Recent basaltic volcanism in the Iskut-Unuk rivers area, northwestern British Columbia

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Abstract: The Iskut-Unuk rivers area contains eight Recent volcanic centres comprising alkali-basalt lava flows, pillow lava, hyaloclastite and cinder cones, including: the Iskut River, Tom MacKay Creek, Snippaker Creek, Cone Glacier, Cinder Mountain, King Creek, Second Canyon and Lava Fork centres. Lava flows range from 70 000 to ~150 years. The oldest volcanic rocks underlie the Iskut River Lava Flats and the youngest occur at the Lava Fork centre. The lavas erupted from each centre are similar in mineralogy. Most contain plagioclase and olivine phenocrysts and clinopyroxene occurs as a groundmass phase. Plagioclase megacrysts characterize lavas from a number of volcanic centres, but are particularly abundant in lavas from Snippaker Creek and Cone Glacier. Crustal xenoliths are abundant in Lava Fork and Cone Glacier lavas but less common elsewhere. Many of the volcanological features are attributable to volcanic eruptions occurring near and beneath glaciers.

Résumé : La région des rivières Iskut et Unuk renferme huit centres volcaniques actifs à l'Holocène ayant émis des basaltes alcalins sous forme de coulées massives, de coulées en coussins, d'hyaloclastites et de cônes de scories. Ces centres ont pour nom : Iskut River, Tom MacKay Creek, Snippaker Creek, Cone Glacier, Cinder Mountain, King Creek, Second Canyon et Lava Fork. L'âge des coulées de lave varie de 70 000 à environ 150 ans. Les roches volcaniques les plus anciennes gisent sous les plaines de lave de la rivière Iskut et les plus récentes se trouvent au centre de Lava Fork. Les laves éjectées de chaque centre ont des minéralogies semblables. La plupart contiennent des phénocristaux de plagioclase et d'olivine sertis dans une matrice à clinopyroxène. Des mégacristaux de plagioclase caractérisent les laves de plusieurs centres volcaniques, mais sont particulièrement abondants dans les laves des centres de Snippaker Creek et de Cone Glacier. Des xénolites de matériel crustal abondent dans les laves de Lava Fork et de Cone Glacier, mais sont plus rares ailleurs. Un grand nombre de caractéristiques volcanologiques sont attribuables à des éruptions volcaniques se produisant à proximité ou au-dessous de glaciers.

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INTRODUCTION

The Stikine Volcanic Belt includes a number of relatively small Recent cones and related lava fields along with three large compositionally diverse volcanic complexes: Level Mountain (Hamilton, 1981), the Edziza-Spectrum Complex (Souther, 1989) and Hoodoo Mountain (Souther, 1990a; Edwards and Russell, 1994). Souther (1990b) named the Recent cinder cones and lava flows scattered south of the Iskut River the Iskut-Unuk River Cones (Fig. 1). Volcanoes within the Stikine Volcanic Belt are disposed along several short en échelon segments. Souther (1990a) suggested that the southern part of the belt where the Iskut-Unuk rivers volcanic rocks are located is associated with north-trending extensional structures. These structures probably developed in response to shear along the adjacent, transcurrent boundary between the continent and the Pacific plate.

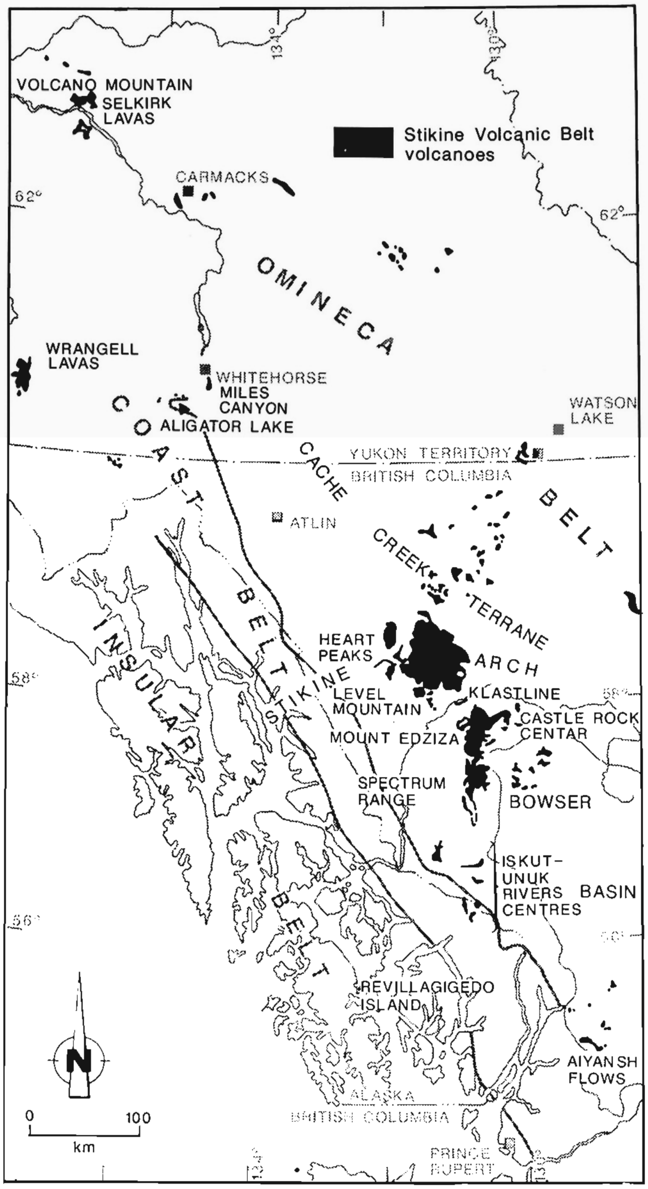

Figure 1. Location of the Iskut-Unuk rivers volcanic centres within the Stikine Volcanic Belt (after Souther and Yorath, 1991).

