VOLCANISM IN THE MIDDLE ALDRIDGE FORMATION, PURCELL SUPERGROUP, SOUTHEASTERN BRITISH COLUMBIA

Trygve Höy, B.C. Geological Survey Branch, D.L. Pighin, Consolidated Ramrod Gold Corporation and P.W. Ransom, Cominco Ltd.

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INTRODUCTION

The Aldridge Formation in southeastern British Columbia is the basal unit of the Purcell Supergroup, a thick sequence of predominantly clastic and carbonate rocks of Middle Proterozoic age. The base of the Purcell Supergroup is not exposed in Canada; in the United States it is inferred to rest unconformably on Archean and Proterozoic basement crust (Winston and Link, 1993). It is overlain unconformably by Upper Proterozoic Windermere Group or by lower Paleozoic clastic or carbonate rocks.

The Purcell Supergroup comprises dominantly turbidite deposits of the Aldridge Formation, overlain by shallow-water clastic rocks of the Creston Formation and carbonate rocks of the Kitchener Formation. Upper Purcell rocks are dominated by shallow-water to locally subaerial clastic rocks, with a prominent basaltic unit, the Nicol Creek Formation, exposed in the eastern Purcell Mountains and the Rocky Mountains.

The Aldridge Formation is intruded by a number of thick and continuous gabbroic sills and dikes, referred to as the Moyie sills. These were locally deposited in wet, unconsolidated sediments, and therefore record a magmatic event during Aldridge sedimentation (Höy, 1989). However, despite the interpreted high-level intrusion of voluminous amounts of gabbroic material, volcanic equivalents have not, until now, been well documented or described. This report describes an example of volcaniclastic rocks within the Aldridge Formation and identifies several other possible occurrences.

REGIONAL GEOLOGY

The Purcell Supergroup is exposed in the core of the Purcell anticlinorium in the Purcell Mountains, and in the Foreland thrust and fold belt in the Western Ranges of the Rocky Mountains.

The Aldridge Formation is exposed in the hangingwalls of a number of prominent, northeast-trending, reverse tear faults in the Purcell Mountains. The formation comprises three main divisions: the lower Aldridge includes generally thin-bedded, rusty weathering turbidites with thick sections of massive to laminated siltstone and argillite and a prominent succession of grey weathering, more proximal turbidites, referred to as the footwall quartzites; the middle Aldridge comprises grey weathering, thicker bedded turbidites with common rusty weathering, thinner bedded siltstone successions; and the upper Aldridge comprises massive to laminated argillite and silty argillite. Evidence of shallow-water features within the Aldridge is lacking. The Moyie sills occur at two main stratigraphic intervals: throughout the lower Aldridge and in the middle part of the middle Aldridge.

Correlative rocks in the Northern Hughes Range east of the Rocky Mountain Trench comprise fluvial, alluvial fan and deltaic deposits of the Fort Steele Formation, overlain by a heterogeneous, more carbonate-rich succession with pronounced facies changes indicative of growth faulting (Höy, 1993). The transition between the contrasting facies of the Northern Hughes Range and the Purcell Mountains to the west and Southern Hughes Range marks the edge of the Purcell basin in early Purcell time.

The Aldridge Formation hosts a number of important mineral deposits. The Sullivan mine, at the transition between the lower and middle Aldridge, is a large, stratabound lead-zinc-silver sedex deposit. Numerous vein deposits, including St. Eugene and Bull River, occur throughout the Aldridge, and a number of stratabound copper-cobalt deposits, including Sheep Creek and the Blackbird deposits, occur in correlative rocks in the United States. The Moyie sills, intruded during Aldridge sedimentation, have been suggested to have a genetic link to mineral deposition (Hamilton, 1984; Höy, 1993). This underscores the importance of recognizing other forms of igneous activity within Aldridge rocks.

VOLCANICLASTIC UNITS

The location of inferred volcaniclastic rocks within the Aldridge Formation is shown in Figure 1. The four widely separated occurrences all comprise clastic units, with small clasts of presumed volcanic origin in either a finer grained tuffaceous or epiclastic matrix. The St. Joe tuff and the Mark Creek and Wild Horse fragmentals are at approximately the same stratigraphic level, below a prominent fine-grained laminated marker unit in the upper part of the middle Aldridge (Figure 2). The stratigraphic position of the Elephant Creek fragmental is not as well defined, but it is interpreted to be approximately 80 metres lower. Hence, these volcaniclastic units appear to record at least two separate periods of magmatic activity during Aldridge sedimentation.

ST. JOE TUFF

The St. Joe tuff is the thickest and best exposed of the volcaniclastic units in the Aldridge Formation. It is a discordant zone of fragmentals that cuts across middle Aldridge

