Gladys Lake

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Jurassic and Triassic volcanic and sedimentary rocks in Spatsizi map area, north-central British Columbia

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Abstract

On Stikinia, Lower to Middle Jurassic volcanic and associated sedimentary rocks of the Hazelton Group unconformably overlie volcano-sedimentary rocks of the Upper Triassic Stuhini and Takla groups. In Spatsizi map area, where Hazelton rocks have been informally named the Cold Fish volcanics, Jurassic and Triassic units occupy a northwest-trending belt 85 km long and 10 km wide.

The Cold Fish volcanics, ranging from early Pliensbachian to early Toarcian in age, comprise subaerial to submarine felsic to mafic lava and tuff, and minor shale and limestone. Pliensbachian Cold Fish volcanics from near Nation Peak are arc-related, bimodal rhyolite and basalt-to-trachyte. Rhyolites are mostly tholeiitic whereas the basalt-trachyte suite is transitionally tholeiitic to alkaline.

Stuhini rocks comprise marine and nonmarine flows, and clastites including chert- and limestone-bearing olistostrome and conglomerate. These coarse deposits may yield information on aspects of tectonism during an interval near the Jurassic-Triassic boundary.

Résumé

Dans la région de Stikinia, les roches volcaniques et les roches sédimentaires associées du Jurassique inférieur à moyen sont appelées groupe de Hazelton. Elles sont séparées par une lacune des roches volcano-sédimentaires sous-jacentes du groupe de Stuhini-Takla du Trias supérieur. Dans le secteur de carte de Spatsizi, où les roches de Hazelton sont appelées roches volcaniques de Cold Fish, les unités jurassiques et triasiques occupent une zone d'orientation générale nord-ouest, de dimensions 85 × 10 km.

La succession de Cold Fish, qui se situe entre le Pliensabachien inférieur et le Toarcien inférieur, comprend des laves et tufs subaériens à sous-marins, et quelques schistes argileux et calcaires. Les roches de Cold Fish, du Pliensbachien, qui proviennent des environs de Nation Peak, sont des rhyolites bimodales et des roches basaltiques à trachytiques. Les rhyolites sont principalement tholéiitiques, tandis que la suite des basaltes aux trachytes représente une transition des roches tholéiitiques aux roches alcalines.

Les roches de Stuhini-Takla de la région de Spatsizi comprennent des coulées marines et non marines et des clastites, y compris des olistostromes et des conglomérats contenant des cherts et des calcaires. Ces dépôts grossiers peuvent nous renseigner sur des aspects tectoniques de la limite du Jurassique et du Trias.

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INTRODUCTION

Fieldwork on the Cold Fish volcanic rocks, an informal division of the Jurassic Hazelton Group in Spatsizi (104H) map area, began in 1986. In 1987, investigations continued and expanded to include some nearby Upper Triassic volcanic and sedimentary rocks of the Stuhini Group. These units in the study area (Fig. 1) occur in a northwesterly-trending belt approximately 85 km long and 10 km wide extending from near the confluence of the Stikine and Klappan rivers to 15 km east of Spatsizi River. Because analysis of data began only after the 1987 field season, results are preliminary.

Acknowledgments

The writer is grateful to S. Hedberg, R.B. McFarlane, J. Pardoe and M.D. McPherson for capable and devoted assistance, and C.A. Evenchick and H. Gabrielse for logistical support and intellectual stimulation. Geochemical analyses, provided by the Geological Survey of Canada, were performed by wavelength dispersive X-ray fluorescence on fused disks. Analyses were recalculated to 100 % on a volatile-free basis.