The Iskut-Unuk rivers volcanic assemblage includes eight volcanic centres named after their geographic locations: the Iskut River, Tom MacKay Creek, Snippaker Creek, Cone Glacier, Cinder Mountain, King Creek, Second Canyon and Lava Fork centres. These Recent lava flows and pyroclastic deposits mostly occupy topographic lows (e.g., stream valleys) and mineralogically and chemically are alkali-olivine basalts (Grove, 1974; D.A. Brew, pers. comm., 1990). Recent volcanism in the Iskut-Unuk rivers area spanned 70 000 to ~150 B.P. (B.C. Hydro, 1985).

In 1989 Stasiuk and Russell (1990) visited and sampled most of the Iskut-Unuk rivers volcanic centres. We designed the 1993 field season to complete the sample collection and to ascertain field relationships among volcanic units within each centre. Appendix 1 lists the representative samples and their locations. Crustal xenoliths are common in these volcanic rocks and special efforts were made to collect samples of these diverse materials (Appendix 2). Lastly, unconsolidated basaltic ash was sampled at three locations; pertinent details are given in Appendix 3.

Based on these samples and those collected previously (Stasiuk and Russell, 1990), we are directing future research towards: i) characterizing the chemistry and mineralogy of each centre; ii) investigating source-region processes related to the Iskut-Unuk rivers magmatism; iii) identifying the styles of magmatic differentiation within and between each volcanic centre; and iv) evaluating the role and mechanisms of assimilation.

PREVIOUS WORK

The two southernmost centres, Lava Fork and Second Canyon were briefly noted by workers in the early part of this century (Wright, 1906). Regional mapping programs provided first descriptions for the majority of volcanic centres in the Iskut-Unuk rivers area. Kerr (1948) mapped the Recent flows occurring along Iskut River. Grove (1974) visited and sampled most of the Recent volcanic centres. His work currently represents the only published chemical analyses for Iskut-Unuk rivers volcanic rocks; he published major and trace element data for volcanic rocks from six centres. Grove's (1986) compilation for the Unuk River-Salmon River-Anyox area also gave distributions of Recent volcanic rocks, for the Iskut-Unuk rivers area and beyond.

The most detailed mapping of Iskut-Unuk rivers volcanic centres was conducted by B.C. Hydro, between 1982 and 1984, as a part of their Iskut Canyon and More Creek projects (B.C. Hydro, 1985). This largely unpublished work mainly concerned the Recent volcanic stratigraphy of the area and included 1:50 000 and 1:10 000 scale geological mapping, ^{14}C and K-Ar dating of units and diamond drilling of the Iskut River lava flows. Later regional geological maps (Britton et al., 1988, 1989; Read et al., 1989) include distributions of Recent volcanic rocks in the Snippaker Creek and Unuk River

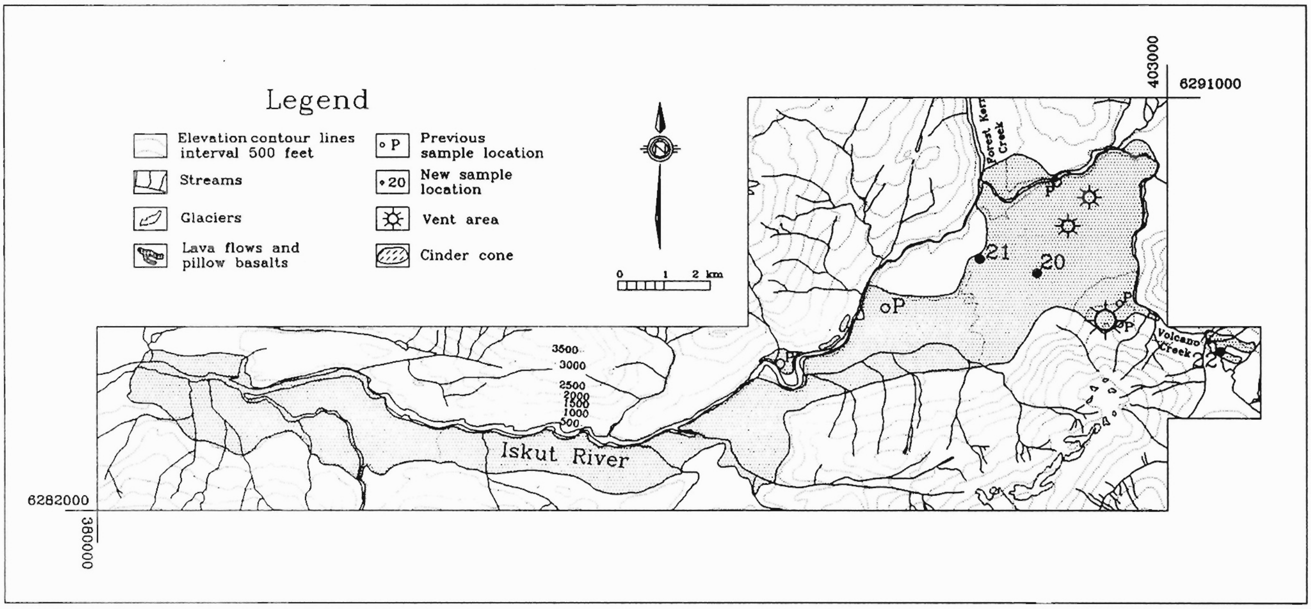

Figure 2. Distribution of volcanic material in the Iskut River and Tom MacKay Creek volcanic centres. Legend distinguishes between lava flows or pillow basalt and cinder cones.

areas. Finally, Elliott et al. (1981) and D.A. Brew (pers. comm., 1990) described lava flows and stratigraphic relationships from the Lava Fork centre. Souther (1990b) compiled and summarized much of the information described above. Stasiuk and Russell (1990) used the maps of previous workers (Kerr, 1948; Grove, 1986; Elliott et al., 1981) when they collected samples.

