Chapter 8  

Stuhini Group

Stuhini Group strata crop out in a northwest-trending belt 0.5 to 8 kilometres wide that extends the length of the study area (Figure 8-1). The belt is continuous to at least the Tulsequah area where the strata were named by Kerr (1948) in the type area of Stuhini Creek, although much of the Tulsequah area originally mapped as Stuhini Group is now recognized to be Paleozoic in age (Mihalynuk et al., 1994a, b). To the north, strata correlative with the Stuhini Group are named the Lewes River Group (see, for example, Wheeler, 1961; Hart et al., 1989a). Early workers in the Yukon included volcanic components of the Lewes River Group with the younger “Mesozoic” Hutshi Group (Souther, 1971; Mortimer, 1986) as well as widespread upper Norian carbonate known as the Sinwa Formation (Souther, 1971). Major lateral facies variations, deposition on surfaces with considerable paleotopographic relief and later disruption by faults preclude assigning a consistent stratigraphic position for most units. Nearly identical lithologies can occur at almost any place within the Stuhini stratigraphy. As a result of its stratigraphic variability, no formation names have been proposed in this report, although some have been adopted from Hart and Radloff (1990). Units with adopted formation names can be traced in at least a discontinuous fashion through the map area from its southern limit to beyond its northern limit where they are mapped in southern Yukon (Hart and Pelletier, 1989a, b; Hart and Radloff, 1990).

Two major arc divisions are developed in the Tagish area. A poorly exposed lower, foliated division is intruded by circa 220 Ma plutons which are nonconformably overlain by upper division strata (Figure 8-2). One of the best sections through the Stuhini Group is at Willison Bay where a nearly complete, relatively undisturbed section of upper division strata is preserved. At the base of the upper division, a granitoid-rich boulder conglomerate gives way upward to pebble conglomerate rich in metamorphic fragments and finally into wackes and argillites. These rocks are succeeded by a thick succession of augite-phyric pillow basalts interlayered with fossiliferous siltstone, and overlain by phreatomagmatic breccia. Topping the succession is quartz-rich volcanic sandstone and conglomerate capped by upper Norian limestone. To a first approximation, Stuhini Group volcanic strata appear to become more felsic with decreasing age.
Basal Contacts & Lower Arc Division

Contacts between the Stuhini Group and metamorphic strata of the Boundary Ranges Metamorphic Suite are not well exposed in the map area. It is possible that parts of the Boundary Ranges suite have Stuhini Group rocks protoliths, and that the contact coincides with an isogradic or structural boundary. At one locality just north of Tutshi Lake, probable Stuhini strata appear to rest unconformably on muscovite-chlorite schists. However, no metamorphic clasts are seen above the contact, which is occupied in part by a carbonate-cemented breccia, that may indicate a fault (Mihalynuk and Rouse, 1988a). A contact between basal Stuhini conglomerate and underlying schists is described in the Tulsequah area by Souther (1971), but this relationship could not be confirmed by recent reconnaissance mapping in that area (Mihalynuk et al., 1996).

At Willison Bay, Stuhini Group strata sit nonconformably above granodiorite dated as $220 \pm 5$ Ma (K-Ar hornblende, recalculated after Bultman, 1979) and $216.6 \pm 4$ Ma (U-Pb isotopic data, Mihalynuk et al., 1997; Appendix A). Intrusion of this granodiorite marks the temporal boundary between lower and upper divisions of the Stuhini arc (Figure 8-2). Only remnants of the lower division are exposed within the map area, but better exposed relics of the lower arc succession occur where the stratigraphy is thicker both south and north of the study area (see Age, Correlation and Tectonic Significance later in this chapter).

Evidence for the lower arc division occurs in three forms: deformed screens within the circa 217 Ma intrusions; deformed strata adjacent the Llewellyn fault; and cobbles within Carnian conglomerate (also called “basal conglomerate” by Mihalynuk and Mountjoy, 1990). Screens and sheared rocks along the fault are dominated by chlorite-epidote schist with relict textures showing...
pyroxene-phyric clasts. These are probably remnants of a volcanic edifice into which the comagmatic, 217Ma plutons intruded. Clasts in the Carnian conglomerate include epidote-chlorite-altered, variegated feldspar-phyric lapilli tuff, dark brown or green pyroxene porphyry, and boulders of volcanic conglomerate as well as 217Ma intrusive phases (Photo 8-1). Second generation conglomerate clasts in particular show that parts of the Stuhini arc had been eroded and redeposited before it was eroded again to form the Carnian Conglomerate at the base of the lower division.