REGIONAL SETTING

Upper Triassic and Lower to Middle Jurassic volcanic and volcano-sedimentary rocks occupy much of Stikinia, the largest accreted terrane in the Canadian Cordillera. In northern British Columbia, Upper Triassic rocks of Stikinia are known as the Stuhini Group; to the south they are called the Takla Group (see Souther, 1977, for distribution). Both groups, which appear to constitute a single volcanic belt, are typified by mafic, alkaline to subalkaline augite porphyry and bladed plagioclase porphyry, and associated breccia, sandstone, limestone and shale (Monger and Church, 1977; Tipper and Richards, 1976; Anderson, 1980). They rest on Late Paleozoic volcanic and sedimentary rocks, notably the Permian Asitka Group. Although generally of Carnian and Norian ages, some sequences, specifically the Moosevale Formation in McConnell map area (94D) southeast of the study area, contain strata of earliest Jurassic age. Submarine facies dominate the Stuhini and Takla groups and subaerial sequences are apparently restricted to local volcanoes that rose above sea level. On the Quesnel Terrane to the southeast, Nicola Group volcanic rocks have similar petrology and volcanic facies and may share elements of a common history with the Upper Triassic succession of Stikinia.

Jurassic volcanic and associated sedimentary rocks are known throughout Stikinia as the Hazelton Group. They commonly rest unconformably on Stuhini and Takla group rocks and are separated from them by a polymictic conglomerate suggestive of an intervening period of uplift and erosion (Tipper and Richards, 1976; Monger and Church, 1977; Mihalynuk and Ghent, 1986). Near Terrace, the conglomerate comprises clasts of Permian limestone in an iron-oxide-stained volcanic matrix (Mihalynuk and Ghent, 1986). Monger and Church (1977) reported a similar unit in McConnell Creek map area containing volcanic detritus from the Takla Group and limestone and chert from the Asitka Group.

Tipper and Richards (1976) restructured the poorly-defined Hazelton Group, identifying three constituent formations and several members and facies. Their work, based on extensive mapping and sampling in the McConnell Creek, Hazelton (93M) and Smithers (93L) map areas, divided the group into the lower Sinemurian to early Pliensbachian Telk-

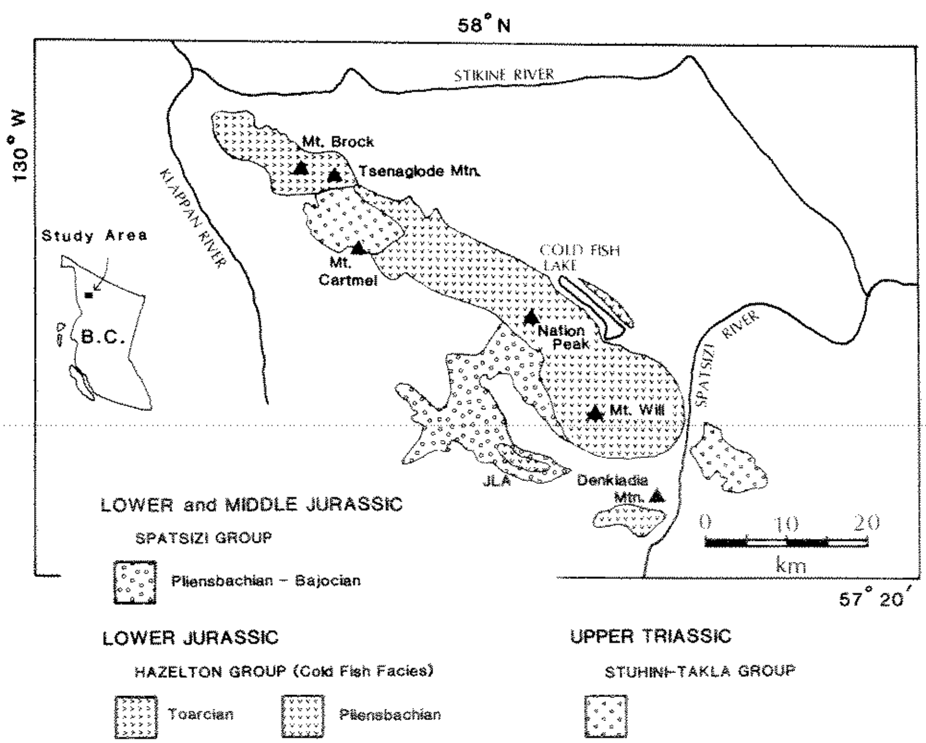

Figure 1. Distribution of Lower Jurassic and Upper Triassic volcanic and sedimentary rocks in Spatsizi (104H) map area, southeast of the confluence of Klappan and Stikine rivers. JAL = Joan Lake Anticline.