THE ISKUT-UNUK RIVERS CENTRES

This report is a compilation of fieldwork results derived from the 1993 field season and B.C. Hydro's Iskut Canyon and More Creek projects. In particular the ages of the volcanic units and most of the distributions result from B.C. Hydro's research (B.C. Hydro, 1985) and this paper largely corroborates the existing maps with few exceptions (e.g., Cone Glacier and Cinder Mountain centres).

Iskut River

Figure 2 shows the distribution of Recent lava flows along Iskut River and three proposed vents which have produced both lavas and cinder. The Iskut River canyon cuts down through at least 10 thick, subaerial lava flows and immediately south of the canyon, these flows form the Iskut River Lava Flats (B.C. Hydro, 1985). At least two younger lava flows can be traced across the Lava Flats (i.e., they overlie older flow surfaces) (B.C. Hydro, 1985). Contacts between these younger lavas and those making up the majority of the Lava Flats are partly marked by differences in vesicularity between the base of one flow and the top of the other. All of the flows observed are porphyritic with plagioclase and olivine phenocrysts, a feature that makes separation of flows in the field difficult. The surfaces of both these younger flows and the Lava Flats are vegetated and characteristically cindery, blocky and hummocky which hindered collection of fresh material (e.g., Sta. 20 and 21).

Flows at the base of the Iskut River Lava Flats are about 70 000 years old, based on K-Ar dating; the overlying basalt flows are dated (^{14}C) at 8730 years (Table 1, B.C. Hydro, 1985). Three cinder cones are identified (Fig. 2). The youngest cone lies to the south and appears to have fed the two youngest flows. It appears to have repeatedly erupted lava which dammed both Tom MacKay and Forrest Kerr creeks (B.C. Hydro, 1985). This inference is based on ^{14}C dating of plant remains in lake sediments associated with these ephemeral dams. These age determinations (Table 1, B.C. Hydro, 1985; Read et al., 1989) suggest lava effusion occurred 3800, 5600 and 6500-6800 years ago; the Iskut River Canyon was eroded to its present configuration in the last 3600 to 3800 years (B.C. Hydro, 1985). The two youngest flows have not been successfully dated.

Tom MacKay Creek

Volcanic rocks in the Tom MacKay volcanic centre occur just east of the Iskut River Lava Flats (Fig. 2) and make up a single flow unit composed of highly weathered, fragmented pillow basalt. Individual pillows (Sta. 22) are 20-40 cm in diameter, very vesicular, radially jointed and commonly have glassy rinds. The pillow lava locally forms 20-30 m high cliffs. These thick, restricted accumulations of pillow lava have probably resulted from volcanic eruption against or close to ice. No samples were previously collected from this centre (e.g., Stasiuk and Russell, 1990).

Snippaker Creek

Recent lava distributions within the Snippaker Creek drainage are shown in Figure 3. The lavas outcrop from stream level to approximately the 1000 foot contour. Representative samples were collected from three localities including: i) the southern terminus (Sta. 17), ii) along Memorial Creek (Sta. 1), and iii) within the Snippaker creekbed towards the northern terminus (Sta. 16). Two flow units were sampled at each location although more flows were observed in the last locality. Here (Sta. 16), Snippaker Creek has incised a narrow, steep-sided canyon through the flow sequence where at least 6 flow units are exposed, each 3-5 m thick. Contacts between flow units are marked by changes in vesicularity between flow tops and scoriaceous flow bases.

Flows from the three localities are indistinguishable. They have grey, vesicular fresh surfaces and are plagioclase and olivine porphyritic; phenocrysts range in size from 0.1 to 1 cm. Previous work has suggested that the vent to these lavas lies upstream of the confluence of Memorial Creek and Snippaker Creek (B.C. Hydro, 1985). The northern terminus of these flows abuts against lavas of the Iskut River Lava Flats and both sets of lavas are plagioclase and olivine porphyritic and indistinguishable in hand sample (B.C. Hydro, 1985).

Cone Glacier

The Cone Glacier volcanic centre comprises two prominent cones and several lava flows (Fig. 4). Lava flows emanate from the Cone Glacier area, cover a portion of Snippaker Creek (to the west) and underlie Julian Lake and the King Creek drainage (to the south). Near the western terminus of the flows only 1-3 flows are exposed and some overlie till or river gravel (B.C. Hydro, 1985). Lava flow surfaces are