**Carnian Conglomerate (Povoas, uTSc)**

Conglomerate forms either discontinuous lensoid to sheet-like subunits or relatively continuous, thick sheets throughout the Stuhini stratigraphy. A sheet that commonly occurs at the base of the exposed Stuhini succession is well developed between Tagish and Atlin Lakes where it reaches thicknesses in excess of 800 metres. It has been previously mapped as a “basal conglomerate” in the Willison Bay area (Mihalynuk and Mountjoy, 1990; Mihalynuk et al., 1990), but it is probably an onlap unit that actually sits some distance above the base of the Stuhini Group, marking the base of the upper division. Similar conglomerate forms mappable units that are variably distributed throughout the Stuhini stratigraphy. The Povoas Conglomerate of southern Yukon is compositionally similar and considered correlative. Hart and Radloff (1990) concluded that it probably rests unconformably above most of the Povoas Formation (mainly augite porphyries). In the Tulsequah map area Souther (1971, p.19) describes similar Stuhini Group conglomerate resting unconformably on contorted phyllite and quartzite; there it has been called the King Salmon Formation. In the Tagish area, Bultman (1979) termed these rocks unit A of the Stuhini Group. On The Cathedral, north of Willison Bay, conglomerate that sits unconformably on potassium feldspar megacrystic granodiorite is comprised almost entirely of boulders and mineral grains derived from it. Just to the south, this contact has been disrupted by faulting.

Conglomerates occur as both clast and matrix-supported varieties. Most are massive and comprised of indistinct lensoid or sheet-like subunits, but locally bedding is well displayed. Matrix material is generally medium to coarse grained, feldspathic and lithic wacke that is dark grey to green; it may be pyritic and rusty weathering. In places massive epiclastics dominate the conglomerate unit.

With minor exceptions, clasts are well rounded and 2 to 20 centimetres, ranging up to 2 metres, in diameter. Lithologies are generally dominated by porphyritic volcanic rocks including pyroxene, hornblende and feldspar-phyric tuffs and possibly flows. Due to the generally dark green to grey matrix, light-coloured felsic intrusive clasts are most conspicuous. They run the compositional spectrum from alaskitic micropegmatite to granite to granodiorite to monzonite to diorite, and include foliated and non-foliated gabbro and hornblende. However, circa 220 Ma potassium feldspar megacrystic granodiorite and granite are most common. Metamorphic clasts are locally abundant and are widespread as a minor constituent (Photo 8-2); commonly these occur as granules.

**Willison Bay**

In the conglomerate at Willison Bay, metamorphic clasts increase in abundance upward from the base of the unit, but no systematic change in the composition of metamorphic clasts is apparent. In order of abundance, they include muscovite-biotite schist and phyllite, chlorite-muscovite schist, amphibolitic gneiss and rare marble. No evidence of aluminosilicates has been observed within the metamorphic clasts, either in hand specimen or in thin section. Sparse clasts of volcanic conglomerate (or tuff with rounded lapilli) consist mainly of variegated fine to medium-grained feldspar porphyry that is typically moderately to strongly chlorite-epidote altered, in contrast to the less altered conglomerate ma-

*Photo 8-1.* A typical outcrop of Upper Triassic Stuhini Group conglomerate. Clasts include those from the circa 217Ma Willison pluton (labelled 217), altered lapilli tuffs (volc) and recycled conglomerate (conglom). All are products of an earlier phase of Stuhini arc development.
trix. Other clast types include wacke, shale, aphanitic volcanic rocks and quartz. Bultman (1979) also noted the presence of appreciable chert clasts, but none were observed within the map area.

At the top of the Willison Bay unit is an approximately 20-metre partially covered interval that includes a pyritic sharpstone conglomerate comprised largely of silicified metamorphic clasts. Mean size is 2 to 3 centimetres within a mica-rich matrix. An overlying, disrupted, dominantly grey-green cherty wacke and argillite unit contains irregular andesitic to basaltic blocks that may be pillow breccia, layers of feldspar and sparse pyroxene-phyric volcanic material, and well bedded maroon tuff that record the onset of renewed volcanism.