wa, the early Pliensbachian to middle Toarcian Nilkitkwa and the middle Toarcian to lower Callovian Smithers formations. They included the chert- and carbonate-bearing heterolithic conglomerate in the Sikanni (basal) facies of the Telkwa. Other facies of that formation are dominated by proximal, submarine and subaerial volcanic rocks, largely calc-alkaline basalt and rhyolite. In contrast, the younger Nilkitkwa Formation comprises mainly volcaniclastic units suggestive of more distal facies. Exceptions are the Pliensbachian and Toarcian submarine to subaerial basalts of the Ankwell and Carruthers members. The trend of younger Hazelton rocks having higher epiclastic/lava ratios is further demonstrated by the Smithers Formation which consists mainly of sandstone and shale with lesser amounts of conglomerate, limestone and tuff. The Smithers is overlain, generally disconformably, by the Ashman Formation of the Bowser Lake Group.

In Toodoggone (94E) map area, north of the region considered by Tipper and Richards (1976), volcanic rocks of similar age to the Hazelton Group were informally named Toodoggone volcanics by Carter (1972). More recently, Panteleyev (1984), on the basis of isotopic dates ranging from 179 to 204 Ma, correlated those rocks with the Telkwa Formation. He described the Toodoggone volcanics, which lies east of the study area, as a "subaerial, intermediate, calc-alkaline to alkaline, predominantly pyroclastic assemblage" and thereby established an additional facies of the Telkwa.

In Spatsizi map area, Gabrielse and Tipper (1984) informally used the Toodoggone name for Lower and Middle Jurassic volcanic rocks. However, because the Cretaceous Sustut Basin separates the volcanic strata in the study area from those in the Toodoggone, correlations are uncertain. Thomson et al. (1986) used the informal term Cold Fish volcanics for Jurassic eruptives in the Spatsizi region and that terminology will be followed in this report.

COLD FISH VOLCANIC AND RELATED SEDIMENTARY ROCKS

Facies and lithologies

The Cold Fish volcanics are a subaerial to shallow marine succession of mafic and felsic lavas, and air-fall and ash-flow tuffs. The subaerial facies, which predominates, is nearly devoid of epiclastic rocks except for lahar. Conversely, the subaqueous volcanics are intercalated with limestone conglomerate, breccia, siltstone and shale (Fig. 2). Although the division between terrestrial and marine is commonly nebulous, fossiliferous limestone locally is stratigraphically continuous with clearly subaerial flows and tuffs. For example, 3.5 km northeast of Nation Peak (Fig. 1), limestone containing abundant pelecypods lies within lavas of uncertain depositional environment overlying welded ignimbrite and highly oxidized (reddened) basic flows. This close stratigraphic and spatial relationship is further indicated by admixtures of limestone and mafic lava observed 9 km northwest, and 5 km east-northeast of Nation Peak.

