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Geology of Ealue Lake east-half (104H/13E) and Cullivan Creek (104H/14) map areas, British Columbia

P.B. Read and J.F. Psutka

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GEOLOGY OF

EALUE LAKE EAST-HALF (104H/13E) AND CULLIVAN CREEK (104H/14) MAP AREAS, BRITISH COLUMBIA

(notes)

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GEOLOGY OF EALUE LAKE EAST-HALF (104H/13E) AND CULLIVAN CREEK (104H/14) MAP AREAS, BRITISH COLUMBIA

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The mapped area straddles the Stikine River from its confluence with Klappan River in the west to its junction with Cullivan Creek in the east. Although the area is accessible by boat along the Stikine, Klappan and McBride rivers and by road along parts of the old British Columbia Railway grading beside the Klappan River, only a helicopter provides easy access to the remainder. The map area was included in the regional mapping of the Stikine Project (Officers of the Geological Survey of Canada 1957), followed by that of Eisbacher (1974) who concentrated on the Sustut Group which underlies the eastern side of the area, and then covered by Gabrielse and Tipper (1984). Since then, Evenchick (1986, 1987, 1988, 1989) and others (Evenchick and Green, 1990; Cookenboo and Bustin, 1990; Ricketts, 1990) have remapped the Spatsizi sheet outside of this area.

The map area lies on the northern edge of the Middle Jurassic to Lower Cretaceous Bower Basin, crosses the Lower to Upper Cretaceous Sustut Basin, and includes part of the southern flank of the Stikine Arch. Underlying the northern edge of the Bowser Basin are Lower Jurassic to Carboniferous and possibly older sequences of volcanic and minor sedimentary rocks. This basement consists of strongly deformed Paleozoic limestone, phyllite, greenstone and marginally foliated plutons unconformably overlain by augite porphyry basalt of the Middle Triassic "Tsaybahe Group". A thick sequence of green, maroon and grey volcanic and minor sedimentary rocks of Early Jurassic age either disconformably overlie a thin section of Upper Triassic sediments belonging to the Stuhini Group, or lie unconformably on Carboniferous and(?) older rocks. Widespread conglomerate of the Bowser Lake Group unconformably overlies Triassic and/or Jurassic volcanic rocks. The gently deformed Lower and Upper Cretaceous Sustut Group unconformably lies on a folded and faulted basement of Carboniferous and(?) older to Triassic and/or Jurassic strata.

During parts of the summers from 1981 to 1984, R.L. Brown, L.S. Lane, J.M. Moore, J.F. Psutka, and P.B. Read geologically mapped the area. The following officers of the Geological Survey of Canada, M.J. Orchard (initials MJO, Table 1), T.P. Poulton (TPP), A.R. Sweet (ARS), H.W. Tipper (HWT) and E.T. Tozer (ETT) made the fossil determinations summarized in Table 1. The geological mapping was funded by B.C. Hydro in 1981 and 1982 and by the Geological Survey of Canada in 1983 and 1984. H.W. Tipper, C. Evenchick and H. Gabrielse contributed their paleontological and stratigraphic expertise.

STRATIGRAPHY

(a) Unnamed Carboniferous and(?) older units (**Pv**, **Pc**, and **Pp**):

Carboniferous and(?) older rocks lie on both sides of Pitman Fault and span the map area along the south side of Stikine River valley. All Paleozoic rocks are phyllitic and so strongly deformed that the facing and stratigraphic order of the units are unknown. Medium to dark green, mainly aphanitic, but locally porphyritic (plagioclase or augite) volcanic rocks (**Pv**) dominate. The north slopes of Tsaybahe Mountain, west of the map area, expose a few hundred metres of grey to white limestone **Pc** of Carboniferous to Permian age (**F122** (Read, 1984)). In the map area, thin limestone lenses occur locally but none is fossiliferous. Light green phyllite, probably developed from tuff, some chert, and rare limestone of unit **Pp** are faulted against the north side of Railway pluton, and outcrop farther east as lenses within unit **Pv**. All Paleozoic rocks show polyphase, noncoaxial folding which distinguishes them from the Mesozoic units.