**Tagish Lake to Moon Lake**

An orange to tan-weathering, clast-supported conglomerate separates Stuhini Group strata and Sinemurian Laberge Group argillites. It forms a laterally continuous belt extending from Tagish Lake to Moon Lake. Compositions vary from one entirely dominated by carbonate clasts to one dominated by intrusive and volcanic clasts and thickness varies from zero to several hundred metres. At two widely separated places, where it is not developed, there are instead dark grey, orange-weathering, scoria-rich carbonate lenses up to 10 metres thick. These lenses have been analysed for microfossils, but are apparently barren. Thus, it is not known whether this conglomerate is of Late Triassic or Early Jurassic age.

**Bennett Lake**

A conglomerate unit that straddles Bennett Lake was previously mapped as Paleozoic to Triassic in age (Mihalynuk and Rouse, 1988b) but is now known to be at least as young as Late Triassic. This unit sits above foliated Late Triassic granodiorite and contains abundant clasts of both granodiorite, and highly stretched quartz-rich metasediments (Photo 8-3). Locally it is foliated.

**Pyroxene-phyric Basalt & Sediments (uTSp)**

Coarse pyroxene-phyric basalt is a characteristic lithology of the Stuhini Group. These basalts commonly display evidence of subaqueous eruption and may be well pillowed, such as at Willison Bay. Elsewhere they may comprise massive flows with interflow marine sediments, as both southeast of Racine Lake and at Willison Bay. In the Willison Bay area, grey to black and green-mottled, resistant, massive and pillowed flows of basaltic composition rest with apparent conformity on conglomerates and associated sediments. They typically contain variable proportions of medium grained, subhedral to euhedral pyroxene and feldspar (up to 20% each) and fine grained plagioclase in an altered glass matrix (Photo 8-4). Flow and pillow interiors are vesicular. Individual flows are typically 2 to 5 metres thick, but may be in excess of 20 metres. Pillows are normally from 0.3 to 2 metres in diameter. Locally, the basalts are cut by gabbroic dikes.

Photo 8-2. Stuhini Group conglomerate rich in metamorphic clasts like the Wann River gneiss (W) as well as circa 217 Ma Late Triassic granodiorite (217), limestone (L), hornblende and pyroxene-phyric volcanics (H, P) in a medium to coarse-grained volcanic matrix (6 inch ruler for scale).
Interlayers of siltstone and siliceous argillite mark periods of brief, local volcanic quiescence. These weather rusty, are normally less than 3 metres thick and drape over irregular pillowed flow tops. Compared to the over and underlying basalts, they are recessive, although they are compact and hard, with a subconchoidal fracture. Fine parallel beds are characteristic, but rare ripple cross stratification has been observed. These sediments are rich in bivalves, particularly *Halobia* of Carnian to Norian age. Contacts between sedimentary layers and the overlying basalts are irregular as a result of scouring and uneven loading by successive flows. Norian conodonts were recovered from interpillow micrite (Appendix B). Pillow morphologies and structures in sedimentary interlayers indicate a right-way-up stratigraphy.

Coarse augite-phyric breccia and flows are common between Brownlee and Racine lakes. Due to the proximity of the Llewellyn fault, they are typically foliated. Where exposure is good, they are interlayered with wackes and other fine-grained sediments. In places they are juxtaposed with conglomerates, but contacts have not been observed and this could be due to structural interleaving.

Possible subaerial equivalents of the pyroxene-phyric flows, breccia and tuff occur in the Fantail Lake area where they are well exposed just east of the Llewellyn fault on the ridges south of Brownlee Lake. In other locations, as south of Moon Lake, voluminous piles of coarse, black breccia were deposited.

Subaerial deposits between Fantail and Brownlee Lakes exceed 300 metres in thickness. Breccias are resistant, rounded to blocky weathering, dark green and monolithic, composed dominantly (50 to 80%) of blocks and bombs(?). Idiomorphic pyroxene phenocrysts (20 to 40%, up to 1.5 cm diameter) are conspicuous in both clasts and matrix (Photo 8-4). Plagioclase occurs as subhedral phenocrysts of lesser, but variable abundance and size. Matrix and phenocryst alteration includes chlorite and lesser epidote. Near Moon Lake, bright maroon, well bedded pyroxene crystal tuffs are believed to be of subaerial origin.

A change from subaqueous to subaerial or at least to shallow subaqueous environments is indicated in the Willison Bay section by incompetent coarse breccias abruptly overlying pillow basalts. These breccias are thought to be phreatomagmatic in origin.