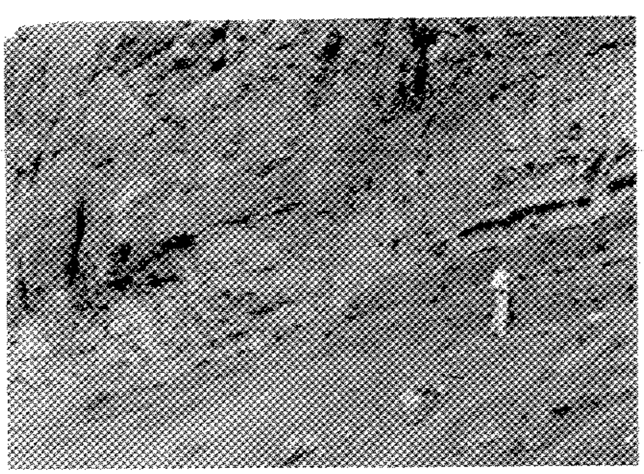

Figure 2. Massive Cold Fish basalt overlying limestone and shale interbeds, 5 km east-northeast of Nation Peak.

Another facies distinction can be made between sequences comprising abundant mafic lava flows interlayered with rhyolites and clastic rocks, and those in which mafic extrusives are virtually absent. In the latter, thick (20-100 m) flow-banded rhyolite flows and highly welded ignimbrite sheets are predominant and suggestive of an intracaldera setting. Although structural evidence for the morphology is scarce, rhyolitic dykes coincident with block faults were observed 8 km east-southeast and 5 km east-northeast of Nation Peak. Rhyolite-ignimbrite facies are concentrated toward the southeastern end of the study area, from near Mount Will to Spatsizi River. Excellent exposures over 600 m thick are present above Will Creek, 5 km southeast of Mount Will.

Contrasting sequences with higher proportions of basic lava are found in the Joan Lake Anticline and throughout the Jurassic belt northeast of Mount Will. Mafic flows are aphyric to porphyritic, with plagioclase, and in basaltic flows, serpentine-after-olivine pseudomorphs, dominating the phenocryst populations. Bladed plagioclase porphyry, hosting abundant tabular plagioclase phenocrysts 6-12 mm long, is common in the Pliensbachian succession. Pyroxene grains, although common, are nearly everywhere small (<2 mm) and low in relative abundance. Most basic flows are partly amygdaloidal (especially at their tops) and partly dense. Vesicles are variably filled with chlorite, calcite, celadonite, zeolites, quartz and, less commonly epidote, generally suggestive of zeolite grade metamorphism. Subaerial flows, usually 5-15 m thick, exhibit reddened margins and varicoloured autoclastic breccia. They are interbedded with rhyolite, tuffaceous rocks, and less commonly, lahar. Air-fall tuff, identified by good internal stratification, is generally red or green. Welded ignimbrite, somewhat less common, is usually light-grey weathering, poorly sorted and non-stratified. Rhyolite has planar to highly contorted flow-banding, in many places autobrecciated and, in places, weathers rusty due to oxidation of pyrite. Marine extrusions, typically green, are generally brecciated, palagonitized, and interbedded with sedimentary rocks. Well-exposed marine sections are present 9 km northwest and 5 km northeast of Nation Peak. The various elements of this composite, marine to nonmarine facies suggest that the rocks were deposited on the flanks of a gently to moderately sloping, oceanic or coastal volcanic edifice.

Intruding the Cold Fish volcanics, in addition to rhyolite dykes, are mafic dykes, rhyolitic sills and, in at least two places (9 km east of Mount Will and 9 km west of Mount Brock), felsic granitoid plutons. A general lithologic similarity to Cold Fish volcanics and an absence of younger volcanic strata in the region (except for distinctive Tertiary flows of the Stikine Belt) suggest that the fine-grained intrusions are comagmatic with the eruptive rocks. Furthermore, extrusive and intrusive aphanites occupy the same chemical fields (Figs. 3 to 5). Leucocratic granitic rocks east of Mount Will are crosscut by green dykes of intermediate composition, suggesting that they were emplaced prior to cessation of Cold Fish volcanism.

