain vesicular clasts, and have a plagioclase-rich volcanic matrix. At Salmon Glacier, two distinct members are differentiable: a lower porphyritic andesitic volcanic breccia to block tuff (Unuk River formation of Alldrick, 1991), separated by plagioclase-hornblende-potassium feldspar megacrystic flows or sills from an upper, maroon, well bedded epiclastic conglomerate to sandstone member (Betty Creek Formation of Alldrick, 1991).

Contact Relationships:

The Unuk River Member conformably overlies the Jack Formation in sections exposed at Eskay Creek, John Peaks, Salmon Glacier, and Treaty Glacier. At Johnny Mountain, the Unuk River Member forms the lowermost unit of the Hazelton Group and unconformably overlies the Triassic Stuhini Group. The upper contact is defined as a transition to either epiclastic dacitic rocks of the Brucejack Lake Member, or to marine sedimentary rocks of the Treaty Ridge Member.

Age:

The age of the Unuk River Member is constrained by fossils collected from bounding units, and by isotopic dating of volcanic flows at Johnny Mountain. An older limit of Upper Hettangian to Lower Sinemurian is provided by fossil collections from the underlying Jack Formation (described above). Treaty Ridge Member strata overlying the Unuk River Member at Eskay Creek and near John Peaks contain Upper Pliensbachian ammonites, bracketing the age of the former to Sinemurian or Pliensbachian.

U-Pb zircon dates at Johnny Mountain corroborate this timing: Plagioclase-phyric dykes cutting dacite to andesite Unuk River Member flows have a U-Pb zircon age of 192 ± 3 Ma, while samples from the unit itself yield U-Pb zircon ages of 193 ± Ma. Overlying felsic tuffs, correlated with the Brucejack Lake Member, provide a further bracketing constraint of 194 ± 3 Ma (M.L. Bevier, pers. comm., 1994).

Brucejack Lake Member: Felsic pyroclastic rocks and rhyolite flows

Dacitic to rhyolitic pyroclastic rocks, epiclastic

rocks, and volcanic flows within the Betty Creek Formation are assigned to the Brucejack Lake Member. These rocks are well exposed in reference sections at Brucejack Lake, south of John Peaks, and Johnny Mountain. Dacites in the Granduc Mountain area are also included within the Brucejack Lake Member. Rocks previously mapped as Betty Creek Formation in its type area near the Salmon Glacier are included within the Brucejack Lake Member. The Brucejack Lake Member is not recognized in the north central part of the map area at Eskay Creek or between Snippaker and Harrymel Creeks.

Near Granduc Mountain, the Brucejack Lake member comprises a megaclastic breccia and laterally equivalent lapilli tuff which overlies bedded crystal to dust tuff and volcanic conglomerate. To the north, water-lain crystal and ash tuffs just south of John Peaks, and multiple thin cooling units of crystal-rich welded lapilli tuff at Treaty Creek are likely equivalents. Possible vent areas for the tuffs at Brucejack Jake comprise massive, flow banded dacite domes which grade outward into autobreccia and massive, hematitic mud matrix volcanic breccia, and potassium-feldspar megacrystic flow-banded flows. In the western Iskut River area at Johnny Mountain, dacitic to rhyolitic flows and welded lapilli tuff which overlie the lower Hazelton andesite-dacite sequence form the Brucejack Lake Member.

Age:

Numerous new U-Pb dates indicate that the early pulse of felsic volcanism in the Hazelton Group near Iskut River spanned a 5-10 million year period. The oldest age of 194 ± 3 Ma was obtained from flow rocks interlayered with lapilli tuff at Johnny Mountain (M.L. Bevier, pers. comm., 1994). This section also represents some of the most felsic rocks included in the Brucejack Lake Member. Zircon extracted from bedded ash tuffs at John Peaks yielded a slightly younger U-Pb age of 190 ± 1 Ma (R. Anderson, pers. comm., 1994). Several other isotopic ages fall within the 185-188 Ma range: Vent-related dacite at Brucejack Lake yields U-Pb dates of 185.6 ± 1.0 Ma and 185.8 ± 1 Ma. Laterally equivalent potassium feldspar megacrystic dacite flows yield overlapping ages of 187.7 +5.8 / -1.5 Ma. In the Granduc Mountain area, the dacite breccia is nearly identical in age to Brucejack samples at 186.6 ± 5.6 Ma.