(b) "Tsaybahe Group" (**mTRp, mTRva, mTRs,** and **TRva**):

The lowest two units of the "Tsaybahe Group" underlie an area west of the confluence of the Klappan and Stikine rivers. Up to a few hundred metres of light green or grey-green siliceous phyllite, phyllite and grey argillite comprise unit **mTRp** which contains fossils of Middle Triassic age (**F124**, (Read, 1984)) immediately west of the map area. Overlying coarse augite (5 mm) porphyry meta-andesite and meta-basalt flows and pyroclastic rocks of unit **mTRva** extend southward to the Pitman Fault.

South of McEwan Creek fault and west of Klappan River, unfossiliferous rocks of units **TRva** and **mTRs** are of uncertain stratigraphic correlation. Immediately west of the map area along the southeast shore of Ealue Lake and within the sheet underlying hills 3976' and 4409' west of Klappan River are augite (1-4 mm) porphyry flows, breccia and tuff. Although Gabrielse and Tipper (1984) designated these rocks as part of the Lower and Middle Jurassic Toodoggone Volcanics, augite porphyry volcanic rocks are more likely Triassic. Based on the presence of ubiquitous augite and the wacke-rich composition of the underlying sedimentary rocks, the volcanic rocks are tentatively correlated with the "Upper Volcanic Unit" **TRva** of the "Tsaybahe Group" rather than the Stuhini Group, which consists of either sedimentary rocks only or mixed sedimentary rocks and aphanitic andesite within the map area. Underlying the augite porphyry volcanic rocks are green tuffaceous wacke, grey siltstone and argillite, and very rare unfossiliferous limestone. The presence of significant amounts of wacke and the absence of siliceous phyllite and chert favour a correlation of these rocks with the "Middle Sedimentary Unit" **mTRs** rather than the "Basal Sedimentary Unit" of the "Tsaybahe Group".

(c) Stuhini Group (units **uTRcg, uTRc, uTRgv, uTRs,** and **uTRw**):

Upper Triassic rocks in the map area are correlated with the Stuhini Group as defined by Souther (1971, p. 19) to include all the Upper Triassic volcanic and sedimentary rocks that lie above the mid-Triassic unconformity and below the Sinwa Limestone. Because the Sinwa Limestone is absent along this part of the southern flank of Stikine Arch, the upper limit is placed at the top of fossiliferous Upper Triassic rocks. The Stuhini Group outcrops in two areas east of the Klappan River. North of McEwan Creek, approximately 100 m of granitic pebble to cobble conglomerate (**uTRcg**) with thin fossiliferous limestone lenses (**uTRc**) of Late Triassic, Early to Middle Norian age (**F128**, Table 1) nonconformably cap part of the southeastern edge of Railway pluton of Late Triassic age. South of McEwan Creek, McEwan Creek fault forms the northern boundary of an area of Upper Triassic rocks extending 11 km northwesterly from Cartmel Mountain. Within the map area, Upper Triassic rocks form two 2500 to 3000 m thick panels of intercalated volcanic and tuffaceous sedimentary rocks which face northeasterly. In the panels, the green andesite (**uTRgv**) is mainly aphanitic breccia, tuff and flows with finely porphyritic (plagioclase, ±augite) variants. A distinctive breccia horizon contains white Lower Permian limestone clasts (**F161'**) ranging from a few centimetres to 30 metres on edge. The fossiliferous sedimentary rocks are divided into a tuffaceous argillite- and siltstone-rich unit **uTRs** (**F167**) and a wacke-rich unit **uTRw** with a basal breccia and conglomerate (**F155, F160** and **F162**). In distinction to the common grey and maroon shades of Lower Jurassic rocks, Upper Triassic strata of the map area are dominantly olive to grey-green. In contrast to the coarse augite-bearing volcanic rocks and minor sedimentary component of the "Tsaybahe Group", the volcanic rocks of the Stuhini Group are aphanitic to sparsely porphyritic and accompanied by a significant volume of sedimentary rocks.