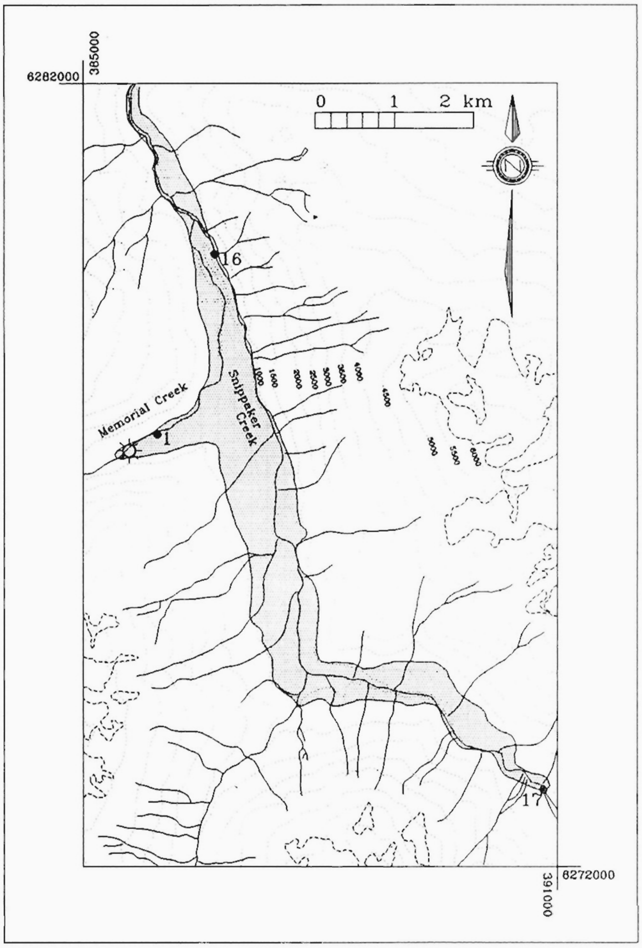

Figure 3. Distribution of Recent volcanic rocks for the Snippaker Creek centre. Legend is as in Figure 2.

Table 1. Summary of radiometric age determinations of Iskut-Unuk rivers volcanic centres.

Centre	Date (yrs)	Method	Notes	Reference
Iskut River	70,000±30 000	K-Ar	Basal flow 1 from Lava Flats	B.C. Hydro (1985)
Iskut River	10,000±10 000	K-Ar	Flow 2 on top of flow 1	B.C. Hydro (1985)
Iskut River	8780±150	^{14}C	Cinder on top of flow 2	Read et al. (1989)
Iskut River	8730±600	^{14}C	Cinder on top of flow 2	B.C. Hydro (1985)
Iskut River	6800±160	^{14}C	Damming Tom MacKay Creek	B.C. Hydro (1985)
Iskut River	6500±160	^{14}C	Damming Tom MacKay Creek	B.C. Hydro (1985)
Iskut River	5400±160	^{14}C	Damming Tom MacKay Creek	B.C. Hydro (1985)
Iskut River	3970±120	^{14}C	Damming Forrest Kerr Creek	B.C. Hydro (1985)
Iskut River	3930±80	^{14}C	Damming Forrest Kerr Creek	Read et al. (1989)
Iskut River	3800±160	^{14}C	Damming Tom MacKay Creek	B.C. Hydro (1985)
Iskut River	3660±90	^{14}C	Damming Forrest Kerr Creek	B.C. Hydro (1985)
Iskut River	3540±70	^{14}C	Damming Forrest Kerr Creek	Read et al. (1989)
Iskut River	2610±70	^{14}C	Damming Forrest Kerr Creek	Read et al. (1989)
Iskut River	2535±75	^{14}C	Youngest ash deposit	B.C. Hydro (1985)
Iskut River	2555±60	^{14}C	Youngest ash deposit	B.C. Hydro (1985)
Cinder Mountain	33,000±2400	^{14}C	A single lava flow	B.C. Hydro (1985)
Lava Fork	>70,~150	Tree ring	An estimate of top flow	B.C. Hydro (1985)
Lava Fork	>350	Tree ring	An estimate of second flow	B.C. Hydro (1985)
Lava Fork	360±60	^{14}C	On surface of one of flows	Elliott et al. (1981)
Lava Fork	~130	^{14}C	On "the lower flows"	Grove (1986)

blocky and heavily vegetated except above 3500 feet on the saddle immediately in front of Cone Glacier. The recent retreat of Cone Glacier has left the lava exposed and striated.

Cone Glacier takes its name from a 300 m high, well-exposed volcanic cone (west cone) of grey cinder, hyaloclastite and basaltic ash (Appendix 3). At the northern side of west cone the lowest unit is pillow lava. The pillows are radially jointed and have glassy rinds and a concentric distribution of vesicles. Hyaloclastite breccia overlies the pillowed lava and consists of fragments of lava and glass in a brown-gold coloured, devitrified basaltic glass matrix (palagonitized sideromelane). The majority of pyroclastic material making up the cone is cinder which represents subaerial eruptions. There are no flows observed which definitely originate from the vent. The majority of lavas in the Snippaker Creek drainage probably have a source to the east of west cone.

Another well-dissected and nearly vegetation-free cone of red cinder and scoria (east cone), northeast of Cone Glacier, may be the source to the lavas in the Snippaker Creek drainage. North of Cone Glacier on the south side of Snippaker Creek (Sta. 6-9) a cliff provides exposure of up to seven different flow units. They are generally 2-3 m thick with scoriaceous and brecciated bottoms and tops. All of the lava flows are characterized by abundant, coarse (up to 4 cm long) megacrysts of euhedral glassy feldspar. The lavas also contain phenocrysts of feldspar and olivine, 2-3 mm in diameter. Cinder and scoria derived from both west and east cones are mineralogically similar. Diverse crustal xenoliths are found in most of the lava flows (Fig. 5); the majority are granitic. For example, the lava flow at Station 15 contains abundant xenoliths ranging from granitic to grey aphanitic igneous clasts. The latter suite of clasts is concentrated at the base of the flow and, therefore, probably was incorporated into the lava after it was erupted.

Figure 4. Cone Glacier and Cinder Mountain volcanic centres. Map delineates three vent areas and lava distributions associated with the two centres. Legend is as in Figure 2.

