VOLCANIC CENTRES IN THE STEWART COMPLEX (103P AND 104A, B)

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KEYWORDS: Regional geology, Stewart complex, volcanic centres, Hazelton Group, Stuhini Group, Bowser Lake Group.

INTRODUCTION

Upper Triassic to Lower Jurassic volcanic sequences surround and underlie sedimentary rocks of the Middle Jurassic Bowser Lake Group in central British Columbia. The large lobe of Lower Jurassic strata exposed along the western edge of the Bowser Basin (Figure 1-27-1) has been termed the Stewart complex (Grove, 1986).

The Stewart complex is well known as the setting for the Iskut, Sulphurets, Stewart and Kitsault (Alice Arm) gold-silver mining camps. Several camp-scale mapping programs have been undertaken since 1911 and Hanson (1929, 1935) mapped the southern part of the district during the 1920s and 30s. The first mapping and compilation study of the entire region was completed between 1965 and 1968 by E.W. Grove (1986) who presented a composite stratigraphic column and discussed correlation problems created by facies changes.

This report presents a reconstruction of the Upper Triassic and Lower Jurassic stratigraphy and paleotopography within the Stewart complex, based on fieldwork started in 1982. The interpretations are derived from a study of facies variations along strike, calculations of stratigraphic thicknesses and a review of modern analogues in volcanic arc environments (Figure 1-27-2). The coloured geological maps in Grove's 1986 bulletin are good location maps for topographic features mentioned in this report.

STRATIGRAPHY

Nomenclature for early to middle Mesozoic strata in northwest British Columbia is evolving. Differing formational subdivisions within the Hazelton Group have been proposed by Tipper and Richards (1976), Grove (1986), Thomson *et al.* (1986), Thorkelson (1988) and Diakow (in preparation). Anderson (personal communication, 1988) suggested stratigraphic division into four regionally extensive groups while retaining locally defined formation names wherever practical. Proposed formational and group names for the Stewart complex are presented in Table 1-27-1, together with a brief summary of characteristic lithologic features.

FACIES RELATIONSHIPS

The significance of facies changes within volcanic and sedimentary rocks of andesitic stratovolcanoes has been reviewed by Williams and McBirney (1979), Moore and Morton (1982), Ayres (1982), MacKay School of Mines (1983), Easton and Easton (1984), Fisher and Schmincke (1984), Kokelaar and Howells (1984), Wood and Wallace (1986), and Cas and Wright (1987). In particular, Fisher and Schmincke, Wood and Wallace, and Cas and Wright provide tables of diagnostic criteria. Facies indicators used in this study are discussed in the following sections, and the paleotopographic reconstructions are presented in Figures 1-27-3, 4 and 5.

VENT FACIES (CENTRAL FACIES)

The only vent-facies rocks identified within the Stewart complex are located on the west edge of the Mount Dilworth snowfield. Vent facies include very coarse angular megabreccias (Plate 1-27-1), and an accumulation of milled boulders of fallback breccia (Plate 1-27-2) in close association along strike. These breccia textures are displayed within the Premier Porphyry feldspar-hornblende crystal tuffs that are the extrusive equivalent of Premier Porphyry dykes which cut the underlying rocks.

PROXIMAL FACIES

Diagnostic features of the proximal volcanic facies have been identified in four widely separated areas within the complex and occur in the Stuhini Group and are coincident in the Unuk River, Betty Creek and Mount Dilworth formations of the Hazelton Group, indicating the Lower Jurassic extrusive centres were relatively long-lived (2 to 3 million years).

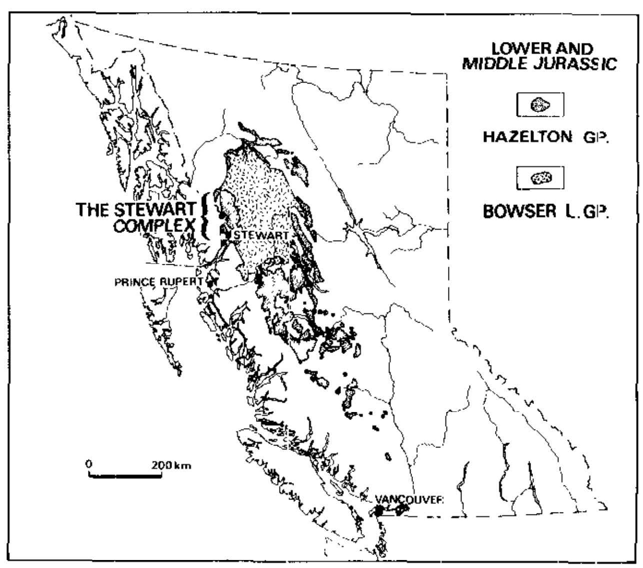


Figure 1-27-1. Distribution of the Hazelton Group in British Columbia.

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1.