(d) Lower Jurassic Volcanic and Sedimentary Rocks: (units **lJbv, lJbs, lJbcg, lJbc, lJg, lJc, lJbvr, lJrv, lJvr, lJrs, lJgv, lJgs,** and **lJgc**)

In the map area, dated Lower Jurassic strata consist of more than 4000 m of volcanic rocks with a sedimentary sequence containing up to 600 m of tuffaceous

sediments at or near the base. Although the mainly coarse tuffaceous sediments of the map area are unlike the dominantly grey shale and siltstone in the type area of the Spatsizi Group, Thomson et al. (1986) included the basal tuffaceous sediments of the map area in the Spatsizi Group. This usage has been retained. In spite of Thorkelson (1988, p. 46) noting that the Lower Jurassic (Toarcian) volcanic rocks of the map area are indistinguishable from the "Cold Fish Volcanics" of Pliensbachian age that lie southeast of the map area, the Toarcian and(?) younger volcanics and intercalated sediments **overlying** the Spatsizi Group are informally named the "Brock Volcanics" to distinguish them from the "Cold Fish Volcanics" which **underlie** the Spatsizi Group. The Middle Jurassic (Bajocian) porphyritic volcanics and associated sediments (**mJcg, mJs, mJgv,** and **mJvp**) near Mount Sister Mary are excluded.

(d.1) "Cold Fish Volcanics" (unit **lJbv**)

On both sides of Klappan valley between McEwan Creek and the Stikine River, 500 to 600 m of sparsely porphyritic (plagioclase), green and maroon flows, breccia and tuffs (**lJbv**) underlie sedimentary rocks of the Spatsizi Group. Although similar volcanic rocks extend up to 10 km west of the map area, they are locally absent beneath the Spatsizi Group such as on the east side of Railway Pluton. South of the map area, the "Cold Fish Volcanics" thicken and extend for 50 km southeasterly.

(d.2) Spatsizi Group (units **lJbs, lJbcg, lJbvr,** and **lJbc**)

The thickest sedimentary succession, up to 600 m thick, outcrops near Klappan River valley and, on the basis of sparse exposures, it may extend southwest of the map area to join the thin sequence immediately underlying the Bowser Lake Group (Evenchick and Green, 1990). On the east side of the valley, the sediments of **lJbs** are grey-green, locally maroon, tuffaceous wacke, siltstone and shale interbedded with intermediate volcanic breccias and rhyolite flows and tephra of unit **lJbvr.** Smith et al., (1984) have described the most fossiliferous section near **F138** where latest Pliensbachian (H.W. Tipper, pers, comm., 1989) and Early Toarcian sediments (**F131**) overlie a thin unfossiliferous basal conglomerate (**lJbcg**) that nonconformably rests on Railway pluton. The sedimentary succession continues for 3 km west of the map area where unit **lJbs** contains several beds, each up to 20 m thick, of chert pebble conglomerate (**lJbcg**) and light grey and maroon limestone (**lJbc**).

(d.3) "Brock Volcanics" (units **lJg, lJc, lJbvr, lJrv, lJvr, lJrs, lJgv, lJgs,** and **lJgc**)

The "Brock Volcanics" lie south and southwest of Cullivan fault from west of Cullivan Creek to at least 50 km west of the map area. This dominantly Toarcian volcanic assemblage is characterized by sparsely porphyritic (plagioclase) volcanic rocks in maroon, green and grey hues, local rhyolite flows and tephra, and rhyolite or rhyodacite sills. Thin tuffaceous sedimentary lenses develop here and there. The unit is informally named after Mount Brock, which along with Tsenaglode Mountain, yield the most complete exposure section.