Remnants of three lava flows are found on the eastern margin of east cone. The provenance of these lavas is somewhat ambiguous because they are equidistant to the Cinder Mountain centre (see below). Based on the presence of abundant large feldspar phenocrysts and the fact that these lavas occur at an elevation below or equal to the remnant of east cone, these lavas are interpreted as part of the Cone Glacier centre.

Cinder Mountain

Cinder Mountain volcanic centre is east and northeast of Cone Glacier (Fig. 4). The distribution of volcanic units shown in Figure 4 is an estimate because ice, snow, talus and minor vegetation obscure the rocks. Cinder Mountain lava flows and hyaloclastite breccia are mainly exposed on the south and west slopes of Cinder Mountain and as a single outcrop to the north near Copper King Glacier.

Hyaloclastite breccia is the most voluminous unit found at Cinder Mountain (Fig. 6a, b). It is a golden-brown volcanic breccia comprising basaltic fragments and basaltic glass in a matrix of palagonitized sideromelane. The hyaloclastite varies from basaltic rock fragment-dominated breccia with very little matrix to breccia that is dominantly basaltic glass fragments (Fig. 6a). These variations define the prominent 10-50 cm scale layering observed in the hyaloclastite (Sta. 13). Basaltic dykes with chilled margins commonly cut the hyaloclastite breccia. Elsewhere massive basalt bodies apparently intrude the hyaloclastite and grade into pillow-like bodies with glassy rinds. These dykes are light-grey in colour, very massive and have rare, small feldspar crystals and are distinct from lavas erupted from the Cone Glacier centre.

The breccia is more finely and regularly layered (Fig. 6b) where the hyaloclastite breccia is in contact with basement rocks (plutonic and metamorphic rocks) (e.g., Sta. 19). The layers comprise different basaltic glass contents and internal planar and cross-laminations suggest significant transport and reworking (Fig. 6b). Layering parallels depositional surfaces which dip up to 30° to the north, and probably reflects the paleoslopes along which the hyaloclastite debris was transported.

Close to Copper King Glacier, near the head of Harrymel Creek, the remnant of a single flow is exposed. It overlies till and itself is overlain by an ablation moraine (B.C. Hydro, 1985). The flow forms a 15-20 m high wall of columnar jointed basalt (e.g., Sta. 18). ^{14}C dating of a sample recovered from the underlying till-basalt contact gives an age of 33 000 ± 2000 years (Table 1, B.C. Hydro, 1985). The lack of megacrystic feldspar and xenoliths and overall paucity of phenocrysts suggest the lava was erupted from the Cinder Mountain centre.

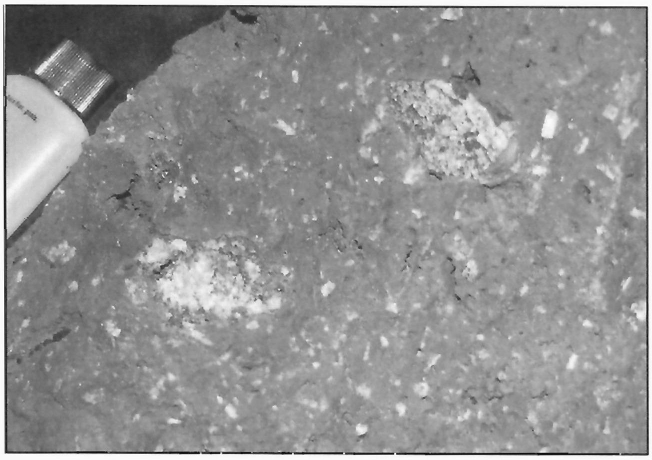

Figure 5. Large (5-7 cm) xenoliths found in uppermost flow at Cone Glacier. Also visible are large (0.5-1 cm) feldspar phenocrysts characteristic of Cone Glacier lavas.

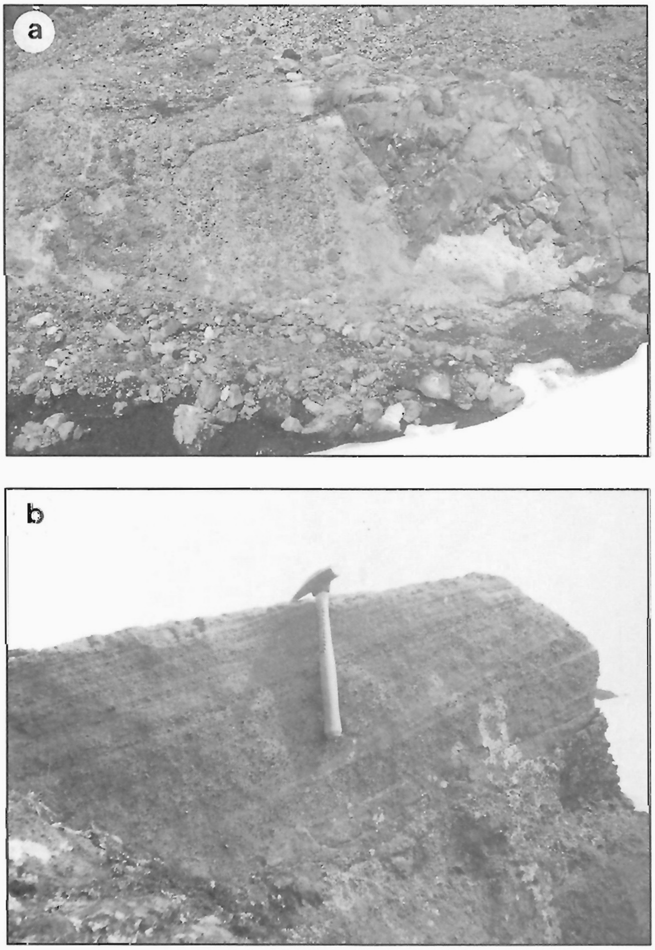

Figure 6. Hyaloclastite breccias from Cinder Mountain: upper photograph (6a) shows massive lava (right side) intruding layered coarse- and fine-grained hyaloclastite breccias; lower photograph (6b) shows finer scale layering and internal structure of hyaloclastite deposits immediately overlying bedrock.