Thomson et al. (1986) examined sedimentary rocks within and adjacent to the Cold Fish volcanics. Based largely on ammonite biostratigraphy and to a lesser extent on lithology, they defined the Spatsizi Group and five constituent formations. Comprising mostly shale, siltstone and waterlain tuff, the group was depicted as a partly coeval, basinward equivalent to the Cold Fish volcanics ranging in age from early Pliensbachian to early Bajocian. Its relationship to the Cold Fish is therefore similar to that between the shaly and volcanic facies of the Nilkitkwa Formation (Tipper and Richards, 1976). Additionally, the tuffaceous and fine-grained clastic character of the Spatsizi generally fits lithologic descriptions given by Tipper and Richards for the Smithers Formation. Another similarity with the Smithers is the nearly conformable relationship with the overlying Ashman Formation of the Bowser Lake Group.

Age determinations of the Cold Fish volcanics, inferred from stratigraphic relations with Spatsizi rocks and related fossiliferous strata within the volcanics, were given by Thomson et al. (1981). They divided the Cold Fish volcanics in the study area into a Toarcian sequence on the northwestern end, a larger Pliensbachian sequence extending from the Toarcian part southeastward to Spatsizi River, and a Bajocian section east of the river. Tentatively, the Bajocian part is now considered to be part of the Stuhini-Takla assemblage for reasons which are given later. Because no striking lithologic differences between the Toarcian and Pliensbachian were observed, the Cold Fish volcanics appears to be without strong time-dependent variations.

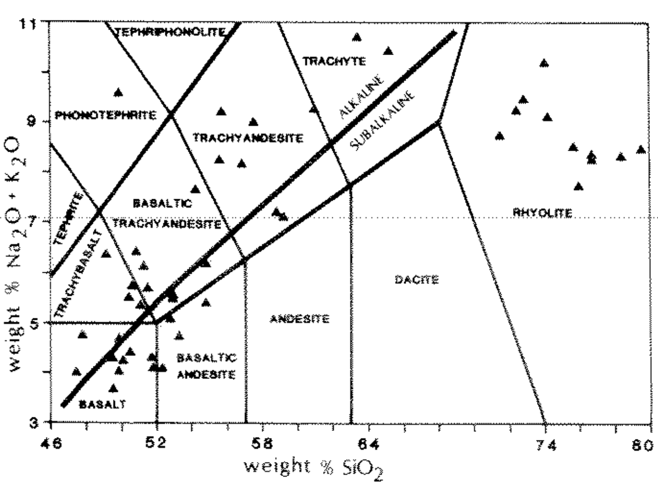

Figure 3. Total alkalies vs. silica classification diagram (Zanettin, 1984). Alkaline/subalkaline curve from Irvine and Baragar (1971). Symbols represent Cold Fish rocks from Nation Peak area.

Chemistry and petrography

Preliminary geochemical analysis of the Pliensbachian volcanics from the Nation Peak and Joan Lake Anticline regions defines a bimodal mafic-felsic suite. From a collection of forty-six lavas, dykes and sills only five have silica contents between 58 % and 71 %. According to the IUGS total alkalies vs. silica classification diagram (Zanettin, 1984; Fig. 3), eleven specimens are rhyolite and the remaining thirty-five define a basalt to trachyte trend. Twenty-two of the latter have silica values less than 54 %. The transitionally alkaline nature of the basalt to trachyte suite is shown by the discriminant curve of Irvine and Baragar (1971). Because K_2O and Na_2O ratios vary greatly, consistent subdivision into sodic and potassic domains is not possible. Rhyolites, on the other hand, cluster well inside the subalkaline field. Their apparent lack of association with the more basic rocks suggests that they may have, at least in part, a separate petrogenetic history.