The bulk of the "Brock Volcanics" are sparsely porphyritic (plagioclase) volcanic rocks that are mostly green (units **lJg** and **lJgv**) and less commonly maroon-grey (unit **lJrv**). Intercalated in the volcanic rocks are lenses from one to several kilometres in length composed of pink flow-layered rhyodacite (**lJvr**) or thin bioclastic limestone (**lJc** and **lJgc**) and tuffaceous sedimentary rocks (**lJrs** and **lJgs**). This complex interfingering of volcanic and minor sedimentary rocks lies between Cullivan and McEwan Creek faults. The ridges of Mount Brock and Tsenaglode Mountain expose most of the sequence in a northeasterly facing and dipping panel that is folded at its eastern end. A few critical fossil collections from the intercalated sedimentary lenses suggest that the entire volcanic sequence above the Spatsizi Group is Toarcian. About 100 m above the top of the Spatsizi Group, fossiliferous limestone (**lJc**) yields an Early Toarcian age (**F133**), about 400 m above the top, an unmappable sedimentary lens in

lJg contains mid-Toarcian fossils (**F137**), and about 4000 m above the top, the highest sedimentary intercalation has Toarcian fossils (**F146**). The remaining collections from units **lJrs** (**F135**) and **lJgc** (**F142, F143,** and **F144**) yield less precise age determinations.

(e) Unnamed Upper Triassic and/or to Jurassic units (**ŦJrv, ŦJvr, ŦJgv,** and **ŦJs**):

Unfossiliferous volcanic units underlie two areas south of the east end of McEwan Creek fault, form the basement along the southwestern side of the Sustut Basin within and west of Cullivan Creek, and outcrop in a large part of the map area north of Pitman fault. Two northeasterly dipping and facing panels of volcanic rocks with minor intercalated sedimentary rocks overlie fossiliferous rocks of the Stuhini Group south of McEwan Creek fault. In both panels, the base of the unnamed units is set at the top of the highest underlying fossiliferous unit. In the eastern panel, the distribution of map units near **F162** may be interpreted as indicating truncation of the underlying Upper Triassic unit **uŦw**. In both panels, the overlying unit is maroon-grey aphanitic and sparsely porphyritic (plagioclase) volcanic rocks (**ŦJrv**). The remainder of the 2000 m thick section is green aphanitic to sparsely porphyritic (plagioclase) volcanics (**ŦJgv**), and less rhyodacite flows and tephra (**ŦJvr**), and tuffaceous sediments in green, grey and maroon hues (**ŦJs**). All of these rocks are lithologically similar to the "Cold Fish Volcanics" and dissimilar to the Stuhini Group.

Within and west of Cullivan Creek, sparsely porphyritic volcanic rocks and unfossiliferous sediments form a 2500 metres thick northeasterly dipping and probably facing panel that underlies the Sustut Group southwest of Cullivan fault.

The large area of unnamed Upper Triassic to Lower Jurassic rocks north of Pitman Fault extends over 40 km from west of Beggerlay Creek to beyond the eastern edge of the map area. McBride River pluton, Three Sisters plutons, and Beggarlay Creek pluton, the latter dated at 218±29 Ma (Anderson, 1983), all intrude the massive, buff to green aphanitic to sparsely porphyritic (plagioclase) volcanic rocks (**ŦJgv**). The massive volcanic rocks are devoid of layering, intercalated sedimentary rocks, and fossils. A kilometre south of the confluence of the Klappan and Stikine rivers, green porphyritic (plagioclase and augite) breccia of **ŦJgv** apparently overlies Carboniferous or older greenstone (**Pv**). On Mount Sister Mary, a Rb-Sr whole-rock isochron gave an age of 191±9 Ma (Gabrielse et al., 1980). Five kilometres north of Mount Sister Mary, Tipper reported fossiliferous tuffaceous sediments of Early Toarcian age (Gabrielse et al., 1980) that probably are the extension of the easterly dipping, tuffaceous lens (**ŦJs**) on the north side of mountain, but the intervening few kilometres are not mapped. Overlying the lens are grey-maroon, sparsely porphyritic (plagioclase) volcanics (**ŦJrv**) and intercalated rhyodacite (**ŦJvr**). Of the four Triassic and/or Jurassic units on the north side of Pitman fault, the grey-maroon volcanic (**ŦJrv**), rhyodacite (**ŦJvr**), and tuffaceous sedimentary rocks (**ŦJs**) are lithologically akin to the "Brock Volcanics", and even unit **ŦJgv** seems more similar to the "Brock Volcanics" than to rocks of the Stuhini Group.