King Creek

The King Creek centre dominantly comprises pillow lava and associated breccia. The lavas are exposed in a steep narrow creek south of Cone Glacier (Fig. 7) where they form a 40-50 m cliff. The pillow lava and overlying breccia are exposed from stream-level to about 1070 m elevation (Stasiuk and Russell, 1990). Individual pillows are commonly surrounded by scoriaceous breccia (Sta. 14). A 1-2 m wide vertical dyke crosscuts the pillow lavas. As at Tom MacKay Creek, the restricted extent of thick pillowed lava and associated breccia suggest that the lava was erupted against or close to ice.

Second Canyon

The Second Canyon centre comprises a single blocky lava flow where eruption forced the Unuk River against its eastern bank (Fig. 8). Subsequent dissection of the lava formed Second and Third canyons. The walls to these canyons are 15 m high cliffs of columnar jointed basalt lava (B.C. Hydro, 1985). The lava flow overlies fluvial sediments and the presence of a scoriaceous, flow-structured lava surface suggests that the eruption was postglacial (B.C. Hydro, 1985). The source to the lava flow is either a tree-covered cone located at the confluence of Unuk River and Canyon Creek or on the slope immediately above Canyon Creek, about 4 km upstream from the same confluence (Fig. 8, B.C. Hydro, 1985). A sample of the flow collected in 1989 (Stasiuk and Russell, 1990) suffices because all sources agree that there is only a single flow unit (e.g., B.C. Hydro, 1985; Stasiuk and Russell, 1990).

Lava Fork

The Lava Fork volcanic centre comprises basaltic ash and at least three flows, which are exposed at the confluence of Blue River and Unuk River. Dissection by the Unuk River at the southern terminus formed the First Canyon (B.C. Hydro, 1985). The distribution of volcanic material shown in Figure 9 includes undifferentiated cinder and ash deposits as well as lava flows. A layer of basaltic cinder and glassy ash covers the lava flows as well as the area to the east towards Leduc Glacier and Twin John Peaks (Grove, 1986). The youngest flow erupted from a vent located on a ridge on the eastern side of Lava Fork valley. The lava flowed south, along the valley and southeast along Blue River valley, damming the river and forming Blue Lake. Near the main vent, the volcanic rocks overly basement rocks, including foliated biotite-quartz-schist intruded by granodiorite. A possible vent for the older flows is a tree-covered cinder cone located 4 km downstream of Blue Lake (B.C. Hydro, 1985).

Near its source, the youngest lava flow has ropey pahoehoe surfaces and forms well-developed small lava channels and lava tubes. Spatter, cinder and ash are abundant around the vent. Downslope and away from the vent, the flow surface abruptly changes to aa and splits into two main streams (north and south forks). The lava streams form large channels (Fig. 10) with several generations of prominent levees. Accretionary lava balls are common on the flow surface of the north fork lava (Sta. 23). They are approximately 5 m in diameter and consist of a red cinder breccia coated by massive flow which exhibits radially oriented irregular jointing. Xenoliths of basement rocks occur in both the interior and exterior portions of the lava balls.

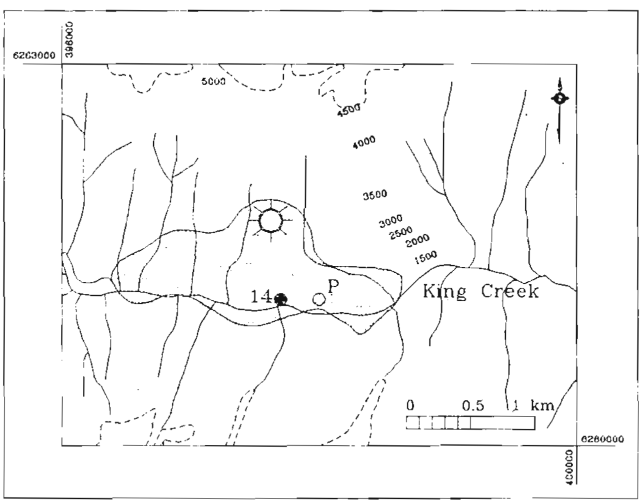

Figure 7. Distribution of King Creek volcanic rocks. Legend as in Figure 2.