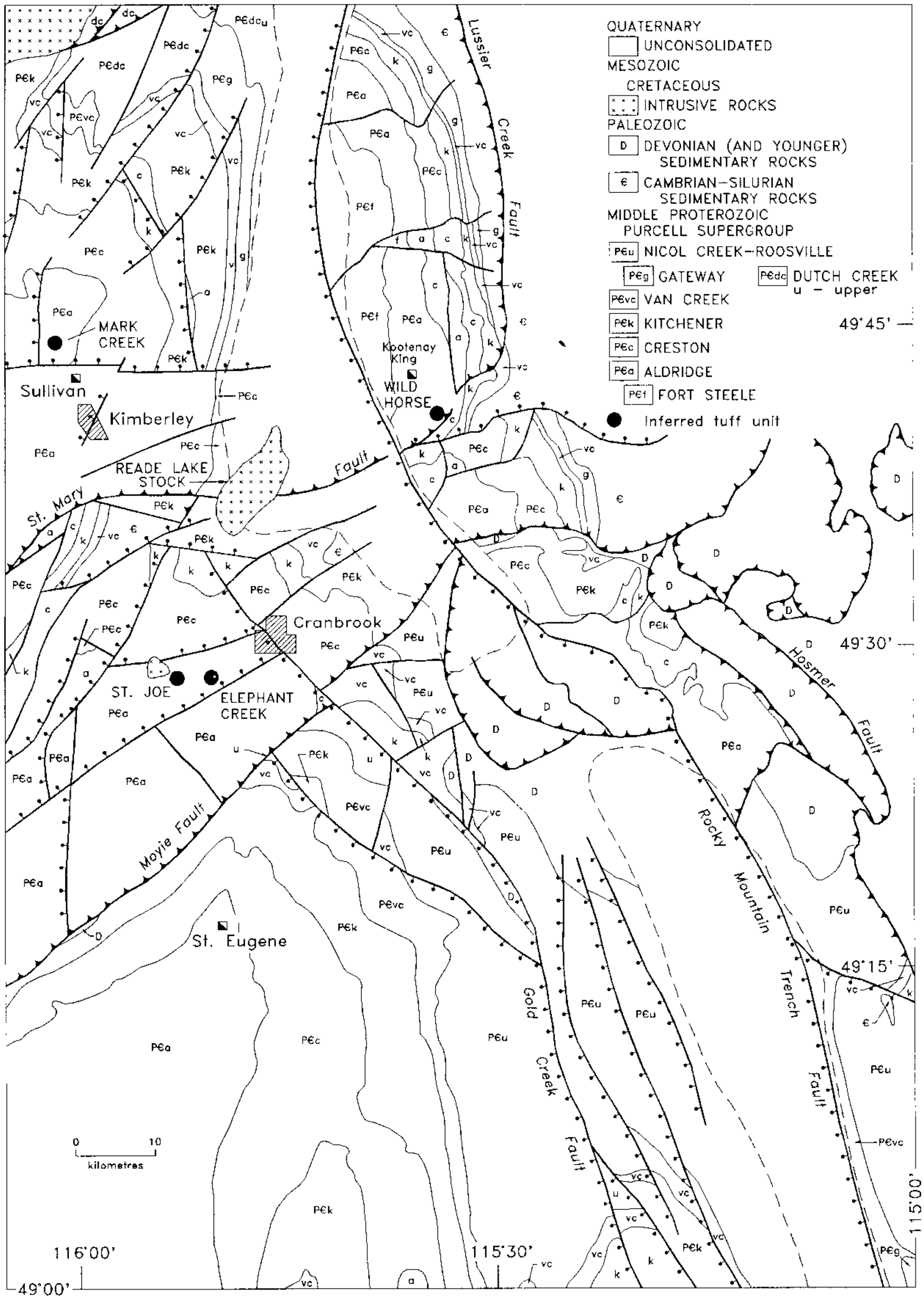

Figure 1. Geological map of the Fernie west-half map-area, showing locations of the known and inferred middle Aldridge volcaniclastic units (base map from Höy, 1993).

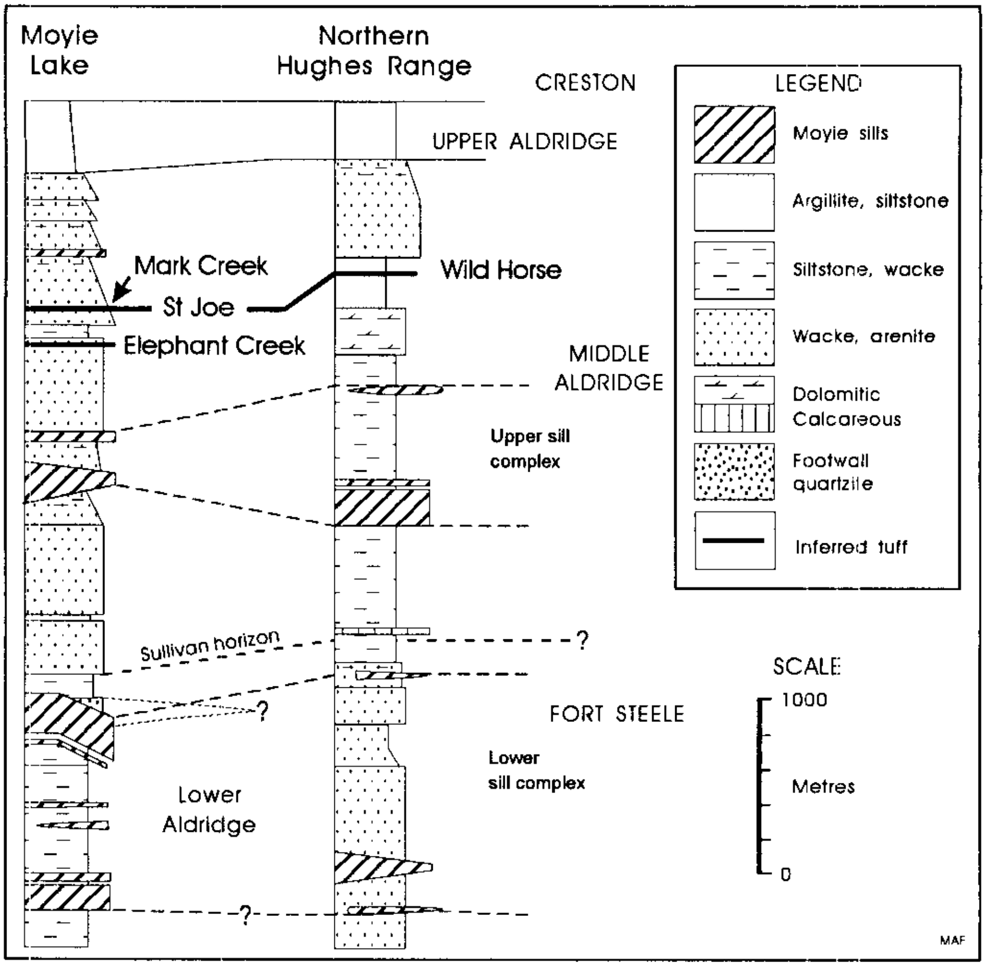

Figure 2. Schematic sections of the Aldridge Formation, showing distribution of Moyie sills and stratigraphic position of volcaniclastic units.

turbidites and is overlain conformably by laminated argillaceous siltstone.

The St. Joe tuff is cut by a small lead-zinc-silver vein that has been intermittently explored since the turn of the century by underground work, trenching and diamond drilling. The most recent exploration, by Cominco Ltd. in the mid-1980s and by Consolidated Ramrod Gold Inc. in 1993 and 1994, included detailed surface mapping (Pighin, 1982; 1983) and diamond drilling to test for both vein and possible sedex style mineralization; a second (sedimentary) fragmental unit, the Lower St. Joe, approximately 100 metres stratigraphically lower, contains small sulphide and tourmalinite clasts (Pighin, 1983; Turner *et al.*, 1993). The Lower St. Joe fragmental is overlain by a thin, discordant sulphide lens and underlain by patchy tourmalinized argillite. It is not described further in this report.

The St. Joe tuff is located approximately 8 kilometres southwest of Cranbrook on the heavily wooded slopes of a small creek that drains westward into Kiakho Creek. Access is by the four-wheel-drive Fassifern road that exits Highway 3 south of Cranbrook.

REGIONAL GEOLOGY

The St. Joe tuff is in gently dipping, thick-bedded turbidite layers in the upper part of the middle Aldridge. It is conformably overlain by a laminated, silty argillite marker unit.