---

**Photo 8-3.** Photomicrograph of possible Late Triassic conglomerate atop Late Triassic granodiorite. Highly strained quartz-rich clasts are predominant, but no nearby source of the clasts has been recognized. Length of photo represents 2.5mm of sample.

**Photo 8-4.** Photomicrograph of typical pyroxene-phyric basalt of the lower Stuhini Group. Long dimension of photo represents 2.5mm of sample.
Phreatomagmatic Breccia (uTSpb)

Phreatomagmatic breccias are recognized only at the south end of Atlin Lake (including Willison Bay) where Bultman (1979) mapped them as ‘Unit C’. These breccias contain conspicuous, poorly lithified, dark brown to black, monolithologic blocks in a dusty green to tan, crystal-rich matrix. Both clast and matrix-supported varieties occur. Breccia fragments are angular, vesicular and rich in coarse pyroxene and serpentinized olivine (Photo 8-6). They range in size up to 50 centimetres, but are normally less than 20 centimetres in diameter. Matrix material is a crystal-lithic tuff of the same overall composition as the blocks. Strain has been preferentially partitioned into this unit due to its incompetence. It is cut by abundant quartz and carbonate-coated fractures generally having offsets of only a few centimetres.

Compositional similarity to underlying effusive pillow basalts can be seen by a comparison of their oxide geochemistry (see Age, correlation and tectonic significance below). Changes from dominantly effusive to pyroclastic volcanism may reflect a shift to a more hydrous magma, or alternatively, could result from a decrease in the depth of subaqueous eruption and reduced confining pressure that led to violent, steam-generated explosive eruptions. This sequence of events could result if the rocks were part of an emergent volcanic pile that was built up to within about 300 metres of the water surface, where abundant generation of steam is possible (Tanakadote, 1935). Overlying cross-stratified epiclastics and coralline boundstones (Photo 8-5) support the interpretation of an up-section transition to shallower water conditions.

Heterolithic Lapilli Tuffs (uTSv)

Dark green to grey or maroon heterolithic lapilli tuff is a common lithology, occurring at several horizons within the Stuhini Group. Angular, scoriaceous fragments to rounded volcaniclasts comprise 20 to 80% of the rock. Fragments are aphanitic or feldspar, pyroxene and hornblende porphyritic (crystals less than 3 mm). Alteration of the unit is locally intense producing epidote-chlorite clots that mantle phenocrysts. Some fragments have trachytically aligned plagioclase phenocrysts and microlites.

Limestone Boulder Conglomerate (uTSl)

This conglomerate is orange to yellow weathering, clast supported and varies from a conglomerate comprised exclusively of limestone boulders to one with a large proportion of intrusive and volcanic clasts. Clasts other than limestone increase in abundance to the east. The conglomerate may be several hundred metres thick and is persistent laterally. In places, however, it is not developed. For example, at Kirtland its stratigraphic position is occupied by a dark grey, orange-weathering, foliated carbonate with scoria-rich layers (less than 10 m thick) that is overlain by epiclastics. The lithologies and succession at Kirtland are identical to a section on the ridges southwest of Moon Lake. It is not known if this conglomerate is Upper Triassic or Lower Jurassic as it separates strata of definite Upper Triassic Stuhini Group affiliation and Pliensbachian argillites of the Laberge Group.

Epiclastic Strata (uTSvc)

Accumulations of epiclastic strata are common within the Stuhini Group. Units vary in thickness and clastic character from thin beds between individual cool-
Coarse, quartz-bearing, dominantly volcanic sandstones crop out between the basalt flow/breccia unit and the Upper Norian Sinwa (?) carbonate in the Willison Bay area. This unit is discontinuous and varies greatly in thickness, it apparently ranges up to 800 metres. Lensoid beds of this type are also common within and above the Carnian (basal) conglomerate unit and locally are continuous enough to constitute mapable units (see Figure GM97-1: The Cathedral area).

Clasts, commonly up to cobble size and less often to boulder size, are dominantly porphyries of various types. Phenocryst assemblages are: plagioclase (subhedral, less than 5 mm, 60%) and hornblende (10%) in a light mauve to pink groundmass; plagioclase, quartz and biotite; plagioclase, sanidine and quartz; fine-grained plagioclase and pyroxene. Compositions include dacite, latite, andesite and basalt; intrusive clasts range from granite to diorite. The volcanic clasts typically contain authigenic chlorite and epidote.