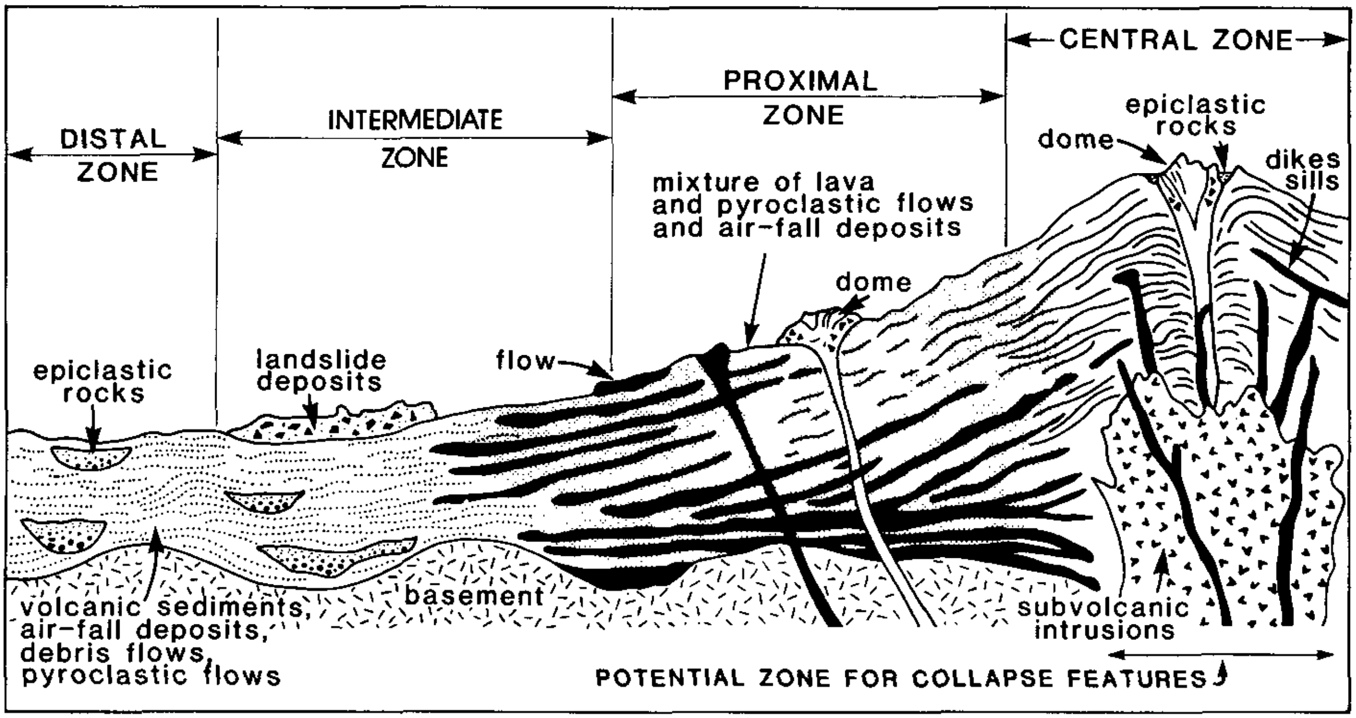


Figure 1-27-2. Facies variation in a stratovolcano (modified from Williams and McBirney, 1979).

TABLE 1-27-1. FORMATIONS.

AGE	GROUPS	FORMATIONS	MEMBERS	LITHOLOGIES
Bathonian	Bowser Lake	Ashman	Main Sequence Basal Conglomerate	Turbidites, wackes, intraformational conglomerates Chert pebble conglomerates
Bajocian to Toarcian	Spatsizi(?)	Salmon River	Pyjama Beds Basal Limestone	Thin bedded, alternating siltstones and mudstones Gritty, fossiliferous limestone
Toarcian		Mount Dilworth	Upper Lapilli Tuff Middle Welded Tuff Lower Dust Tuff	Dacitic lapilli tuff with flow-banded clasts Dacitic welded ash flow and lappilli tuff Dacitic dust tuff
Pliensbachian	Hazelton	Betty Creek	Sedimentary Members Volcanic Members	Hematitic volcaniclastic sediments, and turbidites Andesitic to dacitic tuffs and flows
Sinemurian to Hettangian(?)		Unuk River	Premier Porphyry Upper Andesite Upper Siltstone Middle Andesite Lower Siltstone Lower Andesite	Two feldspar + hornblende porphyritic tuffs Massive tuffs with local volcaniclastic sediments Turbidites, minor limestones Massive tuffs and minor volcaniclastic sediments Turbidites Massive to bedded ash tuffs
Norian to Carnian	Stuhini		Volcanic Members Sedimentary Members	Pyroxene porphyry flows and tuffs Turbidites, limestones, conglomerates

Proximal facies within the Stuhini Group are exposed above treeline along the east side of the Kitsault River valley. Extensive accumulations of basaltic pillow lavas, massive to medium-bedded scoria, and crystal tuffs and tuff breccias are exposed 3 kilometres southwest of Kinskuch Lake.