The fragmental is less than a kilometre south of the Cranbrook fault, an east-northeast-trending normal fault. Other similar trending faults, including the St. Mary, Boulder Creek and Moyie faults, have documented or inferred Middle Proterozoic movements, and hence it is possible that the Cranbrook fault is also the locus of an Aldridge-age growth fault. The fault is cut by an Early Cretaceous quartz monzonite intrusion, the Kiakho stock (Höy and van der Heyden, 1989).

DETAILED GEOLOGY

A detailed surface map of the St. Joe tuff is shown in Figure 3, measured sections in Figure 4 and a schematic north-south section in Figure 5. The location of diamond-drill hole 94-6 (ddh 94-6) and analyzed samples are also shown on Figure 3.

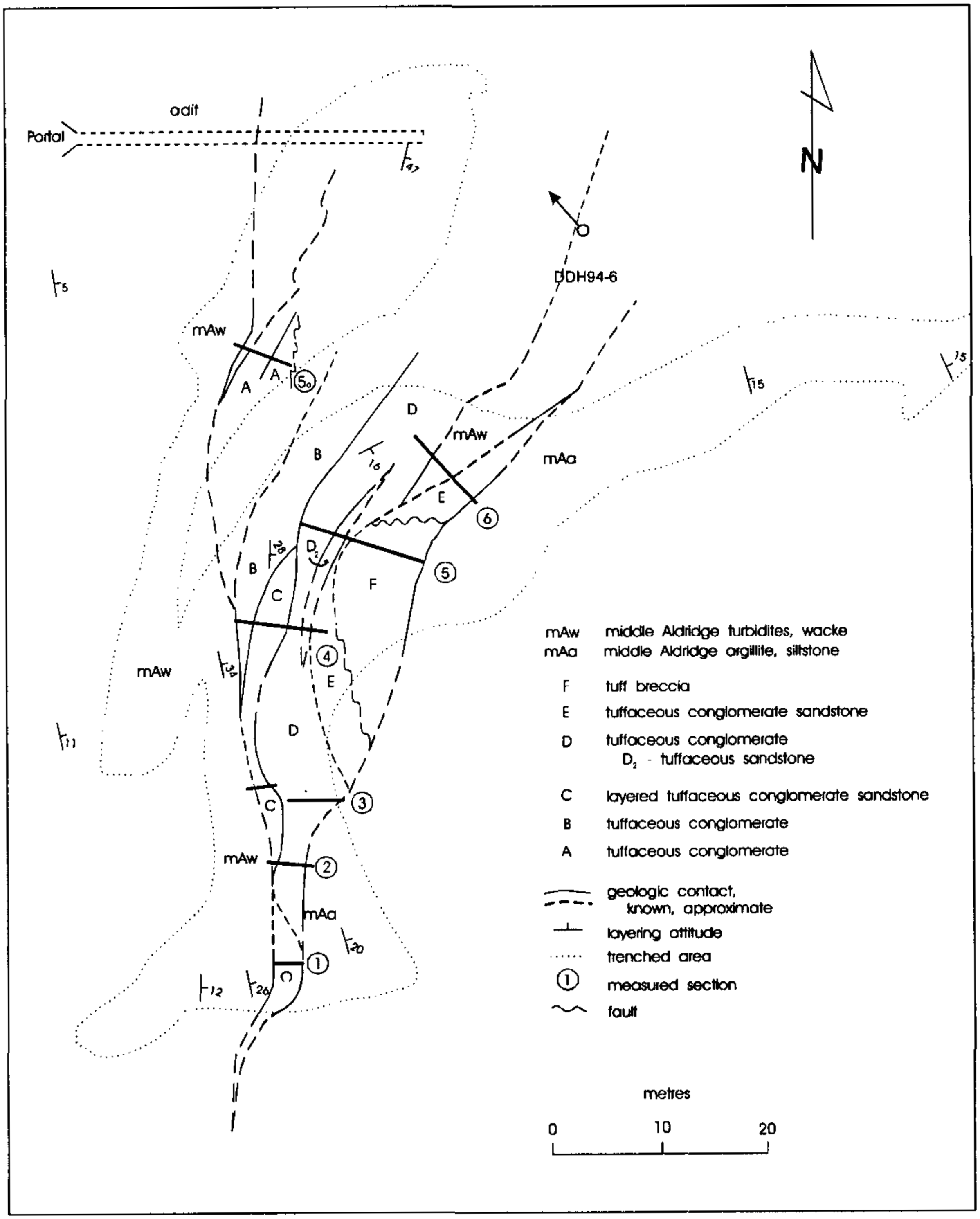

Figure 3. Geological map of the St. Joe tuff (modifed from Pighin, 1983).