(f) Unnamed Middle Jurassic units (**mJcg, mJs, mJgv,** and **mJvp**):

North of Pitman fault and east of Mount Sister Mary, are erosional remnants of a south-southeasterly dipping sheet composed of 2000 m of unfossiliferous sedimentary and overlying volcanic rocks. At the north edge of the map area, a basal chert pebble conglomerate layer (**mJcg**) unconformably rests on maroon volcanic rocks of unit **ŦJrv**. Southwards the sedimentary rocks **mJs** thicken to at least 500 m of maroon to grey-green argillite to wacke with lenses of conglomerate. Overlying the sedimentary rocks are 1500 m of grey-green and minor maroon sparsely porphyritic (plagioclase) flows capped by maroon plagioclase porphyry (**mJvp**) volcanic rocks. Within the map area at **F123**, sandy limestone of unit **mJs** contains only plant fossils, but to the north Tipper (pers. comm., 1989) has found Middle Bajocian fossils in the basal sedimentary unit.

(g) Bowser Lake Group (**JBcg**):

The map area lies on the northern edge of the Bowser Basin. East of the Klappan River at the north end of the Eaglenest Range, a 2000 m thickness of clastic rocks dominated by chert pebble to cobble conglomerate (**JBcg**) was assigned by Gabrielse and Tipper (1984) and Evenchick (1988) to the Bowser Lake Group. Although the rocks are folded, they apparently form an easterly dipping succession truncated on the northeast by Cartmel Lake fault (section V-V'). Farther northeast, a fault wedge up to 300 metres thick of mainly conglomerate forms part of the southwest wall of South Fork fault (section V'-W). The conglomerate underlying the peaks of Eaglenest Range belongs to the uppermost of the four lithologic units Evenchick identified in the Bowser Lake Group. The conglomerate near the base of the group in McEwan Creek and in the fault wedge may not be part of the uppermost lithologic unit. About 0.5 km south of the map area, Sweet reported on a well preserved and highly varied assemblage of palynomorphs of Middle or Late Jurassic age taken from one of the rare shale and sandstone intercalations (**F168**). In a small stream on the east side of Klappan valley, a few kilometres south of the map area, Tipper (pers. comm., 1989) found Late Jurassic (Kimmeridgian?) fossils, in rocks underlying conglomerate of the uppermost unit, which limit it to a late Late Jurassic age. Conglomerate near the base is unfossiliferous.

(h) Sustut Group (**lKbx, lKs, uKcg,** and **uKs**):

The map includes the area that Eisbacher (1974) and Evenchick (1987) viewed as the northwestern end of the Sustut Basin. The Sustut Group and its component Tango Creek and overlying Brothers Peak formations are stratigraphic units of a late-orogenic clastic wedge that fills the basin. The basin does not end within the map area, but continues at least another 80 km to the northwest where a large outlier of the Tango Creek Formation forms some of the magnificent cliffs of the Grand Canyon of the Stikine (Read, 1983). Eisbacher's subdivisons, even to the member level, are applicable within the map area and to the northwest in the Grand Canyon. Because of A.R. Sweet's investigations in 1984 (Table 1), the ages of the units are more precisely known, and some ages differ significantly from those available to Eisbacher. South of the Stikine River widely scattered outcrops indicate that the group underlies the forested hills drained by Cullivan Creek. A faulted sliver lies southwest of Cullivan fault near **F165**.