In the Unuk River formation, proximal facies are indicated by a general coarsening of tuff breccia textures in the Upper Andesite member at Mount Dilworth. In the Premier Porphyry member, thick blankets of rhythmically bedded, thinly laminated to thin-bedded airfall crystal tuffs crop out along the south side of Brucejack Lake (Plate 1-27-3), on the upper west slope of Troy Ridge, and eastward (uphill) of the Premier minesite (Plate 1-27-4). These latter units are locally welded and may display columnar jointing. In one exposure bomb sags are preserved within bedded crystal tuff of the Premier Porphyry member (Plate 1-27-5).

Proximal facies in the Betty Creek formation are indicated by wedging out of sedimentary units toward paleotopographic highs, the presence of columnar-jointed dacitic ash-flow tuff units, and preservation of extensive pillow lava units. Smaller scale proximal indicators include accumulations of accretionary lapilli (Plate 1-27-6) and armoured lapilli (Plate 1-27-7). Proximal base-surge dune forms provide directional indicators (Plate 1-27-8).

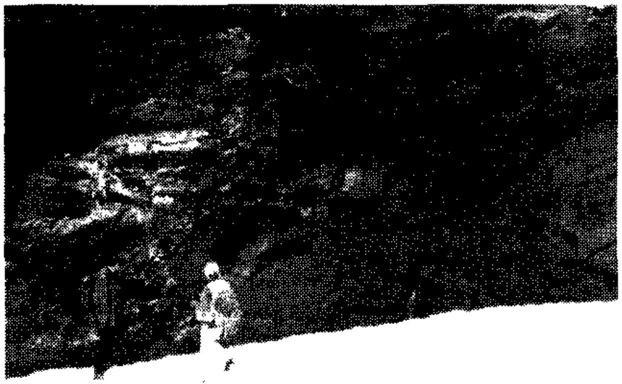


Plate 1-27-1. Monolithic megabreccia of blocks of potassium feldspar megacrystic lava in similar crystal tuff. West edge of Mount Dilworth snowfield.

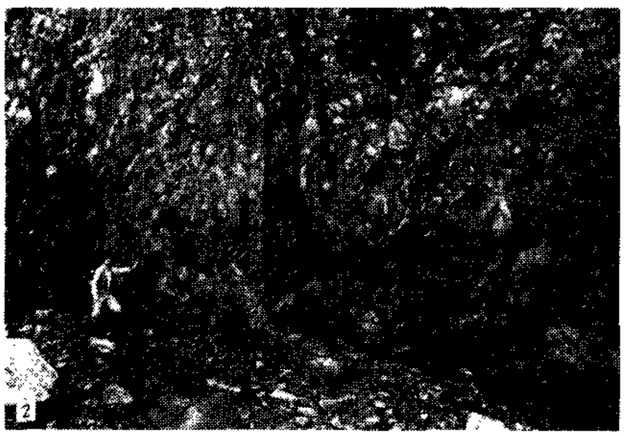


Plate 1-27-2. Vent-facies fallback breccia of milled boulders of Premier porphyry in similar matrix material. Outcrop 150 metres north of Plate 1-27-1.

Within the Mount Dilworth formation, proximal facies in the middle member are indicated by fiammé-rich welded ash flows with well-preserved cooling units. In the upper member, delicately swirled flow-banded dacitic bombs and spatter show progressive coarsening along strike toward a vent. Base-surge dunes occur locally near Mount Dilworth. Pale bluish grey chalcedonic veins which cut the upper member may have been deposited from heated fluids moving up and away from the welded middle member.

INTERMEDIATE FACIES

In the Stewart complex diagnostic features of the transitional or intermediate facies include: zones of lateral facies change from strongly welded to weakly welded ash flows (that is, the disappearance of fiammé along strike), roughly equal proportions of sediments and tuffs, rapid thickening of epiclastic sedimentary wedges along strike, predominance of fine lapilli tuffs and ash tuffs, and the presence of minor lenses of pillow lava with limited strike extent.

DISTAL FACIES

Distal volcanic facies indicators within the Stewart complex include a predominance of thin-bedded turbidite sequences with minor limestones, waterlain dust-tuff beds, and local pillow-breccia beds and mature heterolithic conglomerates. All these features are well displayed in both Upper Triassic and Lower Jurassic strata in the McTagg Creek area and along the Johnstone Icefield to the north. This region at the north of the Sulphurets map sheet records either a major gap between centres along an arc, or the fore-arc or back-arc sedimentary basin. A similar, perhaps less distant, basin is suggested by the thick succession of sedimentary rocks with minor interbedded tuffs in the vicinity of the 4-Js mineral prospect west of Heel Lake.

SUBAERIAL VERSUS SUBAQUEOUS FACIES

A distinction between subaerial and subaqueous depositional environments places important constraints on genetic models for mineral deposits and therefore on exploration strategies. Together with trace element studies and lead isotope data, facies analysis can help distinguish between island arc and continental margin tectonic settings for ancient stratovolcanoes.

In the Late Triassic Stuhini Group, the abundance of major carbonate units, thick sections of turbiditic sediments and characteristic pillow lavas all indicate a subaqueous environment.