Treaty Ridge Member: Upper sedimentary sequence

Heterogeneous sedimentary strata including sandstone, conglomerate, turbiditic siltstone, and limestone characterize the Treaty Ridge Member of the Betty Creek Formation. Many of the rock types of the Jack Formation are present in the Treaty Ridge Member, but the occurrence of clasts derived from Unuk River member volcanic rocks, and the absence of the distinctive granitoid clast conglomerate serve to differentiate the two units. In areas lacking strata of the Unuk River and Brucejack Lake Members, such as near the Bruce Glacier, the base of the Treaty Ridge member is difficult to establish.

The Treaty Ridge Member varies from a few metres to several hundreds of metres thick. Thickest measured sections are present at Treaty Creek and Eskay Creek, while at Johnny Mountain the unit is non-existent. The most distinctive rock type within the unit consists of rusty brown to tan weathering, bioclastic sandstone and intercalated siltstone or argillite. At Salmon Glacier, this rock type forms a layer 2-3 m thick, and represents the total thickness of the Treaty Ridge Member. To the north at Treaty Ridge, the bioclastic unit is succeeded by a several hundred metre thick turbiditic mudstone to sandstone section. Bioclastic sandstones are also present in the Member at Eskay Creek and John Peaks, where they are interstratified with siltstone, arenitic sandstone, and heterolithic rounded cobble conglomerate. West of these areas, a thick, grey weathering, medium-bedded limestone and siltstone sequence is a probable stratigraphic equivalent.

Age:

Abundant and diverse fauna within the Treaty Ridge Member which span Upper Pliensbachian to Upper Aalenian stages (Nadaraju, 1993) suggest that the unit records a long period of volcanic quiescence. Upper Pliensbachian ammonite collections provide age constraints at three locations: at Eskay Creek, bioclastic sandstones contain ammonites *Tiltonicerous* cf. *propinquum* and *Protogrammoceras*. A lithologically similar section at John Peaks and interstatified limestone and siltstone sections to the west at Lyons Creek both yield the Kunae Zone (Upper Pliensbachian) ammonite *Arieticeras* cf *algovianum.* At Treaty Creek the base of the member is slightly younger: here diverse faunal collections from the bioclastic sandstone includes Toarcian belemnites (G. Jakobs, J. Palfy, pers. comm.). Higher in this same section, ammonites *Tmetoceras* cf. *Kirki, Leioceras,*

and *Pseudoliocerous* constrain an Upper Aalenian age for turbiditic mudstone and siltstone. Together, these fossil occurrences suggest that sedimentation spans the Upper Pliensbachian, the Toarcian, and most of the Aalenian stages, although no single section includes fauna diagnostic of all three stages. Isotopic ages in the Iskut River area are consistent with a magmatic gap in this time period.

Salmon River Formation: Bimodal volcanic unit

The upper part of the Hazelton Group in the Iskut River area comprises dacitic to rhyolitic flows and tuffs, localized interlayered basaltic flows, and intercalated volcaniclastic intervals. Although these different rock types can easily be mapped separately on a property scale, their interfingering nature and lack of continuity dictate that they be grouped into a single unit for regional mapping purposes. This part of the Hazelton Group has attracted the most attention of geologists due to its association with mineralization at Eskay Creek, but at the same time its distribution, internal stratigraphy, and age are poorly understood. Previous workers have mapped felsic volcanic components as the Mount Dilworth formation, and mafic volcanic components as a distinct facies of the Salmon River Formation. These assignments become problematic with latest mapping constraints which demonstrate that locally more than one felsic horizon exists, and that mafic volcanic rocks occur both above and below these felsic intervals.

The accompanying maps assign all Hazelton Group rocks above the Treaty Ridge Member to the Salmon River Formation, which is subdivided into the Bruce Glacier, Troy Ridge, Eskay Rhyolite, and John Peaks members.

Bruce Glacier Member:

The Bruce Glacier Member of the Salmon River Formation comprises widely distributed dacite to rhyolite flows, tuffs, and epiclastic rocks. These rocks vary from as little as a few tens of metres to over 400 metres in thickness, with thickest accumulations on the west limb of the McTagg Anticlinorium between the Bruce Glacier and the Iskut River valley. Lithofacies within the member are highly variable both regionally and vertically in a given section. Deposits proximal to extrusive centres include banded flows, massive domes with carapace breccias, autoclastic megabreccias, and block tuffs. Extrusive centres have been identified at several locations in the Iskut River area, including Brucejack Lake, Julian Lake (near the headwaters of Snippaker Creek) and Bruce Glacier. These felsic extrusive centres are characterized by thick, domal porphyritic centres, grading outward to flow breccias and talus piles. Slightly to densely welded lapilli to ash tuffs characterize more distal equivalents. Reworked tuffs locally form thick epiclastic accumulations and may fill in paleobasins adjacent to extrusive centres.