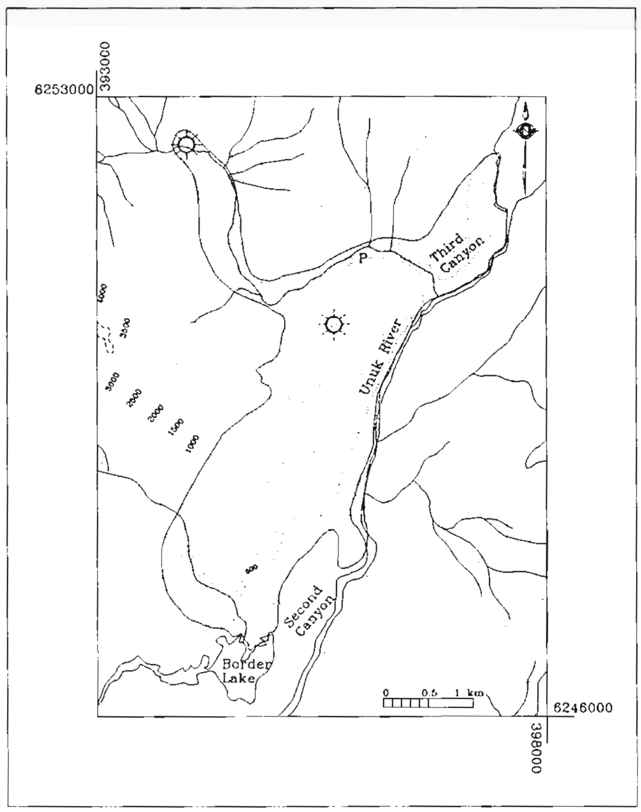

Figure 8. Distribution of volcanic rocks from the Second Canyon centre. Legend as in Figure 2.

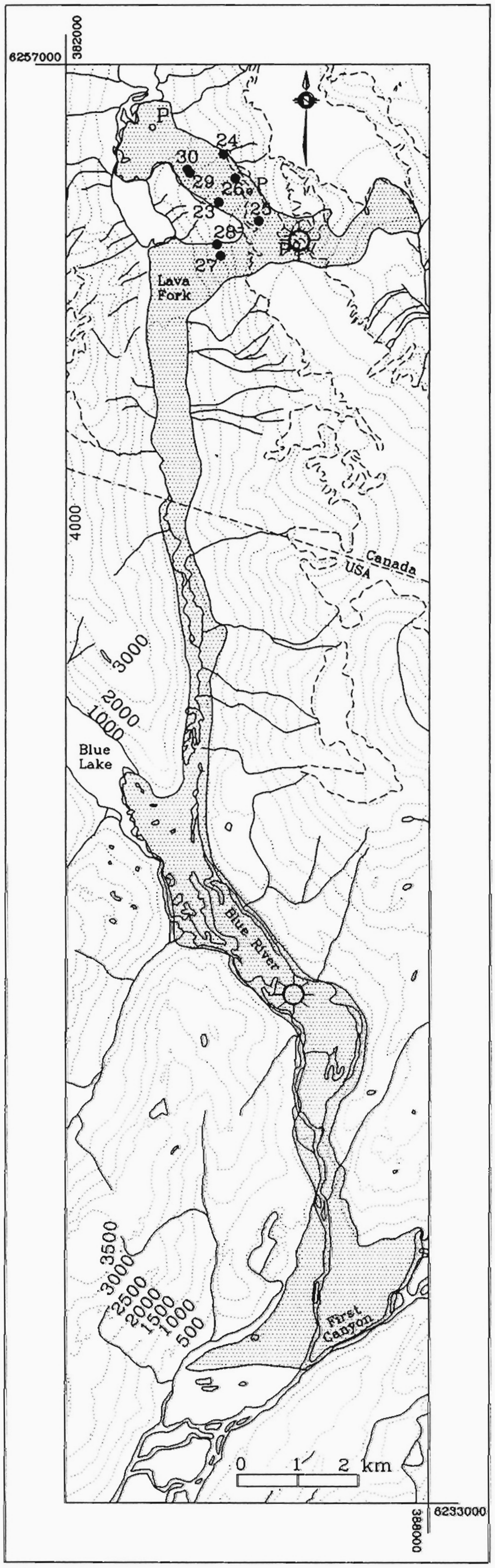

Figure 9. Distribution of lavas and cinder associated with the Lava Fork centre. Legend as in Figure 2.

Crustal xenoliths are common throughout the lava and are mainly granitic rocks or metamorphic schist. The xenoliths are mainly angular, range from 1 to 30 cm in diameter, and resemble the basement rocks underlying the main vent area. The degree of reaction between lava and xenolith is highly variable. Many show no signs of reaction (e.g., reaction rims) whereas others are porous, granular and friable. Commonly, the host basaltic melt has invaded these latter xenoliths along thin fractures.

^{14}C dating of a partly charred conifer log from the surface of one of the flows yielded an age of 360 ± 60 BP (Table 1, Elliott et al., 1981). Grove (1986) argued for an age of 130 BP based on ^{14}C dating of material associated with the lower flows. Subsequent dating, using tree-ring counts, gives a minimum age of 70 years old for the youngest flow (B.C. Hydro, 1985). Based on tree ring counts on living trees, and observations of the lava flow surface it is estimated to be around 150 years old. Living trees on the surface of an underlying flow give a minimum age of 350 years (B.C. Hydro, 1985).

Figure 10. Typical lava channel with well-developed levees from the Lava Fork volcanic centre.

DISCUSSION

Recent volcanic rocks within the Iskut-Unuk rivers area are alkali-olivine basalt lava flows and pyroclastic material. They are petrographically similar, generally being fine grained, porphyritic basalts containing phenocrysts of plagioclase and olivine. Megacrysts (0.5-4 cm) of glassy plagioclase are common; to date they are recognized in lavas from every centre except Second Canyon and Cinder Mountain. The groundmass comprises plagioclase, olivine, opaque minerals, glass and titanaugite. Clinopyroxene is conspicuously rare as a phenocryst. There are few mineralogical differences between lavas from different centres. The Cinder Mountain lavas are distinct in that they typically contain few phenocrysts, have a trachytic groundmass, and apparently lack xenoliths.

The diversity of feldspar habits in the lavas is one of the more remarkable features of these volcanic rocks. They occur in a wide variety of sizes (megacryst to microphenocryst), forms (euhedral to corroded), and compositional zonations (strong oscillatory zoning to unzoned). The extent to which they are cognate versus xenocrystic is not immediately obvious, although given the pervasive occurrence of crustal xenolith some of the populations probably relate to assimilation processes.