Epiclastics appear massive where poorly exposed, but on clean exposures they display planar bedding, grading and large scale, low-angle (2 to 5 m) trough cross stratification. Irregular distribution of the epiclastic strata probably results from their deposition in small disconnected basins in a topographically variable volcanic terrain.

One of the best exposures of this rock type is a distinctive maroon epiclastic to coarsely conglomeratic unit just below the Sinwa limestone on southern Copper Island. It appears to be a mixture of stratigraphically higher and lower units: it contains blocks of a distinctive underlying phreatomagmatic unit and of an overlying fossiliferous carbonate (Photo 8-5). These outcrops probably represent debris flows deposited in front of a migrating Sinwa Formation reef front. Abundant quartz and quartz-feldspar-phycite dacite clasts in the unit are believed to be derived from the youngest of the Stuhini Group volcanic rocks. These rocks are included with the volcaniclastic unit on Figure GM97-1.

Epiclastic strata can be grossly subdivided into two main types: those dominated by quartz-bearing coarse volcanic sandstone, and those of more variable grain size including wackes to conglomerates that are commonly rich in hornblende. Both are diachronous.
Argillite (uTSa)

Argillite or silty argillite occurs at several localities within the Stuhini Group. It is interbedded with siltstone as intraflow sediments within the “pyroxene-phyric basalt” unit with which it is included; it dominates the matrix of wackes, and is included with “epiclastic strata”. It also occurs above the Carnian conglomerate unit and adjacent to carbonate of possible Sinwa Formation. It is most widespread adjacent to the carbonate and forms a more or less continuous and correlatable unit. Locally, it is exposed both above and below the carbonate unit, and in both cases, is well laminated to irregularly bedded and dark brown to black. It can be pyritic, but this is not necessarily characteristic.

Argillite is perhaps best exposed near Brownlee Lake where it is deformed within the Llewellyn fault zone. Massive argillites are maroon, green and brown, and weather into angular gravel-sized fragments. These rocks are easily mistaken for aphanitic intrusives except that in rare instances weathered surfaces preserve original sedimentary layering. Immediately adjacent to the fault these rocks are transformed into chlorite schist which may be tectonically mixed with fault material derived from other lithologies. These argillites grade “upwards” (tops uncertain) and eastwards into clastic rocks of volcanic provenance. Volcanic sandstones and wackes are brown to grey, recessive weathering, calcareous, fissile and common throughout the Stuhini stratigraphy. On the ridges northwest of Brownlee Lake wackes sit “above” (east of) the augite porphyries, but south of Brownlee Lake the opposite relationship is observed. Foliation of this unit generally increases towards the Llewellyn fault with 1 to 2 metre wide zones of high strain up to several hundred metres away from the main fault trace.

Argillite is not exposed on the shores of Willison Bay adjacent to the carbonate unit, but on the ridges to the north, an argillite tens of metres thick crops out above(?) coarse-grained epiclastic strata that enclose lenses of carbonate. At eastern Tutshi Lake, argillite below the carbonate unit becomes increasingly calcareous on approaching the carbonate. Above the carbonate, argillite is locally in apparent stratigraphic contact, but where it is missing, its position is occupied by wacke or carbonate-clast-rich conglomerate.

Argillite deposition was appears to have been more-or-less continuous, but thick argillite accumulations only occur where more rapid sedimentation of coarse clastics or volcanic strata did not overwhelm the fine clastic component.

Carbonate (Sinwa Formation?, uTSs)

A poorly bedded and generally fossil-poor carbonate consistently marks the contact between rocks of the Upper Triassic Stuhini and Lower Jurassic Laberge groups. It can be traced at this stratigraphic interval for over 320 kilometres from the Tulesequah area (see Chapter 13, Photos 13-12, 13) to near Whitehorse. This unit resembles, but may not correlate with carbonate layers that immediately underlie fine-grained, Lower Jurassic clastic strata of the Inklin Formation. Between the Tulesequah and Cry Lake map areas, however, these carbonate units are together carried in the hangingwall of the King salmon thrust over coarse-grained strata of the Lower Jurassic Takwahoni Formation (Thorstad and Gabrielse, 1986). In the Tagish area, Bultman (1979) mapped these carbonates as Upper Triassic Sinwa Formation based upon lithologic similarity and along strike continuity with rocks mapped at the type locality in the Tulesequah map area (Souther, 1971). Northern parts of the belt are directly correlative with the “Hancock Member” which attains thicknesses of 600 metres in southern Yukon (Hart and Radloff, 1990).