On a tholeiitic/calc-alkaline discriminant diagram (Fig. 4; modified from Miyashiro, 1974) the samples near-

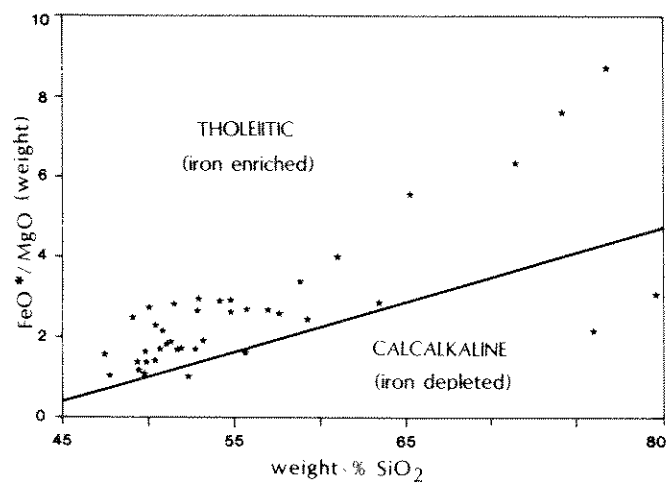

Figure 4. Tholeiitic/calc-alkaline discriminant diagram (Miyashiro, 1974). FeO* = total Fe as FeO (weight). Symbols represent Cold Fish rocks from Nation Peak area.

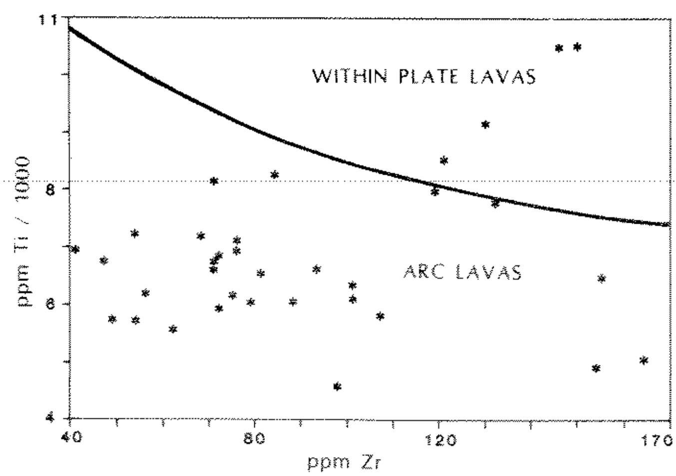

Figure 5. Ti vs. Zr diagram showing intraplate and arc fields (modified from Pearce et al., 1981). Symbols represent Cold Fish basalt-trachyte rocks from Nation Peak area.

ly all fall in the field of relative Fe enrichment. Six rhyolites having extreme enrichment are not shown. However, because the basalt-trachyte suite is marginally alkaline, it cannot be properly classified as tholeiitic and is best described as transitionally tholeiitic to alkaline. The rhyolites can be broadly classified as tholeiitic although two specimens plot on the field of Fe depletion.

The basalt-trachyte suite was further categorized on a Ti vs. Zr diagram (modified from Pearce et al., 1981; Fig. 5). Most samples plot in the arc lavas field suggesting a subduction-related origin.

The basalt-trachyte suite is characterized by a fractionating assemblage of olivine, plagioclase and clinopyroxene. Olivine is consistently pseudomorphed by serpentine (or other mafic phyllosilicates) and opaque oxides (Fig. 7). Plagioclase phenocrysts, variably saussuritized, are present as scattered grains and, less commonly, glomerocrysts. Clinopyroxene, the most stable silicate phase, is locally contact-twinned on (100). Magnetite is present as a phenocryst in some samples.

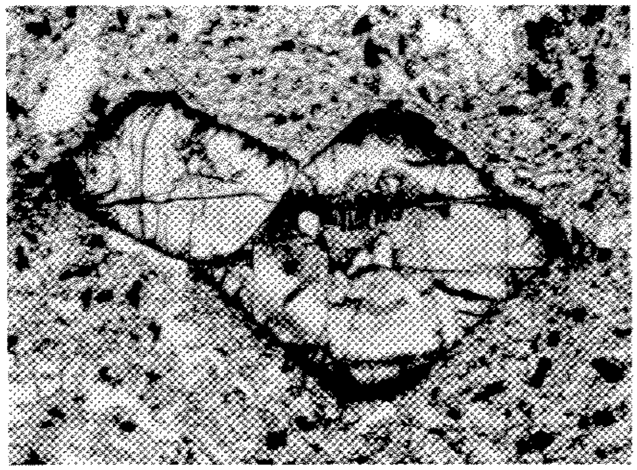

Figure 6. Serpentine-after-olivine pseudomorphs in Cold Fish basalt. Plane light; magnification = 32x.