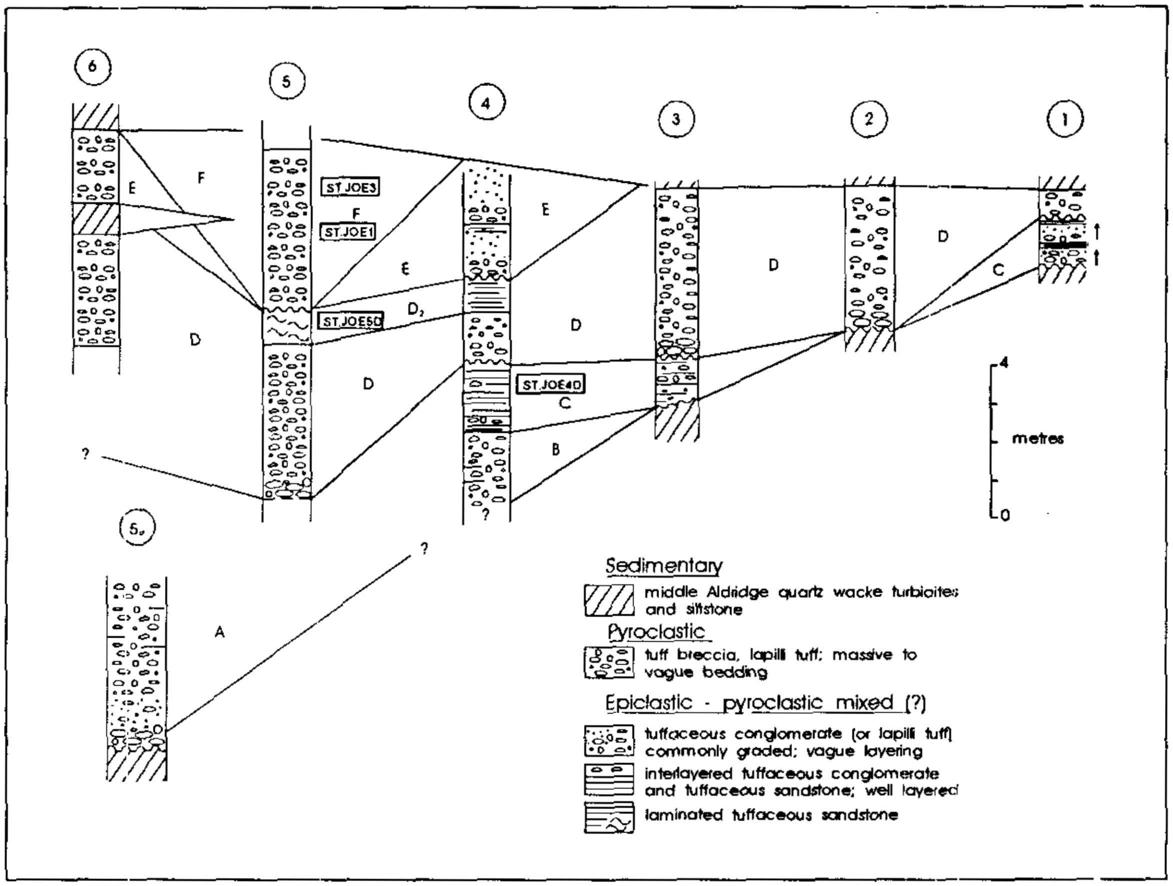

Figure 4. Measured sections through the St. Joe tuff, sections are located on Figure 3.

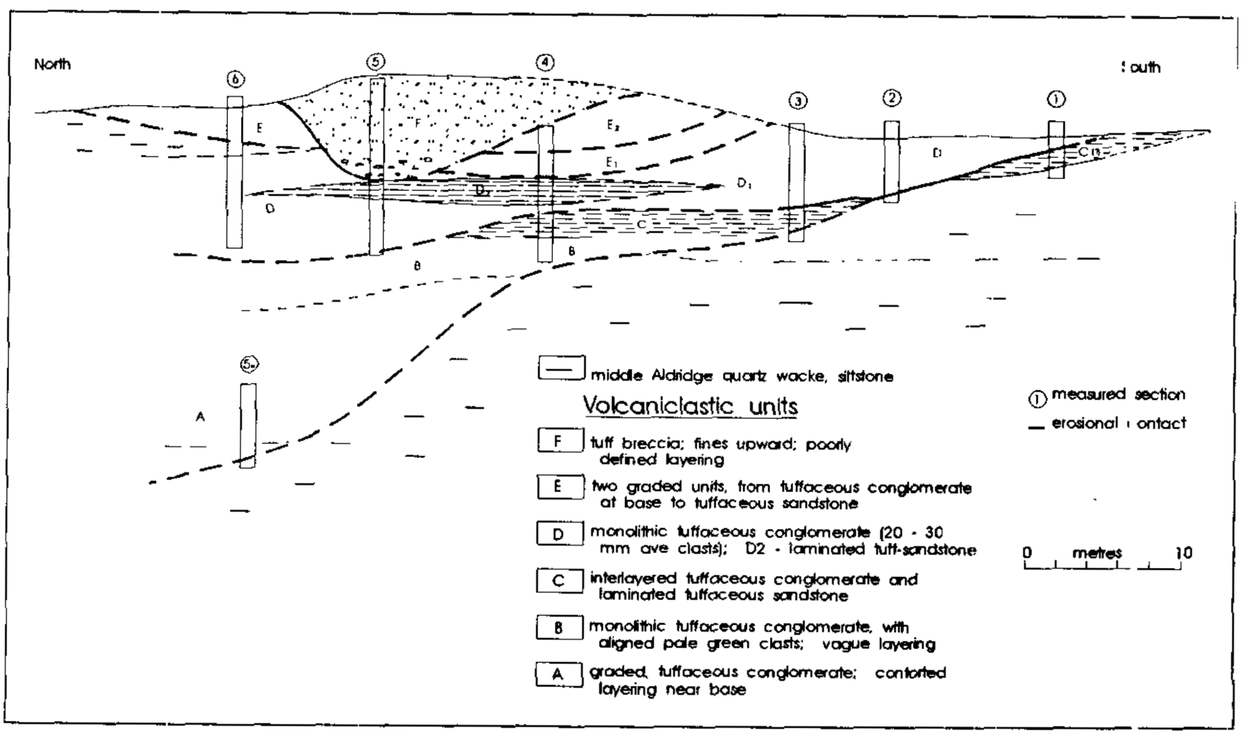

Figure 5. An interpretive north-south section through the St. Joe tuff.

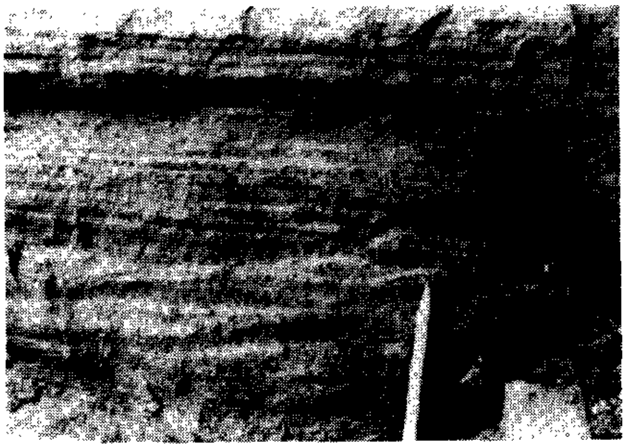

Photo 1. St. Joe tuff, section 4, unit C: well layered lapilli tuff and laminated tuffaceous sandstone(?); note general fining-upward nature of unit, occasional large isolated clasts, and locally low-angle crossbeds

Photo 2. St. Joe tuff, section 4, unit E?; contorted tuffaceous sandstone(?) layer near the base of a graded lapilli tuff - tuffaceous sandstone sequence.

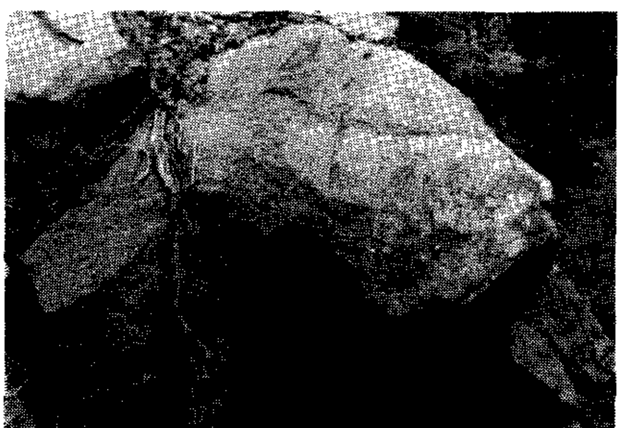

Photo 3. St. Joe tuff, section 4, unit E; large disrupted (rotated) block near the base of Unit E; note normal layering above wedge and disrupted massive unit below; (pencil scale).