The Tango Creek Formation consists of 2000 m of sandstone, siltstone and shale of the Tatlatui Member (**lKs**) which is locally and characteristically muscovite-bearing. Here and there are pebble conglomerate or sedimentary breccia lenses up to 100 m thick of the Niven Member (**lKbx**). The lenses lie at the base or near the middle of the Tatlatui Member. Fossils from one of the basal lenses (**F165**) yielded an Early Cretaceous (Barremian to preferrably Early or Middle Albian) age for the Niven Member. Several fossil localities in the Tatlatui Member show that it ranges in age from Early Cretaceous (Barremian to preferrably Early or Middle Albian) near the base (**F165**), Middle or Late Albian throughout most of the member (**F145, F151,** and **F153**), to early Late Cretaceous (Coniacian to Santonian) within 250 m of the top of the member. Near the top of the Tatlatui Member are thick grey siltstone layers and thin sandstone beds which abruptedly pass up section into a 1000 m thick sequence of interbedded conglomerate and minor sandstone and shale of the Laslui Member (unit **uKcg**) of the Brothers Peak Formation. The base of the formation is set at the first appearance of conglomerate. Above unit **uKcg**, the Laslui Member consists of 200 m of green lithic sandstone and waterlain rhyolite ash (**uKs**); the thin tuffaceous mudstone and lignite of the uppermost Spatsizi Member are absent. The conglomerate-bearing portion of the Laslui Member (**uKcg**) is of Late Cretaceous (Early or Middle Campanian) age at **F141** and **F147**, and the overlying sandstone-rich part of the member (**uKs**) is late Late Cretaceous (Early Maastrichtian) at **F132**.

INTRUSIONS

The bulk of the plutonic rocks belong to the Hotailuh Batholith and lie along and north of the Stikine River valley, and a few lie to either side of Klappan River valley. With the exception of the undated McEwan Creek pluton, the plutonic rocks range in age from probably pre-Triassic to Middle Jurassic and include members of the Upper Triassic Stikine plutonic suite and Jurassic Three Sister plutonic suite. Small hypabyssal intrusions invade all rock units older than the Bowser Lake Group.

Within the map area, the Stikine plutonic suite contains Beggerlay Creek and Railway plutons. Railway pluton (**Tmd**) is an unfoliated, weakly metamorphosed monzodiorite that nonconformably underlies dated Upper Triassic sediments. Zircons yield a radiometric age of 227±9 Ma (Table 2) which is consistent with its intrusive relations to Permian and(?) older rocks immediately west of the map area. Beggerlay Creek pluton (**EJadi**)is unfoliated but characteristically metamorphosed to subgreenschist facies. A K-Ar radiometric date of 218±29 Ma (Table 2) from amphibole weakly constrains the age of the pluton and permits its observed intrusive relations with the unfossiliferous volcanic wallrocks of Triassic and/or Jurassic age.

The Three Sisters plutonic suite contains fresh and unfoliated intrusions ranging from granite of the potassic marginal phase, through quartz monzodiorite, granodiorite and diorite. The suite intrudes unit **TrJv**, but intrusive relations among the various rock units are not exposed within the map area. Zircons from McBride River Pluton immediately north of the map area, gave a radiometric age of 166±8 Ma (Anderson et al., 1982). Zircons from the potassic marginal phase 35 km northwest of the map area yielded a radiometric age of 170±1 Ma (Anderson et al., 1982).

The Carboniferous or older metasedimentary and metavolcanic rocks host intrusions ranging from leucogranite and leucogranodiorite (**Pg**) to quartz diorite, tonalite and gabbro (**Pqd**). These intrusions lie between Pitman and Cullivan faults and within the map area; west of the area, they outcrop between Pitman and McEwan Creek faults. The locally foliated intrusions are elongate east-southeasterly parallel to the foliation of the host rocks. All intrusions are incipiently metamorphosed to chlorite zone assemblages. Because the intrusions are restricted to Paleozoic host rocks, they may be of late Paleozoic age. To the present, attempts to radiometrically date zircons from a foliated body of leucogranite have been unsuccessful (Table 2). Such a date would yield, not only an age for the intrusive suite, but also a maximum age for the deformation of the Paleozoic host rocks.