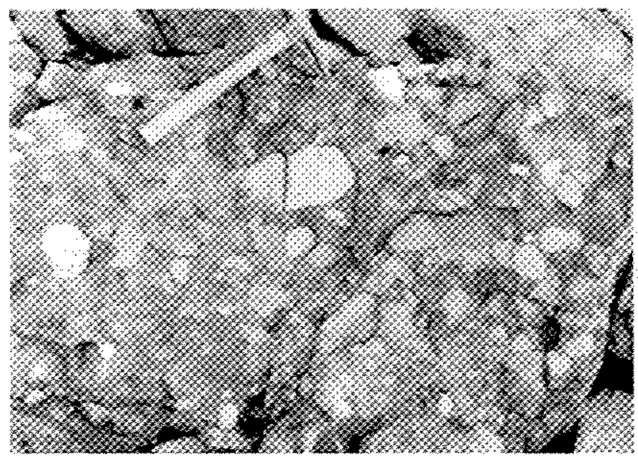

Figure 7. Chert and limestone conglomerate in (?) Upper Triassic rocks 5 km east of Spatsizi River.

UPPER TRIASSIC ROCKS

Triassic rocks near Mount Cartmel were mapped by Gabrielse and Tipper (1984) and previous workers (Fig. 1). They comprise a sequence of mafic flows, intermediate to felsic breccia, conglomerate, siltstone, sandstone, and locally, sedimentary melange. The flows are predominantly aphyric although augite porphyry, plagioclase porphyry and hornblende-plagioclase porphyry are present. In the submarine facies, which is dominant, lavas are greenish-grey and intercalated with marine sedimentary rocks. Typically, the latter are finely laminated siliceous siltstones showing ball and pillow load structures. In some places, notably 6 km north of Mount Cartmel, the siltstones host heterolithic pebbles, cobbles and boulders. There, clasts of aphyric and augite porphyry, micritic limestone and granitoids are set in a highly deformed siltstone matrix. Six kilometres north-northeast of Mount Cartmel the deposits are entirely clastic, and rhythmically bedded siltstone coarsens upward and is overlain by an olistostrome hosting carbonate cobbles and boulders, and chert granules. One limestone block exceeds 5 m in diameter. Overlying the melange is a sequence of sandstone, conglomerate and breccia.

East of Spatsizi River a section of felsic and mafic flows, airfall and ashflow tuff and various sedimentary rocks structurally overlie Toarcian strata of the Spatsizi Group. Thomson et al. (1986) interpreted that contact to be stratigraphic and considered the volcanic sequence to be of Bajocian age. Evenchick (1986) re- interpreted the contact as a thrust fault and correlated the volcanics with Pliensbachian eruptive rocks west of Spatsizi River.

The volcano-sedimentary package east of the river is herein tentatively correlated with the Stuhini and Takla groups based on striking lithologic similarities to the Upper Triassic rocks near Mount Cartmel. The most conspicuous unit east of the river is a polymictic conglomerate containing clasts of chert, limestone, and volcanic rocks in a sandy, purple matrix. The chert clasts, granule to cobble size, are red, green, light blue, white and black, and variably rounded but commonly angular. Limestone clasts, mostly pebbles to boulders, include crinoidal and micritic varieties, and are generally more dispersed than the chert fragments. On weathered surfaces they form recessive pockets among more resistant lithoclasts. Volcanic clasts include large (1 cm) augite basalt and hornblende-plagioclase porphyries. The chert-rich matrix also forms sandstone lenses and massive to cross-stratified beds within and below the conglomerate. Locally abundant cobbles of granitic rocks are present (C.A. Evenchick and H. Gabrielse, pers. comm., 1986).