The map and sections show that the St. Joe tuff comprises a number of fining-upward cycles, each with a coarse base that scours the underlying unit, and each generally capped by a finer grained laminated or massive unit. The tuff succession pinches out to the south; its maximum thickness in the northern part of the trench and in ddh 94-6 is approximately 22 metres.

The measured sections (Figure 4) clearly show the graded nature of individual units (Photo 1) and truncations by successively younger units. The lowest unit (A, section 5a, Figure 4) is a fining-upward sequence with a sharp base that scours underlying, locally contorted massive turbidites. Clast sizes decrease up-section into a massive clastic unit that contains abundant aligned, angular 1 to 2-centimetre, pale green and pale grey clasts. Unit B, exposed in section 4 and in the lower part of hole 94-6, is similar to the top of unit A and hence may be correlative as shown in Figure 4. It is overlain gradationally by unit C, a layered succession of generally finer grained clastics that contains occassional large clasts and occassional coarse layers similar to those of unit B. Occassional low-angle crossbeds indicate current activity. A similar exposure at the base of the most southern section (1) suggests that the original thickness of unit C may have been at least 8 metres. Units A to C comprise a thick fining-upward succession at the base of the St. Joe volcaniclastic succession.

In thin section, pale grey clasts are dominated by extremely fine crystalline silicates, minor biotite and trace calcite. Mineralogy of the silicates is not known, but scanning electron microscope analyses (Pighin, 1982) suggests that they are predominantly plagioclase rather than quartz. Dark green clasts are composed primarily of chlorite. Clast matrix includes abundant biotite, commonly rimming clasts, plagioclase, quartz and minor calcite and pyrrhotite. Unit C consists mainly of subangular, broken quartz grains, plagioclase, aligned biotite and chlorite, and intergranular calcite.

Unit D scours the underlying volcaniclastic units, removing a considerable portion of unit C in sections 3 and 4, and part of unit B in section 5. It comprises a monolithic fragmental with 2 to 3-centimetre, pale green, aligned angular clasts. It is generally massive, although some grading is apparent as coarse clasts are more common near the base. A laminated, pale green sandstone within the unit (unit D2) suggests that D may comprise two separate volcaniclastic sequences with possibly an upper fine-grained unit largely removed by scouring at the base of unit E. A drill intersection (ddh 94-6) shows that the top of unit D comprises closely packed aligned clasts in a white calcite matrix. Calcite also occurs in cores of many of the clasts, but is not present as late veinlets. This habit suggests that calcite is an early mineral, related to fragmentation, rather than a late alteration phase.

In thin section, the pale green clasts of unit D are similar to the green clasts of unit B, composed mainly of chlorite. The matrix is also similar, but typically contains more dispersed calcite.

Units E1 and E2 comprise two fining-upward sequences, each with a coarse volcaniclastic unit at the base (with clasts greater than 10 cm diameter) and capped by a massive to vaguely laminated, pale green tuffaceous siltstone. Layering in the base of unit E1 is locally highly contorted and disrupted (Photos 2 and 3).

The coarsest unit (unit F) occurs near the top of the volcaniclastic succession (Figure 5). Subrounded blocks up to 10 centimetres in long dimension occur within a finer grained, granular matrix. Occassional clasts have wel -defined rims, comprising dominantly chlorite and minor plagioclase (Photo 4).

The clasts have variable compositions and textures; none, however, are similar in texture to the coarse Moyie sills. Some clasts are dominantly chlorite (Photo 5) whereas others contain feldspar and (?)quartz phenocrysts; others comprise a fine granular mixture of dominantly feldspar and chlorite. The groundmass is primarily broken feldspar and quartz crystals with abundant biotite and chlorite.

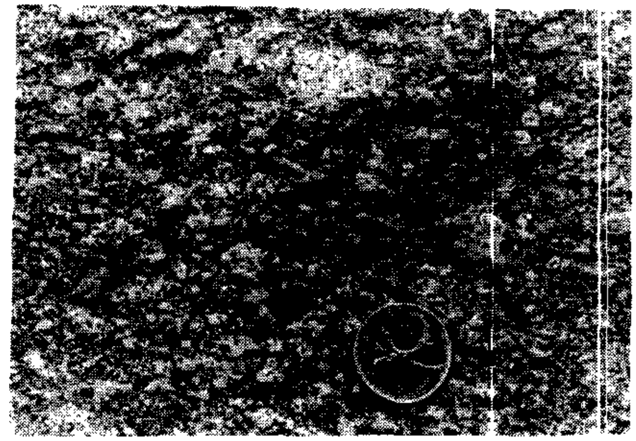

Photo 5. St. Joe tuff, section 2, unit D; monoli hic lapilli tuf' comprising angular, fine-grained, mafic chlorite clasts within a dominantly feldspar-chlorite tuffaceous matrix.

GEOCHEMISTRY

Analyses of a number of hand samples of the St. Joe tuff, located on Figure 4, are given in Table 1. A major element alkali-silica plot of these samples, and others analyzed by Cominco Ltd. (Pighin, 1983), shows that the tuffs are subalkaline, with two populations, one with less than 60% SiO_2 and a second with greater than 65% SiO_2 (Figure 6). On a Jensen cation plot, most tuff samples plot in the high-iron tholeiite field (Figure 7), similar to most anylyzed Moyie sill samples (Höy, 1989), whereas the more siliceous samples are calcalkaline basaltic and andesitic in composition.

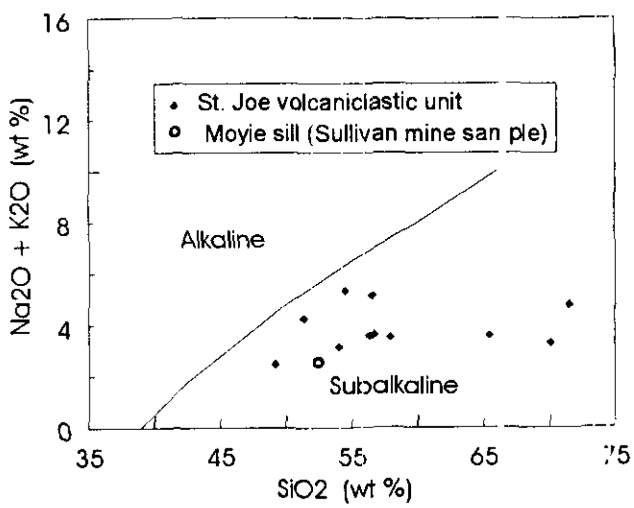

Figure 6. Alkali-silica plot (in weight percent) of samples of the St. Joe tuff; analysis of a Moyie sill, the footwall sil at the Sullivan deposit, is also shown (plot after Irvine and Barager, 1971).