STRUCTURE

The map area covers a 45 km length of the southern flank of the Stikine Arch from the Hotailuh Batholith in the centre of the arch southwards across the Sustut Basin to the northeastern edge of the Bowser Basin. West-northwest and westerly striking faults dominate and important ones, such as Pitman and McEwan Creek, may be long lived. The area straddles the junction between the northwesterly trending folds and contraction faults that characterize the northeastern edge of the Bowser Basin and the west-trending faults that lie along the south flank of Stikine Arch.

Pitman fault, east of its junction with Beggerlay Rapids fault, juxtaposes Paleozoic rocks on the south against Triassic and/or Jurassic rocks to the north. West of its junction with Beggerlay Rapids fault and west of the map area, it sets Paleozoic rocks on the south against the "Tsaybahe Group" to the north. A contradiction to the presence of older rocks on the south juxtaposed against younger rocks on the north, is the presence of the Sustut Group south of the fault. Pitman fault strikes westerly and dips steeply. Although its displacement is unknown within the map area, the subparallel, left-lateral Moose Lake fault, with an offset of 1 km, lies a few kilometres to the north and implies a sense of motion for the Pitman which is compatible with Gabrielse's (1985) observation that the Pitman sinistrally offsets the Kutcho fault by about 4 km.

Farther south, the westerly striking and steeply dipping McEwan Creek fault runs down McEwan Creek, crosses Klappan River, and veers to the southwest before passing under Ealue Lake west of the map area. Rock units, faults and folds terminate against the McEwan Creek fault, but the absence of movement indicators and a discernible pattern of offset features preclude an estimate of motion. In Klappan valley, the apparent extension of unit lJbs across the fault limits lateral displacement to less than 5 km. The faulted extension of McEwan Creek fault east of Cullivan fault lies between the southernmost outcrop of upper Paleozoic rocks on the north and the northernmost outcrop of unit nJv on the south. Because no easterly oriented fault disturbs the Sustut Group at this latitude, motion on McEwan Creek fault must be pre-Sustut.

From the west fork of Cullivan Creek, Cullivan fault strikes west-northwesterly for 20 km before veering to the west and continuing for over 35 km westward to its junction with Pitman fault immediately west of the map area. For most of the length of the fault, rocks on the south side are younger than those on the north side. The west fork of Cullivan Creek cuts through a thin, northeasterly dipping sliver of the basal Tango Creek Formation that has been dragged and truncated by Cullivan fault along its northeastern edge. Farther northwest, the fault limits the westward extension of the Tango Creek Formation. From this point westward, the fault juxtaposes Paleozoic rocks on the north against Jurassic and locally Triassic rocks to the south. Although not exposed, in the west fork of Cullivan Creek, the fault probably dips moderately to the northeast. In section W-Y, the throw measured on the offset base of the Tango Creek Formation is about 3 km and reverse. The significant change in strike along the fault probably precludes significant strike-slip displacement.

Cold Fish Fault (Eisbacher and Tempelman-Kluit, 1972), runs west-northwest along Cullivan Creek for about 10 km before dying out. Eisbacher (1974) linked the fault to the Omineca-Quenada fault and traced the structure for 225 km to the southeast along the southwestern edge of the Sustut Basin. Within the Spatsizi map area, both Eisbacher (1974) and Evenchick (1986) noted that Cold Fish Fault forms the northeastern limit of the "Cold Fish Volcanics", but in the present map area Triassic and/or Jurassic volcanic rocks are present on both sides. In Cullivan Creek, the fault dips 60°SW, and has less than a few hundred metres of throw as measured on the offset unconformity at the base of the Sustut. The fault displacement is so small that the irregular paleotopography of the unconformity controls whether the fault has an apparent normal or reverse movement; section QR shows apparent normal movement. The fault replaces an anticline that should intervene between open synclines to the northeast and southwest (section Q-R). Northwestward, the fault and accompanying syncline to the southwest merge into the northeasterly dipping limb of the Cullivan syncline.