Rocks of the Hazelton Group include both subaerial and submarine facies. Abundant small-scale interbeds of turbidites and limestone clearly indicate the Unuk River formation andesites are subaqueous where they are exposed in the Kitsault and Sulphurets areas. The absence of interbedded limestones and turbidites in the Stewart area, together with the presence of minor hematitic epiclastic conglomerate lenses, suggests the formation may have accummulated above the wave base in the Mount Dilworth – Premier area. The Betty Creek formation is dominantly subaerial in character but facies are alternately subaerial and subaqueous in the Brucejack Lake area and entirely subaqueous further north and west. The Mount Dilworth formation is predominantly subaerial in character but it may have been deposited subaqueously in its most northerly exposures.

STRATIGRAPHIC THICKNESS

Study of stratigraphic thickness variations for the whole thickness of the Hazelton Group did not help delineate volcanic centres, probably because rapid erosion levelled many of the volcanic edifices. Careful documentation of the stratigraphic thickness of individual formations indicates striking changes; thinner formations are most useful because they are more easily traced through complications from folding and faulting.

ANDESITIC STRATOVOLCANOES (REGIONAL BASINWARD THINNING)

The thickness of the Unuk River formation varies from a maximum of 4500 metres in the Stewart area to as little as 500 metres in parts of the Kitsault valley. The Kitsault valley section is interpreted as an intermediate facies because of the overall formational thinning, the increased proportion of interbedded subaqueous sediments (both turbidites and lime-

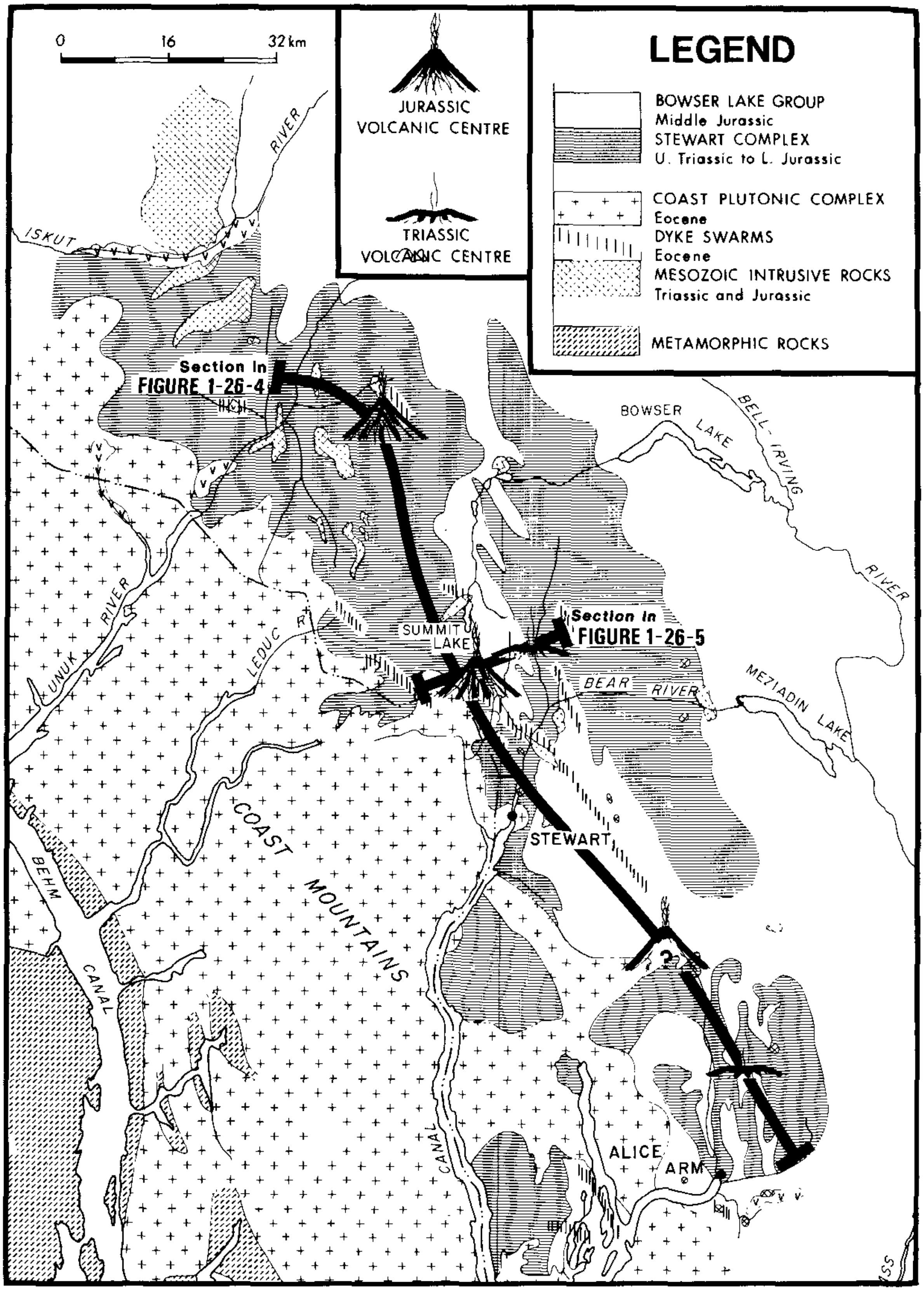


Figure 1-27-3. Distribution of the Stewart complex showing the locations of section lines for Figures 1-27-4 and 1-27-5.