Samples collected for microfossil analysis yield a latest Norian conodont fauna (M.J. Orchard, written communication 1988, 1989, 1990, 1991, Table AB2), but only at localities sampled north of the Tulesequah map area (104K). Samples collected from between Racine Lake and southern Atlin Lake stand a greater chance of being devoid of conodonts as one progresses southward. This is particularly intriguing since carbonates at southern Atlin Lake (Willison Bay) preserve good bedding, a rarity in the carbonate belt, so the lack of conodonts cannot be attributed to recrystallization or deformation. Furthermore, sparse interpillow micrites from lower in the section yield Carnian conodonts (C-153954). Macrofossils obtained from the Sinwa Formation in the eastern Tulesequah map area(104K) confirm a Late Triassic age; however, rarely do these samples yield conodonts (H.W. Tipper personal communication, 1991). Perhaps the southern part of the Sinwa carbonate was deposited in an environment in which the conodont animal did not thrive. Alternatively, perhaps the southern and northern carbonate belts are not correlative.

Age, Correlation and Tectonic Significance

Christie (1957) recognized that much of the Stuhini Group in the Bennett Lake map area (104M) is Triassic. However, correlative rocks to the immediate east, in southwestern Atlin (104N) map area, were originally thought to be Pennsylvanian and/or Permian in age, based upon identification of fossil corals and bryozoa from a ferruginous limestone bed (Harker in Aitken, 1959). Re-
evaluation of the poorly preserved fossils indicated a probable Upper Triassic age (Harker and Tozer in Souther, 1971, p. 23). Within the southern study area, at Second Narrows, a presumably correlative ferruginous limestone bed is intercalated with volcanioclastic strata and pyroclastic rocks of the Stuhini Group. A colonial coral fauna collected from this locality in 1989 was of indeterminate age (C-153948 - Table AB1; Photo 8-5) although Late Triassic conodonts are reported (M. Orchard, written communication, 1999).

To the south, in the Tulesequah area the Stuhini Group sits unconformably on deformed, poorly dated rocks thought to be mainly Lower and Middle Triassic (104K; Souther, 1971). Fossils obtained from the Stuhini succession there include the finely ribbed bivalve Halobia, of Carnian age, and the Norian bivalves Monotis and Halorites (Souther, 1971, p. 22).

New fossil ages from Stuhini Group strata of the Tagish area reported here are entirely Carnian and Norian. New isotopic data from plagioclase that are presumably comagmatic with the arc volcanics also confirm a Late Triassic age, but in detail somewhat contradict the fossil ages (cf. Mihalynuk et al., 1997). In the most complete Stuhini section, exposed at Willison Bay, strata dip consistently to the east away from the Willison Bay granodiorite, which is nonconformably overlain by conglomerate ('basal conglomerate' of Mihalynuk and Mountjoy, 1990) in which clasts of the granodiorite figure prominently. The Willison Bay pluton is dated at 220 ±5 Ma and 216.6 ±4 Ma (recalculated K-Ar, hornblende, Bultman, 1979; U-Pb, zircon, Table AA5). The overlying conglomerate fines upward and then gives way to siltstone and basalt. Halobia from siltstone interbedded with the basalt (C-153962) and conodonts extracted from interpillow micrite within unit uTSp suggest that the unit is Carnian (C-153954; Appendix B), that is, between 235±4 and 223.4±9.5 Ma according to the time scale of Harland et al. (1990); significantly older than the absolute age of the underlying pluton. Assuming that the age data are reliable, an apparent older-younger relationship exists. Four explanations are possible: incorrect fossil identifications, thrust fault duplication, recumbent isoclinal folding, or a poorly constrained time scale.