Underlying the conglomeratic unit, at one locality, are interbedded breccias, sandstones and shales of probable marine origin. Above the conglomerate, are mafic, subaerial augite porphyry and aphyric flows which are overlain by rhyolite and welded ignimbrite. Aphyric and augite (4-12 mm) porphyry dykes crosscut all the units. The succession is interpreted as a nearshore marine flysch and breccia deposit conformably overlain by fluvial chert- and limestone-bearing sandstone and conglomerate, capped by mafic and felsic extrusives, and felsic explosive products of proximal subaerial volcanism. Mafic dykes attest to the probable eruption of additional basaltic lava higher in the section. The coincidence of cross-stratified red-beds and the influx of chert and limestone fragments suggests that regional uplift produced concomitant marine regression and exposure of older units which served as source material for high-energy fluvial deposits. The section hosting the melange unit, north of Mount Cartmel, shows a similar history. There, the appearance of fragmental chert and limestone also marks the end to quiescent basinal conditions and an abrupt transition to deposition of coarser material.

Basalt with large augite phenocrysts has not been identified in the Hazelton Group, including the nearby Cold Fish volcanics, but are present in Stuhini Group near Mount Cartmel and Tsaybahe Mountain, 15 km east of the confluence of the Klappan and Stikine rivers. The presence of augite porphyry clasts within the conglomerate, plus augite porphyry dykes and identical flows which intrude and overlie the conglomerate, indicate that Stuhini-type volcanism pre- and post-dated the change in environmental conditions. It is also reasonable, however, to correlate the conglomeratic unit with the polymictic conglomerate in the Sikanni facies of the Lower Jurassic Telkwa Formation. It seems possible, therefore, that either the Sikanni facies is Triassic or that Stuhini-Takla volcanism locally persisted into the Jurassic. Alternatively, the Sikanni facies could be time transgressive, with more northerly deposits recording earlier periods of uplift.

SUMMARY

Upper Triassic and Lower to Middle Jurassic volcanic rocks on Stikinia are known as the Stuhini (or Takla) and Hazelton groups respectively. They are products of two periods of arc volcanism and related basinal deposition separated by a latest Triassic to earliest Jurassic uplift. Within each group, chemical variations probably reflect physical and temporal variations in tectonic settings.

In the study area, the Pliensbachian to Toarcian Cold Fish (informal) division of the Hazelton Group comprises a zeolite-grade, bimodal, basalt-to-trachyte and rhyolite suite. Subaerial facies, typified by welded pyroclastic flows and reddened lavas, are predominant. Marine tuff and flows, interbedded with limestone and shale, are present locally. Rhyolitic facies are concentrated in the region between Mount Will and Spatsizi River. Geochemistry of flows, dykes and sills indicates that the basalt-trachyte component is transitionally tholeiitic to alkaline whereas the rhyolites, clearly subalkaline, are tholeiitic. Basic units show strong arc affinity. Fractionation was apparently dominated by olivine, plagioclase and clinopyroxene.

Upper Triassic rocks near Mount Cartmel comprise submarine and subaerial volcanic and sedimentary rocks including porphyry flows with large augite phenocrysts and chert- and limestone-bearing olistostromes. Rocks east of Spatsizi River contain clastic chert and limestone deposits similar to those in both the Cartmel rocks and the basal, Sikanni facies of the Hazelton Group. Their ambiguous stratigraphic affinity is compounded by the presence of felsic flows and tuff, typical of the Hazelton, and porphyry with large augite phenocrysts suggestive of the Stuhini and Takla groups. Spatial and temporal aspects of inferred post-Stuhini, pre-Hazelton tectonism may be clarified by determination of deposit age and clast provenance.

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