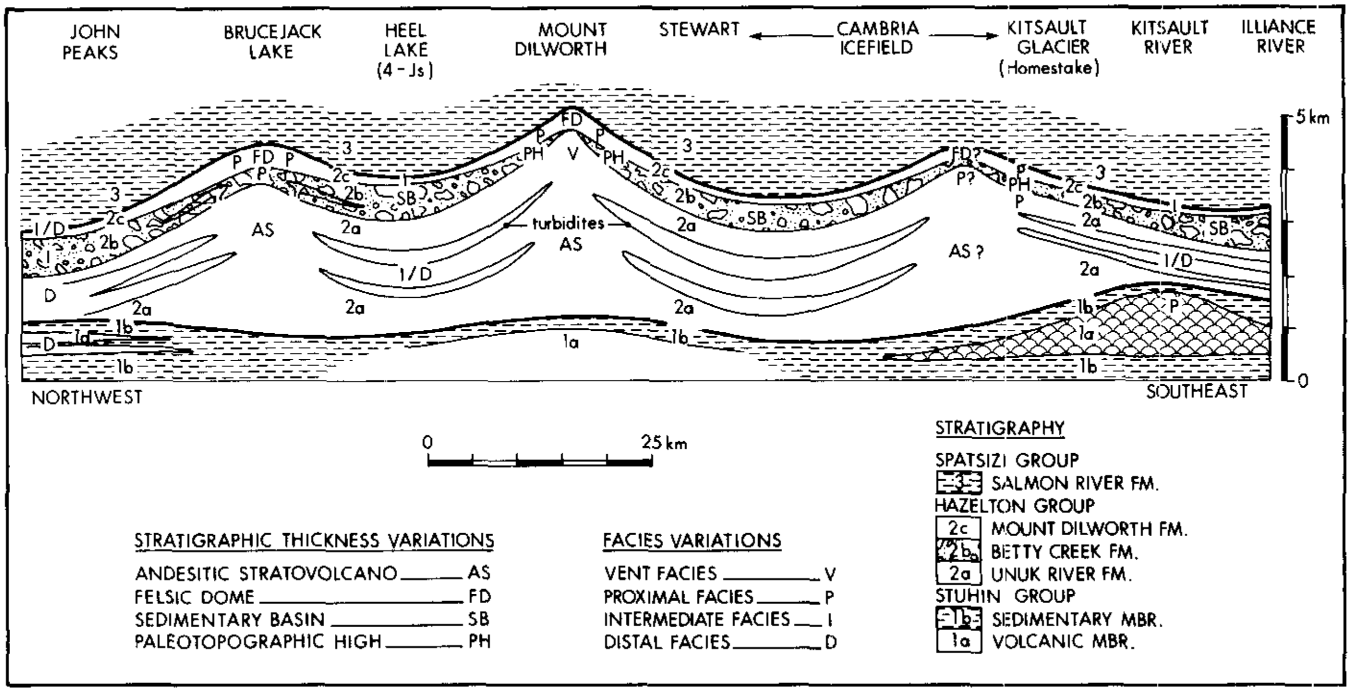


Figure 1-27-4. North-south schematic reconstruction through the Stewart complex.