Plots of less mobile trace and minor elements also suggest two populations of analyzed St. Joe tuff samples. On a SiO_2-Zr/TiO_2 diagram, two samples plot within the rhyodacite-dacite field and two within the andesite field (Figure 8). However, on a Zr/TiO_2 *versus* Nb/Y diagram (Figure 9), the separation between these compositions is not as marked and the more felsic units plot near the andesite-dacite boundary. Therefore, it is possible that the higher silica content of a number of the St. Joe samples reflects alteration, with addition of silica. However, the analyses do reflect the two recognized clast populations: mafic chlorite-rich clasts and the more felsic feldspar-dominated clasts.

For comparative purposes, an analyses of a Moyie sill sample is plotted on some of these diagrams. More mafic tuff members are similar in major element chemistry to Moyie sills but less mobile trace element chemistry indicates that the tuffs are dominantly andesitic in contrast with basaltic Moyie sill compositions (*see* Höy, 1989).

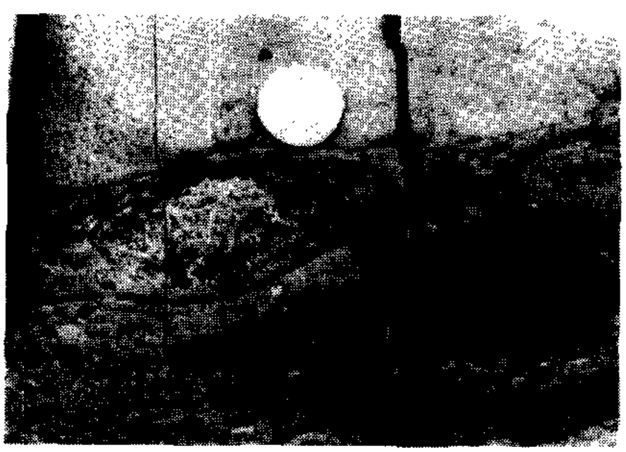

Photo 4. St. Joe tuff, section 4, unit F; mafic chlorite-plagioclase-rich clasts with fine-grained, laminated chlorite rims.

Metal values are anomalous in the St. Joe tuffs. In particular, mafic tuffs of units E and F contain on average 240 ppm Cu (5 samples), considerably higher than the average values for adjacent Aldridge metasediments (43 ppm, 15 samples; Pighin, 1983). Average metal contents of all twenty analyzed tuff samples are 134 ppm Cu, 151 ppm Zn and 51 ppm Pb.

SUMMARY AND DISCUSSION

The St. Joe occurrence comprises a number of graded sequences, each with a coarse base that scours and locally deforms underlying units, overlain by a massive to vaguely bedded monolithic fragmental, and capped by a finer

TABLE 1. ANALYSES OF SAMPLES FROM THE ST. JOE TUFF

Lab Number	Sample Number	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	SUM %
42636	St.Joe1	54.06	1.37	14.64	14.24	0.12	6.71	0.33	2.76	0.38	0.06	99.12
42963	St. Joe3	71.45	0.56	12.39	5.73	0.04	2.07	0.81	4.22	0.56	0.56	99.72
45128	St. Joe4D	70.07	0.56	11.84	7.85	0.11	2.82	1.46	2.63	0.69	0.04	99.81
45129	St. Joe5D	56.35	1.27	14.31	12.87	0.10	5.88	0.57	3.30	0.30	0.25	99.36

Lab Number	Sample Number	Sr (ppm)	Rb (ppm)	Zr (ppm)	Y (ppm)	Nb (ppm)	Ta (ppm)	Ce (ppm)	Cs (ppm)	La (ppm)	Sc (ppm)	V (ppm)
42636	St.Joe1	35	10	216	15	10	15	-	-	-	-	-
42963	St. Joe3	176	24	149	32	10	15	37	32	17	32	231
45128	St. Joe4D	169	31	164	48	7	15	70	-	20	13	100
45129	St. Joe5D	32	105	182	31	11	15	55	-	28	28	278

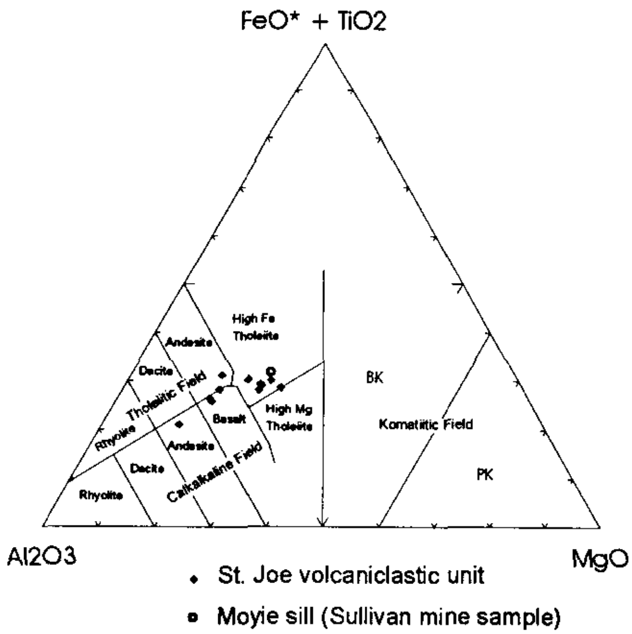

Figure 7. Jensen cation plot of samples of the St. Joe tuff, and a sample of the footwall sill at the Sullivan deposit; (plot after Jensen, 1976).