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APPENDIX 1

Summary of samples collected for bulk chemical analysis.

Sample	Station	Centre	Type	UTM	Notes
SH9301	1	Snippaker Creek	Lava flow	385940, 6277520	
SH9302	1	Snippaker Creek	Lava flow	385940, 6277520	
SH9304	3	Cone Glacier	Lava flow	398370, 6270050	Cindery flow
SH0307	4	Cone Glacier	Lava flow	398310, 6270050	Cindery flow
SH9309	6	Cone Glacier	Lava flow	397650, 6270000	
SH9310	6	Cone Glacier	Lava flow	397650, 6270000	
SH9312	8	Cone Glacier	Lava flow	397620, 6269960	
SH9313	8	Cone Glacier	Lava flow	397620, 6269960	
SH9314	9	Cone Glacier	Lava flow	397550, 6269900	
SH9315	9	Cone Glacier	Lava flow	397550, 6269900	
SH9316	9	Cone Glacier	Lava flow	397550, 6269900	
SH9317	9	Cone Glacier	Lava flow	397550, 6269900	Same as SH9309
SH9318	9	Cone Glacier	Lava flow	397550, 6269900	Same as SH9312
SH9319	10	Cinder Mountain	Lava flow	400380, 6270030	Fractured flow
SH9321	12	Cinder Mountain	Dyke	400120, 6269370	Cuts hyaloclastite
SH9322	13	Cone Glacier	Lava flow	398580, 6269810	
SH9324	14	King Creek	Pillow lava	397700, 6261150	
SH9326	13	Cone Glacier	Lava flow	398580, 6269810	
SH9328	13	Cinder Mountain	Hyaloclastite	398580, 6269810	Above station 13
SH9331	16	Snippaker Creek	Lava flow	386670, 6272820	
SH9332	16	Snippaker Creek	Lava flow	386670, 6272820	
SH9334	17	Snippaker Creek	Lava flow	390820, 6272970	
SH9335	18	Cinder Mountain	Lava flow	403140, 6274330	
SH9336	12	Cinder Mountain	Dyke	400120, 6269370	Cuts hyaloclastite
SH9337	20	Iskut River	Lava flow	400220, 6287170	
SH9338	21	Iskut River	Lava flow	398970, 6287480	
SH9339	22	Tom MacKay Creek	Pillow lava	404130, 6285420	
SH9344	24	Lava Fork	Lava flow	384600, 6255500	Early channel
SH9345	25	Lava Fork	Lava flow	385180, 6254380	Thin flow near vent
SH9346	25	Lava Fork	Lava flow	385180, 6254380	Thin flow near vent
SH9347	25	Lava Fork	Lava flow	385180, 6254380	Thin flow near vent
SH9353	26	Lava Fork	Lava flow	384790, 6255100	Lava channel
SH9354	27	Lava Fork	Lava flow	384480, 6254030	Thin flows in cliff
SH9355	28	Lava Fork	Lava flow	384450, 6254380	Levee in Southern Fork
SH9358	30	Lava Fork	Lava flow	384000, 6255250	Older channel levee
SH9359	30	Lava Fork	Lava flow	384000, 6255250	Younger channel levee
SH9360	30	Lava Fork	Lava flow	384000, 6255250	Lava channel

APPENDIX 2

Summary of bulk samples containing abundant or distinctive xenoliths and xenocrysts.

Sample	Station	Centre	Type	UTM	Notes
SH9305	3	Cone Glacier	Lava flow	398370, 6270050	Talus from flow
SH9306	4	Cone Glacier	Lava flow	398310, 6270050	
SH9308	5	Cone Glacier	Pyroclastic material	398380, 6270160	Green cinder
SH9311	7	Cone Glacier	Lava flow	397570, 6269980	Scoriaceous cinder
SH9320	11	Cinder Mountain	Hyaloclastite	400040, 6269420	Talus
SH9323	14	King Creek	Pillow lava	397700, 6261150	
SH9325	15	Cone Glacier	Lava flow	398170, 6269920	Block on top flow
SH9327	13	Cone Glacier	Lava flow	398580, 6269810	
SH9329	13	Cinder Mountain	Dyke	398580, 6269810	Cuts hyaloclastite
SH9330	13	Cinder Mountain	Pillow lava	398580, 6269810	
SH9340	23	Lava Fork	Lava ball	384520, 6254700	
SH9341	-	Lava Fork	Bomb	384520, 6254700	Close to station 23
SH9342	-	Lava Fork	Bomb	384520, 6254700	Close to station 23
SH9343	var.	Lava Fork	Lava flow	-	North fork
SH9348	var.	Lava Fork	Lava flow	-	North fork
SH9351	-	Lava Fork	Granodiorite	-	Basement rock
SH9352	-	Lava Fork	Bt-qtz-schist	-	Basement rock
SH9356	29	Lava Fork	Lava ball	384040, 6255190	Cinder blocks
SH9357	29	Lava Fork	Lava ball	384040, 6255190	Cinder blocks
SH9361	30	Lava Fork	Lava flow	384000, 6255250	Same as SH9360

APPENDIX 3

Summary of unconsolidated basaltic ash samples.

Sample	Description	UTM	Location Notes
SH9303	Reworked by glacial outwash	398090, 6269720	Station 2 at front of Cone Glacier
SH9350	In situ ash fall deposit	-	Northwest of Lava Fork vent
JKR1	Loose reworked ash on surface of a Nickel Mountain glacier	397325, 6271075	Surface of a southeast facing glacier on Nickel Mountain