The fossils are well preserved and identifications are confident; fossils are not a likely cause. No candidate thrust fault or recumbent fold can be identified in the Willison Bay area. Depositional “way up” indicators are common within the section and none indicate overturned strata on the scale of a large recumbent fold. Similarly, fossil age control and gradational contacts do not support thrust-related older-younger relationships. Small-scale isoclinal folding of argillite along southeast Willison Bay and a partly foliated and partly covered interval along strike northwest of the bay, were originally thought to mark the locus of a significant thrust fault that placed older Stuhini strata over younger, possibly post-Stuhini conglomerate. Even though some motion was undoubtedly accommodated along this disrupted zone, four lines of evidence support an older not younger relative age for the conglomerate. First, the upper parts of the conglomerate grade into wackes with a pyroxene crystal component that increases towards the overlying pyroxene-phryic flows. Second, maroon tuffaceous layers also become increasingly common until pillowed flow units are encountered. Third and most importantly, interflow turbiditic siltstones containing Carnian Halobia, also contain rare clasts identical to the Willison Bay granodiorite, indicating a gradational upward-younging transition from conglomerate to Carnian flows. Fourth, conglomerate units indistinguishable from the ‘basal’ conglomerate occur on the ridges between Nelson and Edgar lakes where they are locally intercalated with primary volcanioclastic strata. Thus, in places they are the same age as some Stuhini volcanic units.

Further, regional-scale intrusive relationships do not support thrust or structural overturning or duplication. Just south of the map area, dikes resembling the 217 Ma granodiorite intrude volcanic strata of the Stuhini Group and along its southwest side the Willison Bay granodiorite “... intrudes metamorphic rocks... along an irregular contact along which large fingers of granodiorite extend into the metamorphic rocks” (Bultman, 1979, p. 26). These “metamorphic” rocks were mapped by Werner (1978) as Stuhini Group, an observation confirmed by later reconnaissance mapping in the Hoboe Creek area (Photos 4-2). Locally, Stuhini pillow basalt and tuff are strongly foliated and easily mistaken for the Boundary Ranges metamorphic rocks, except that relict textures are widespread. Thus, it appears that the Willison Bay granodiorite as a whole is intrusive into the mainly basaltic lower portions of the Stuhini Group and neither it nor nonconformably overlying strata have been translated with respect to the lower the Stuhini stratigraphy. Rather, the lower parts of the Stuhini Group were intruded by the 217 Ma granodiorite, and then uplifted and eroded to provide clasts for conglomerate higher in the sequence. This conglomerate was deposited on an erosional surface with high relief, consequently the ‘basal’ conglomerate marks the base of the younger of two Stuhini arc-building episodes. If field and isotopic relationships are correct, then the absolute age limits of Late Triassic stages as shown in Harland et al. (1990) are in need of adjustment. In particular, the Carnian must be as young as 216.6 ±4Ma (221 +0/-8Ma; see Mihalynuk et al., 1997 for a more detailed discussion).

Geochemistry

Basaltic units within the Stuhini Group are atypical relative to most basalts of the alkaline, tholeiitic or calc-alkaline suites. With the exception of one sample that plots in the dacite field, the others plot as basalt on the alkalis-silica plot of Figure 8-3a (the “dacite” is a sample of
Figure 8-3. Geochemistry of the Stuhini Group: (a) alkalis versus silica classification diagram shows a dominantly basaltic composition with one dacite (fields of Cox et al., 1979); (b) Zr/TiO₂*0.0001-Nb/Y plot of Winchester and Floyd (1977) shows that the samples are subalkaline basalts. This is echoed by the Zr/TiO₂-SiO₂ plot (not shown). (c) alkali-silica and (d) AFM diagrams of Irvine and Barager (1971) show that the samples are subalkaline and of mixed tholeiitic and calcalkalic series. (e) K₂O-SiO₂ plot shows that most samples belong to the shoshonitic series (field divisions of Ewart, 1982); typical basalts contain less than 1 wt% K₂O at 50 wt% SiO₂.
Figure 8-4. Geochemistry of Stuhini Group basalt: (a) Ti-Zr plot of Pearce and Cann (1973) is an ineffective discriminant; (b) the Zr-Y discrimination plot following the method of Pearce and Norry (1979) shows that the samples plot as island arc basalts; (c) the trivariate plot of Ti/100-Zr-Y*3 follows the method of Pearce and Cann (1973), and like (a) is an ineffective discriminant; (d, e) plots of Nb*2-Zr/4-Y and Hf/3-Th-Nb/16 following the method of Meschede (1986) and Wood (1980) both indicate that the basalts were formed at a destructive plate margin, consistent with (b).
The Stuhini arc

Stuhini Group strata record a dynamic environment most simply interpreted as two major arc-building (arc inflation) episodes. Each constructional episode was followed by a period of transgression and widespread erosion. These episodes are most readily observed in the Tagish area, but details of the complex interplay of arc facies locally obscures this two-phase development. However, generalized stratigraphic sections from the Tulsequah (Souther, 1971) and Whitehorse (Wheeler, 1961; Hart and Pelletier, 1989a) areas are consistent with a two-phase arc evolution as illustrated in Figure 8-2. In each area the volcanic arc axis appears to lie west of sediment-dominated arc facies.