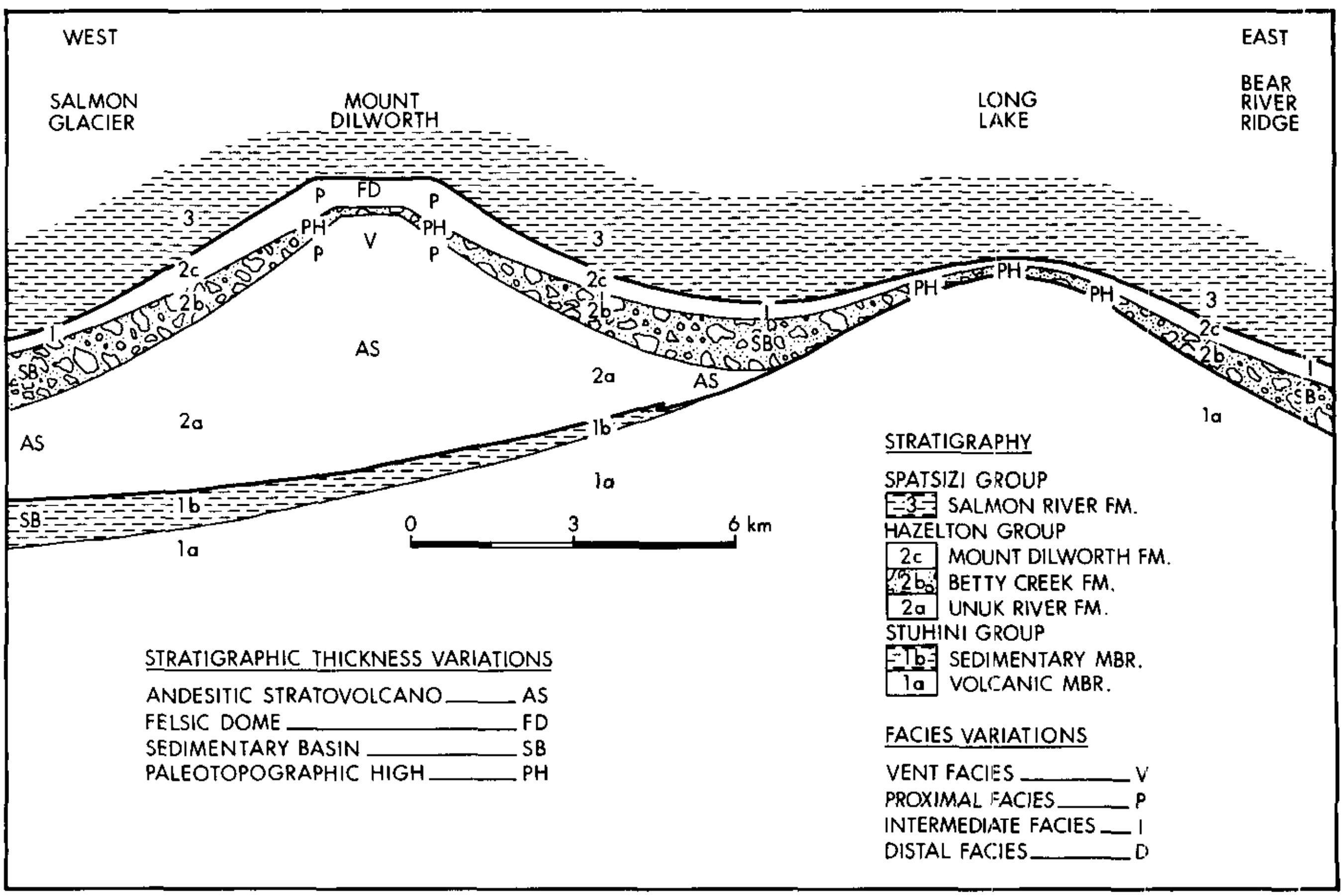
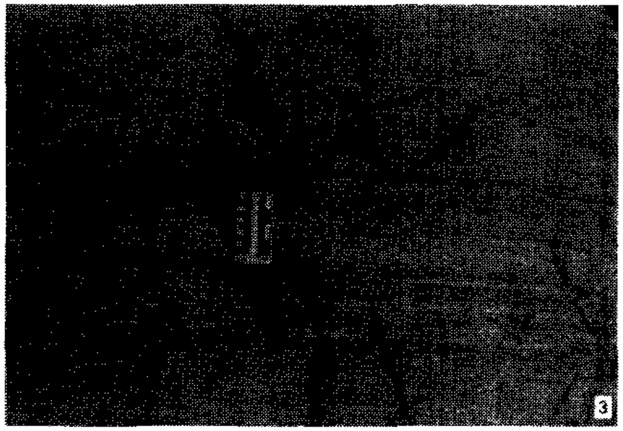
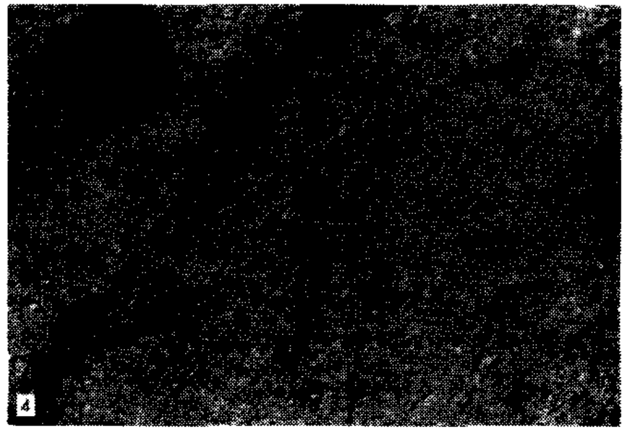


Figure 1-27-5. West-east schematic reconstruction through the Stewart complex.