Troy Ridge Member:

Sedimentary and tuffaceous sedimentary rocks of the Salmon River Formation are assigned to the Troy Ridge Member. This member includes the distinctive black and white striped strata known as the "pyjama beds" at Salmon River and are present to a lesser extent in northern parts of the area and the mineralized contact zone mudstone at Eskay Creek. Contact relations with other Salmon River Formation members are variable: for example, at Eskay Creek the member lies above the Eskay Rhyolite and Bruce Glacier Members, but below the John Peaks Member. At Julian Lakes the member is interstratified with rocks assigned to both the John Peaks and Bruce Glacier members. These types of stratigraphic relationships suggests that the Troy Ridge Member represents sediments accumulated during breaks in local volcanic activity.

John Peaks Member:

Mafic components of the Salmon River Formation, assigned here to the John Peaks Member, are localized in their distribution and are missing from much of the Iskut River area. Generally they occur above the felsic members (Bruce Glacier and Eskay Rhyolite), but at Treaty Creek thick sections of mafic flows and breccias lie below welded tuffs of the Bruce Glacier Member. Mafic sections are thickest at Mount Shirley and near the mouth of Sulphurets Creek, and form intermediate thicknesses at Eskay Creek and Johnny Mountain. Textures present include massive flows, pillowed flows, broken pillow breccias, and volcanic breccias. Plagioclase phenocrysts up to 2 cm long are characteristic of the pillowed sequence south of John Peaks. At Treaty Glacier the mafic component grades upward from pillowed and massive flows into broken pillow breccia, and finally, hyaloclastite matrix supporting abundant irregular globular volcanic fragments.

Eskay Rhyolite Member:

Rhyolite flows, breccias, and tuffs in the Eskay Creek area are assigned to the Eskay Rhyolite Member of the Salmon River Formation. Although this rhyolite is lithologically similar to some exposures of the Bruce Glacier Member, particularly in the Virginia Lake region, it can be distinguished geochemically on the basis of an Al:Ti ratio of greater than 100. At Eskay Creek, the member forms a distinct mappable unit overlying the Bruce Glacier Member and underlying the John Peaks Member, with thicknesses of up to 250 m.

Age:

Age constraints for the Salmon River Formation include U-Pb zircon ages from the Bruce Glacier Member and fossil collections from intercalated sedimentary sections assigned to the Troy Ridge Member. Because of the interfingering relationships of the different members these determinations are interpreted as being representative of the entire formation.

U-Pb zircon dates obtained from the Bruce Glacier Member bracket the age of the unit to around 172-178 Ma. At Bruce Glacier, a U-Pb age of 176.2 ± 2.2 Ma has been obtained from flow-banded dacites near the base of the section. Stratigraphically equivalent flows across the Unuk River valley have yielded a U- Pb age of 173.6 Ma + 5.6/-0.5 Ma (Childe, 1994). In the Snippaker Creek area, two U-Pb ages fall within this same range: 172.3 ± 1.0 Ma, and 178.2 ± 5.0 Ma.

Fossil collections from within the Troy Ridge Member are consistent with U-Pb age determinations of adjacent rocks, but are problematic when compared to biochronological constraints from the underlying Betty Creek Formation. Fossil collections at Eskay Creek indicate a middle Bajocian age for the unit, while slightly older Upper Toarcian ammonites have been collected from the Julian Lakes area. This Toarcian age is older than Upper Aalenian ammonites from the Treaty Ridge Member at Treaty Ridge, indicating that either formations are diachronous across the map area, or that units at Julian Lakes should be reassigned to lower positions.

Mount Dilworth Formation:

The term "Mount Dilworth Formation", as defined by Alldrick (1991) has been applied to felsic volcanic portions of the Hazelton Group throughout the Iskut River area. Recognition that the Hazelton Group contains multiple, temporally distinct felsic volcanic intervals casts many of these assignments in doubt. One objective of the MDRU research program has been to obtain conclusive age data for both the type Mount Dilworth Formation and for mappable felsic intervals to the north, and if possible, to establish map continuity between the type section and more northerly areas. Despite several attempts, no well-constrained age has been determined for the formation's type area, and map continuity is lacking. In order to avoid possible erroneous correlations, the term "Mount Dilworth Formation" has been dropped from the MDRU maps, and the stratigraphic nomenclature used is based on type sections within the area mapped as part of the study. Felsic intervals which might have previously been included in the Mount Dilworth Formation are now assigned to either the Brucejack Lake Member of the Betty Creek Formation, or the Eskay Rhyolite or Bruce Glacier Member of the Salmon River Formation, depending on age and stratigraphic position.

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