The early arc constructional phase is poorly characterized. Exposure is limited and regionally strata dip east and the deepest and oldest Stuhini strata farthest west, adjacent to the Llewellyn fault, have been subjected to ductile deformation. In some localities these strata may include pre-Stuhini rocks, although the section is dominated by medium to coarsely pyroxene-phric basalt breccias and variegated, fine to medium feldspar-phric
lapilli tuffs of Stuhini aspect. Small areas on the south end of Willison Bay may be underlain by these rocks where they are intruded by leucogabbro associated with the Willison Bay pluton. Similar foliated heterolithic and augite-phryic tuff between Skelly and Racine lakes may also be correlatives. Early arc inflation culminated at about the same time as when the Willison Bay pluton was intruded. Dissection of the arc exposed the pluton and resulted in deposition of a thick conglomerate blanket under submarine conditions. Further subsidence is recorded by a gross fining-upward of sediments and deposition of quartzose turbidites that contain Halobia of Carnian age. Effusive volcanism produced voluminous pyroxene-phryic pillow basalt that overwhelmed sedimentary clastic input. Carbonate deposition was sporadic as indicated by sparse interpillow micrite.

A second phase of arc inflation and accumulation of pillow basalts led to shallow water conditions that resulted in widespread phreatomagmatic eruptive activity. Subsequent volcanic strata are dominantly subaerial or littoral, and andesitic to dacitic. Quartz-phryic units occur at the highest stratigraphic levels. Deposition of thick epiclastic units followed cessation of volcanism and a return to subaqueous conditions in Norian time. Clasts and olistoliths of carbonate within the epiclastic strata indicate the establishment of carbonate sedimentation and formation of unstable carbonate banks. Ultimately these banks built up to form the succeeding “Sinwa” Formation. In places carbonate deposition was in relatively restricted lagoons or forearc sub-basins; elsewhere high energy, possibly storm-generated carbonate talus and conglomerate are typical. In both situations, the depositional environment appears to have been a relatively hostile one in which few organisms, including conodonts, flourished.

Mineral Potential

In many parts of British Columbia the Late Triassic epoch is an important time for copper mineralization. In the Tagish area, mineralization of this age is limited to small basaltic copper occurrences west of Edgar Lake and on southern Copper Island. Upper Triassic strata do however host several mineral occurrences, and in some cases may have provided fertile source rocks for later mineralizing events. Copper-gold skarn mineralization in northeast Tutshi Lake map area, for example, is hosted by Upper Triassic carbonate and conglomerate. Similar mineralization occurs in correlatives hostrocks in the Whitehorse copper belt to the north.

Why the Upper Triassic rocks tend to be enriched in copper is uncertain. One reason may be related to high pyroxene contents that characterize the Stuhini Group (as well as coeval volcanics of the Takla and Nicola groups). Careful investigation of similar rocks in the Solomon Islands (Stanton, 1991) shows that copper is partitioned into the melt as olivine and pyroxene crystallize until whole-rock silica reaches about 52%, after which copper is lost through devolatilization. Thus, residual basaltic andesite or quartz dioritic magmas should be copper enriched. Unfortunately, no isolated quartz diorite stocks of Late Triassic age have been recognized in the map area.

Occurrences in rocks of probable but unconfirmed Late Triassic age include a foliated, carbonate-hosted silver-lead-zinc-copper-gold prospect near Moon Lake (Chapter 16) and polymetallic veins along the Llewellyn fault (Brown, Chapter 16). Both showings are likely related to Cretaceous movement on the Llewellyn fault zone.

Bedding parallel and high angle faulting localized at the contact between Norian carbonate and calcareous siltstone of the Laberge Group may have provided an environment suitable for the formation of Carlin-type mineralization (“carbonate-hosted disseminated Au-Ag” in Lefebure and Höy, 1996). However, existence of radiogenic basement rocks appears to be an important metallogenic ingredient in the Carlin trend as it parallels the 0.706 initial strontium isopleth. The Norian carbonate roughly parallels the Mesozoic and Cenozoic 0.705 isopleth (Armstrong, 1988), indicating that the basement rocks are slightly less radiogenic than those of the Carlin trend.