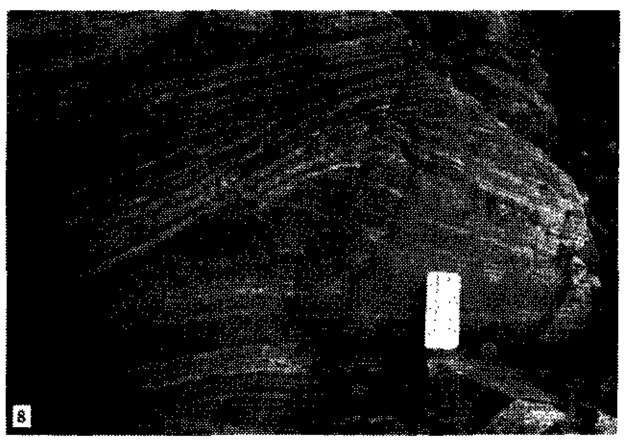


Plate 1-27-3. Thin-bedded, rhythmically bedded, airfall plagioclase crystal tuff. Premier porphyry member. Outcrop 150 metres southeast of Brucejack Lake.

Plate 1-27-4. Thin-bedded, welded, airfall plagioclase crystal tuff. Note single larger potassium feldspar crystal. Premier Porphyry member. Outcrop to the east and uphill from Premier open pit.

Plate 1-27-5. Bomb sag in well-bedded potassium feldspar megacrystic, airfall plagioclase crystal tuff. Premier Porphyry member. Outcrop 200 metres east-southeast of Brucejack Lake.

Plate 1-27-6. Graded bed of fine accretionary lapilli and armoured lapilli, Betty Creek formation. Outcrop 600 metres east of Iron Cap mineral prospect, at snowline.

Plate 1-27-7. Armoured lapilli in lahar deposit, Betty Creek formation. Outcrop 250 metres north of the toe of Bruce Glacier.

Plate 1-27-8. Base-surge dune form in thin-bedded airfall ash tuff indicates blast direction was from left (north). Outcrop 4 metres above Plate 1-27-6.

stones), and a general decrease in lapilli size to fine lapilli. Sediment-hosted, stratabound mineral deposits in the Kitsault area (for example, Kit, MINFILE 103P 245) are similar to those associated with flank deposits on island arc volcanoes in the southwest Pacific.

FELSIC DOMES (LOCAL BASINWARD THINNING)

The Mount Dilworth formation ranges in thickness from 20 metres up to 200 metres. In contrast to the Betty Creek formation, Mount Dilworth strata seem to thicken progressively toward areas of proximal facies that are interpreted as paleotopographic highs. This distribution can be attributed to the highly viscous nature of most felsic flows and some welded tuffs.

SEDIMENTARY BASINS (REGIONAL BASINWARD THICKENING)

The Betty Creek formation shows spectacular thickness changes over relatively short strike lengths. Between Mount Dilworth and the west slope of Mitre Mountain thickness increases from 4 to 1200 metres and further north may be even greater. This is interpreted as a progressively basinward-thickening wedge on the flanks of a volcanic cone.

PALEOTOPOGRAPHIC HIGHS (LOCAL THINNING OF SEDIMENTARY UNITS)

Paleotopographic highs can be interpreted from a combination of features, but are mainly recognized as a consequence of stratigraphic thinning in sedimentary rocks. This is a useful concept in situations where, for example, wedging out of sedimentary strata indicates a proximal setting but there are no proximal or vent facies in the associated volcanic strata. Such a situation occurs at the north end of Long Lake, where a large outcrop area of massive augite porphyry is draped by a thin veneer of Betty Creek conglomerates and sandstones that thicken progressively southward (Figure 1-27-5; Dupas, 1985).

DISCUSSION

Upper Triassic volcanic centres were probably developed within the Stewart complex but are not well exposed or preserved. The massive augite porphyry exposure at the north end of Long Lake is a paleotopographic high that may represent one such centre. Extensive exposures of proximal to intermediate facies augite porphyry flows and bedded crystal tuffs in the Kitsault valley suggest that systematic mapping within the unit would locate another Upper Triassic extrusive centre in that area. Reported pillowed augite porphyry flows just east of the Granduc mine (P. McGuigan, personal communication, 1984) indicate another area which needs further study. The Upper Triassic centres are not coincident with those of Early Jurassic age, although the Long Lake and Mount Dilworth vents are close together.

Lower Jurassic volcanic centres in the Unuk River formation are located in the Big Missouri–Premier area, in the Brucejack Lake area, and may exist along the southwest edge of the Cambria Icefield, northwest of the Kitsault Glacier and the Homestake mineral prospect. West and northwest of Brucejack Lake this formation shales-out into a major basin of distal sediments. A smaller sedimentary basin is exposed in the area around the 4-Js mineral prospect to the southeast.

Volcanic centres within the Lower Jurassic Betty Creek formation seem more diffuse, possibly indicating a long history of eruption or a distribution of facies controlled by Unuk River formation topography. One vent area is near the Mitchell Glacier and additional centres possibly occur near the toe of the Knipple Glacier and at the northeast end of Kinskuch Lake.

Volcanic centres are well documented in the Mount Dilworth formation; on Mount Dilworth, in the Mitchell Glacier area, and near the west side of the Kitsault Glacier.

Several large areas within the Stewart complex remain unmapped, thus there are no data on the location of other volcanic centres around the perimeter of the Cambria Icefield and further to the east, in the large region around the Todd Icefield and in the entire area west of Snippaker Creek. Within the published map sheets, two areas that have not been examined in detail are the southeastern part of the Kitsault map area along the Illiance River and a region within the Sulphurets map area along the east side of the Frankmackie Icefield.