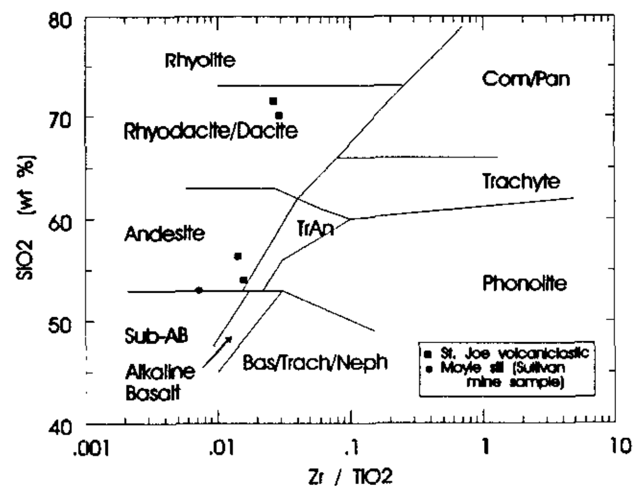

Figure 8. An SiO_2 versus Zr/TiO_2 plot of St. Joe tuff samples (plot after Winchester and Floyd, 1977).

grained, generally well-bedded unit. Clasts within units are typically monolithic, comprising pale green chlorite with minor amounts of plagioclase. Some clasts, particularly near the base of the succession, are pale grey and dominated by plagioclase and biotite rather than chlorite. Some volcaniclastic units are finer grained but are also typically graded. They are mineralogically similar to the groundmass of unit F, with abundant feldspar and quartz crystals and numerous small angular, aligned pale green chlorite-rich clasts.

The dominant monolithic character of the clasts, their unusual mineralogy, distinct from any known Aldridge metasediments, and their angularity, support interpretation as a volcanic unit. The abundance of chlorite and the broken feldspar and quartz grains in the groundmass also support this interpretation. Scouring, rip-up of underlying units, and minor crossbedding indicate deposition as a channel complex. The restricted occurrence of the unit, angularity of clasts, and general lack of contamination by Aldridge metasediments, suggests that it may have been deposited reasonably close to a source area.

The volcaniclastic may represent a pyroclastic deposit or, possibly, a hyaloclastite formed by quenching. Distinction between these deposit types is difficult, particularly after reworking and regional greenschist metamorphism.

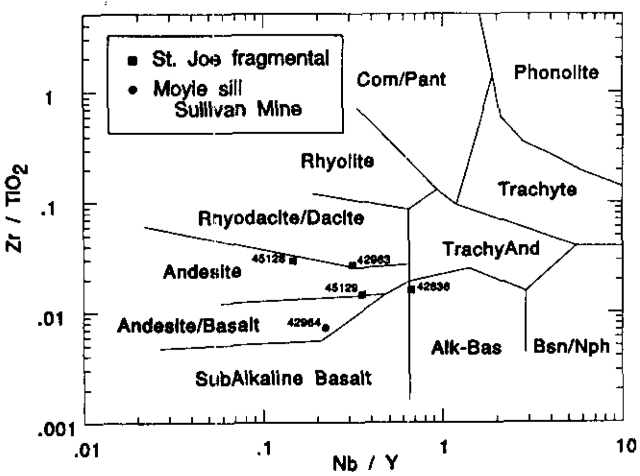

Figure 9. A Zr/Ti versus Nb/Y plot of St. Joe tuff samples (plot after Winchester and Floyd, 1977).

Lack of recognized lava flows, granularity of some (?)juvenile fragments, their abundance and possible armoured textures suggest pyroclastic deposition. Furthermore, lack or absence of vesicules in clasts suggests phreatomagmatic rather than magmatic explosions.

Hence, it is concluded that the deposit comprises dominantly water-lain lapilli and crystal tuff with possibly a tuffaceous conglomerate and tuffaceous sandstone component. Clasts with chloritic rims may be armoured lapilli with alteration of glass to chlorite or may reflect alteration envelopes around pyroclasts. Chloritic clasts may originally have been mafic glass shards whereas pale grey clasts are interpreted to be more felsic lapilli.

The St. Joe volcaniclastic deposit is one of the few known volcanic units within the Aldridge Formation. However, as it in the same stratigraphic succession that hosts the thick accumulations of possibly comagmatic sills, the Moyie intrusions, it may record fragmentation of magma injected to a higher level or possibly a shallower water environment. Although subaqeous venting of tuffs can occur to water depths of greater than 2000 metres, it is much more likely to occur at much shallower depths (<1 km; McBirney, 1963). The presence of quartz, possibly even as phenocrysts, and the major and trace element chemistry suggest a more fractionated magma source than the Moyie sills.

OTHER INFERRED VOLCANICLASTIC UNITS

WILD HORSE RIVER

The Wild Horse River fragmental was discovered by D. Pighin in 1987 during detailed mapping of a lead-zinc vein, the Judy-Lu. It is located on the west bank of Wild Horse River on the walls of the trenched vein and extends for a few metres in natural outcrops. It comprises a light brown weathering layer, 10 to 15 centimetres thick, within strongly cleaved, dark grey to black, middle Aldridge argillite. The succession is overturned, trending north and dipping steeply to the west. Its exact stratigraphic position is not known, but extrapolation to the north (Höy, 1993) indicates that it is near the base of unit A2 of the middle Aldridge, a similar stratigraphic position to the St. Joe tuff (*see* Figure 2).

In hand sample, the Wild Horse River fragmental comprises a variety of small clasts in a light green matrix. The most abundant are 1 to 5-millimetre pale yellow-green angular clasts that are flattened parallel to foliation (Photo 6). They comprise fine-grained feldpspar with minor chlorite and muscovite. Angular, brown shale clasts and quartzitic fragments are rare. The matrix is dominantly feldspar, chlorite, muscovite and minor carbonate (dolomite?) that produces a brown weathering surface. Clasts are matrix supported, comprising approximately 20% of the rock.

Petrographic and scanning electron microscope analyses of one of the pale yellow-green clasts by McLeod (1987) suggest a volcanic origin:

"One fragment has the shape of a tear drop and is about 2 cm in diameter. This fragment has a chilled volcanic-microlitic texture on its edges ... The chilled margins consist of potash feldspar, plagioclase and iron oxide. The core is composed of plagioclase, pyrrhotite and biotite."

Due to limited exposure and intense deformation, it is difficult to interpret the origin of the Wild Horse River fragmental. It is a clastic, layer-parallel unit that is unlike known sedimentary fragmentals in the Aldridge Formation. The clasts are not similar to exposures of Moyie sills and therefore it is interpreted to be a tuffaceous unit. It may be a distal lapilli tuff, or possibly an epiclastic deposit formed by erosion or reworking of a volcanic rock.

MARK CREEK

The Mark Creek fragmental was discovered by A. Hagen in 1979 during regional mapping and exploration by Cominco Ltd. for sedex mineralization in the Aldridge Formation. It is exposed in a number of small isolated outcrops, covering a strike length of a few hundred metres, on the wooded slopes of Mark Creek approximately 3 kilometres northwest of the Sullivan deposit and 2 kilometres north of the Kimberley fault (Figure 1). The exposures are at the same stratigraphic level as the St. Joe tuff, just below a laminated siltstone marker unit.

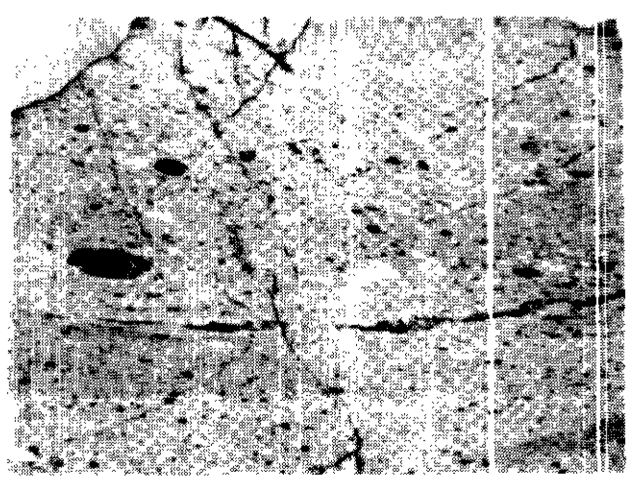

Photo 6. Hand sample from the Wild Horse River showing.

Fragmental outcrops are massive and rusty weathering. Neither layering nor grading are apparant. Fragmental samples are also massive, comprising dark grey, fine-grained siltstone containing isolated, flattened, pale grey and, less commonly, dark grey siltstone clasts, up to a centimetre in length.

In thin section, clasts are dominated by a fine-grained mosaic of feldspar and quartz, with abundant fine muscovite, coarser biotite and variable amounts of chlorite, epidote and opaques. Occassional clasts (or clots?) comprise dominantly chlorite and feldspar. The matrix to clasts is a mixture of feldspar, quartz, aligned fine muscovite, minor chlorite, epidote and pyrrhotite.

This fragmental appears to be dominantly of sedimentary origin. However, the variety of clasts is not typical of most small Aldridge fragmentals, which are dominated by clasts similar in composition to the matrix. Its similar stratigraphic position to the St. Joe tuff and the occurrence of chlorite-rich clasts suggest that it may have a volcanic component.

ELEPHANT CREEK

The Elephant Creek fragmental comprises a small trenched exposure, 10 to 15 metres across, just north of Highway 3a (Figure 1). Based on correlation of marker layers within the Aldridge Formation, it occurs approximately 80 metres stratigraphically lower than the St. Joe tuff. It is similar to the Mark Creek showing, comprising small, angular, pale grey granular clasts in a feldspathic matrix. Rare green clasts, composed dominantly of chlorite, may have a volcanic origin. However, the bulk of both matrix and clasts appears to have a sedimentary origin, and therefore it is classified as conglomerate with a possible tuffaceous component.

SUMMARY AND DISCUSSION

Although magmatism is now well documented during deposition of the Aldridge Formation and development of the Purcell Basin, with intrusion of the Moyie sills (Höy, 1989, 1993), evidence of extrusive activity is rare. Nash and Hahn (1989) describe thin biotite-rich layers within the Yellowjacket Formation in the Blackbird Mining District, Idaho that are interpreted to be mafic metavolcanic rocks. Their average composition (including analyses of related mafic sills) indicates that they are considerably more alkaline than most of the Moyie sills and the St. Joe tuff. However, they are similar in composition to alkalic sills in the Mount Mahon area south of Yahk that are inferred to be part of the Moyie sill suite (Höy, 1989).

Three of the four occurrences of inferred volcaniclastic rocks in the Aldridge Formation are at or close to one stratigraphic level, approximately 1450 metres above the base of the middle Aldridge, and hence are interpreted to record a single period of volcanism. This stratigraphic level records turbidite deposition that immediately preceded a period of relative quiescence and deposition of several metres of dark laminated siltstone.

The distribution of Aldridge volcaniclastics reflects a small number of minor vents, the largest near the St. Joe tuff, the thickest and most proximal of the known occurrences. Failure to recognize them elsewhere within the Aldridge may reflect the environment during deposition; associated rapid turbidite deposition may largely mask all but the thickest and coarsest accumulations.

The St. Joe tuffs record deposition as successive channel deposits and hence suggest epiclastic deposition. However, clasts with fine mafic rims suggestive of armoured lapilli, and broken angular feldspar and quartz grains, suggest clasts may be pyroclasts. It is, therefore, suggested that the St. Joe occurrence is a reworked volcanic tuff. As subaerial deposits are not recognized at this stratigraphic level (or at any other within the Aldridge Formation) the deposit is interpreted to be a subaqueous pyroclastic deposit.

Mafic pyroclastic rocks are common within subaerial environments, and generally restricted to depths of a less than a few hundred metres in submarine (or subaqueous) environments, suggesting that this stratigraphic level may record a widespread regression in middle Aldridge time. A similar but stratigraphically lower regression is described by Cressman (1989) in correlative Prichard Formation rocks in Montana.

The andesitic to possibly dacitic composition of a component of the St. Joe tuffs is unusual for Aldridge magmatism. Moyie sills have a mafic composition, either tholeiitic or transitional. However, it is possible that granophyre, identified in the Crossport C sill in Idaho (Bishop, 1974) may record a more felsic differentiate.

Other evidence for more felsic Aldridge magmatism may be recorded in a boulder conglomerate in the Chipka Creek area southeast of Cranbrook (Höy, 1993). The conglomerate records extensional tectonics during Sheppard Formation deposition and contains clasts of feldspar porphyry that contain zircons that have yielded a preliminary U-Pb date that is similar to the age of the Moyie sills (J. Gabites, personal communication, 1994). Hence, it is possible that mafic magmatism, recorded as Moyie sills, may have a more felsic component that is recorded as pyroclastic volcanism. It is not known if these tuffs are related temporally to intrusion of either the upper or lower sill complex, or record a separate period of Aldridge magmatism.

The St. Joe horizon also records a period of regional low-grade hydrothermal mineralization in the Aldridge with elevated base metal abundances, particularly copper, which are up to four times the background levels of normal Aldridge sediments, and a small crosscutting lead-zinc-silver vein. As well, a small massive sulphide occurrence and tourmalinization occur within a sedimentary fragmental unit approximately 100 metres below the St. Joe tuff (Pighin, 1983; Turner *et al.*, 1993). In the Blackbird District, Idaho, stratabound copper-cobalt deposits and tourmalinization are closely associated with mafic sills and inferred metavolcanic units. The volcaniclastic units, including the St. Joe tuffs, may record extensional tectonics with development of growth faults that acted as conduits for mineralizing solutions localizing base and precious metal occurrences.

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