CONCLUSIONS

Regional mapping has delineated three volcanic centres in Lower Jurassic strata and two probable vent areas in Upper Triassic rocks of the Stewart complex. There is a spatial coincidence between volcanic centres throughout Early Jurassic time that cannot be extended back to Late Triassic time. This suggests there may have been a common magma chamber and vent for Lower Jurassic volcanic rocks in different formations and a fixed subvolcanic heat source over a prolonged period in the Early Jurassic.

The two longest-lived Early Jurassic centres, Brucejack Lake–Mitchell Glacier and Mount Dilworth–Premier, coincide with major gold-silver deposits and dozens of precious metal prospects. This coincidence of mineralization and major eruptive centres is real, not a factor of more detailed mapping within the mineralized areas. A similar correlation of mineral deposits with stratovolcanoes in arc environments has been recognized in the southwest Pacific (Figure 1-27-6).

RECOMMENDATIONS

Four additional tests of this correlation between mineralization and eruptive centres would be:

- a study of stratigraphy and facies relationships around the well-mineralized Illiance River valley,
- a similar program in the Todd Icefield area,
- an investigation of the prediction that a volcanic centre (with associated mineralization?) must lie somewhere to the northwest of the Homestake prospect, and
- a mapping program in the richly mineralized Iskut River–Snippaker Creek area.

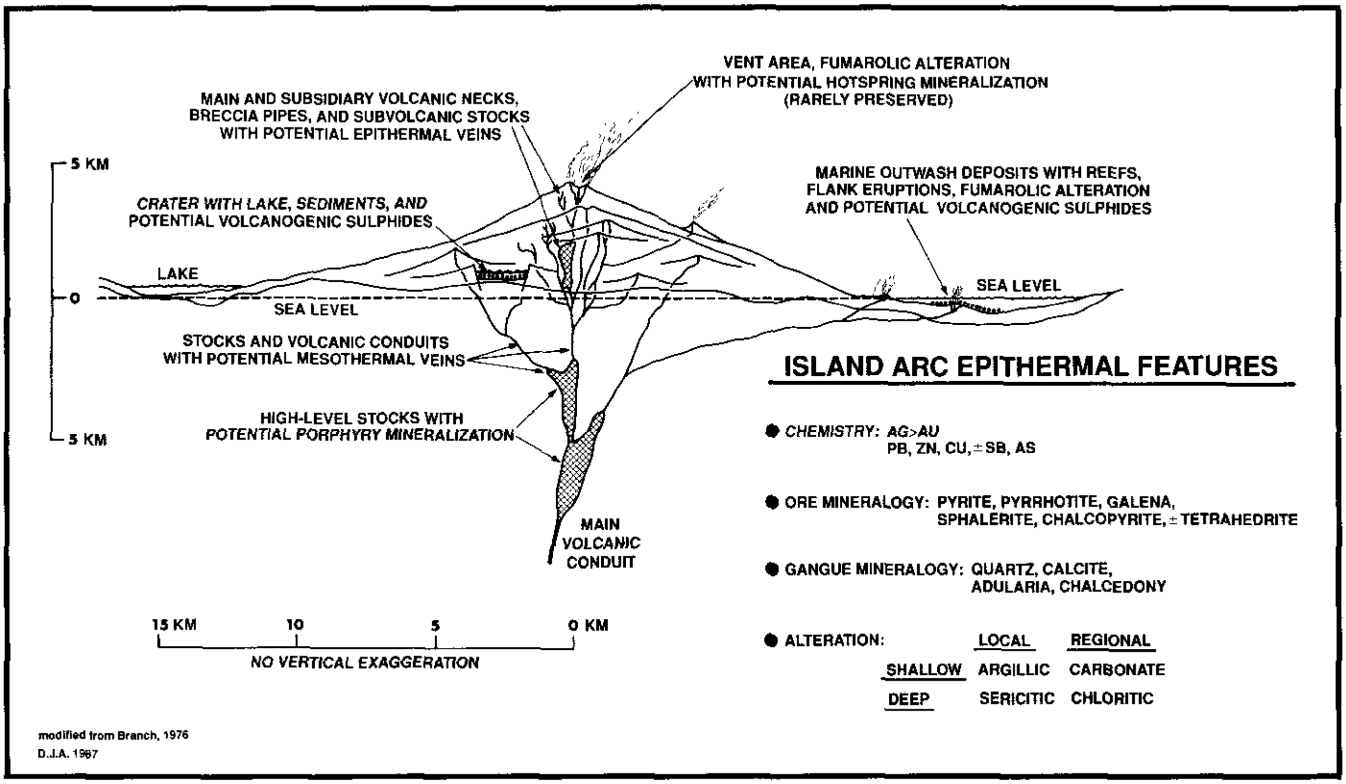


Figure 1-27-6. Distribution of ore deposits within a stratovolcano (modified from Branch, 1976).

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