Cartmel Lake and South Fork faults both strike west-northwesterly, dip steeply, terminate against McEwan Creek fault, and offset the base of the Bowser Lake Group. Evenchick (1988, Fig. 2) showed an unnamed fault close to the northeastern boundary of the Bowser Lake Group; it forms the east-southeastern extension of Cartmel Lake fault. In section V-W, the vertical offset of the base of the Bowser Lake Group across Cartmel Lake fault is about 3 to 4 km, and across South Fork fault, at least 2 km. These offsets assume that the base of the Bowser Lake Group has negligible paleotopography within the area of measurement.

The moderate northeasterly dipping Beggerlay Rapids fault veers from Pitman fault and continues for 10 km northwest of the map area. The throw is only a few hundred metres and probably reverse (section O-P).

An unnamed north-northeasterly striking and steeply dipping fault north of Mount Brock offsets both the Pitman and Cullivan faults. The left lateral offset of about a kilometre may result from accommodation to reverse motion on the curved Cullivan fault.

The few folds observed in pre-Cretaceous rocks are noncylindrical and extend for only a few kilometres. Of the post-Cretaceous folds, Cullivan syncline extends southeastward from the map area for at least 35 km (Eisbacher, 1974). At its northwestern end in the map area, the open, upright to steeply southwest dipping syncline changes orientation across Cullivan Creek. West of Cullivan Creek, the fold tightens, plunges southeasterly and has a steep southerly dipping axial surface (section S-T).

UNCONFORMITIES:

The area contains several significant unconformities which change their character across the westerly striking Pitman and McEwan Creek faults (Table 3). The two oldest unconformities underlie the western side of the area. North of Pitman fault relatively undeformed Middle Triassic sediments of unit **mTRp** overlie well foliated Carboniferous and(?) older greenstone (**Pv**). The relationship of up to 3000 m of Lower and/or Middle Triassic sediments and volcanics of "Tsaybahe Group" overlying upper Paleozoic rocks reappears 60 km to the west near the mouth of the Tanzilla River. All phases of the Stikine plutonic suite, including the 230 Ma old Gnat Lakes Ultramafite, intrude the "group". South of Pitman fault, the "Tsaybahe Group" is missing. Instead, a hundred metres of Upper Triassic sediments (**uTRcg**) of the Stuhini Group nonconformably overlie the 227 Ma old Railway Pluton of the Stikine plutonic suite and west of the map area they overlie Permian with no intervening rocks of the "Tsaybahe Group". Fifteen kilometres southeast of the pluton, and south of McEwan Creek Fault, intercalated Upper Triassic sedimentary and volcanic rocks of the Stuhini Group are over 3000 m thick. The sudden changes in thicknesses of Triassic rock units apparently occurs across Pitman and McEwan Creek faults. Late Triassic to early Cretaceous movement along these faults is a likely cause of the changes in thicknesses of stratigraphic units across them. Apparently these two westerly trending faults have long been active as the blocks they bound moved vertically during the development of the southern flank of the Stikine Arch. During the post-Cretaceous phase of contraction and northeastward directed folding and thrusting of the Bowser and Sustut basins against the Arch, at least Pitman fault was reactivated by a minor amount of sinistral strike-slip movement.

Within the map area, an unconformity probably exists between Upper Triassic rocks of the Stuhini Group and Lower Jurassic rocks of the Cold Fish Volcanics. This unconformity is closely constrained on the east side of Klappan valley south of Railway pluton where fossiliferous Lower to Middle Norian limestone lenses (**F128**) in unit **uTRcg** underlie undated, sparsely porphyritic (plagioclase) volcanic rocks with maroon and grey-green hues of unit **lJbv**. A latest Pliensbachian collection (**F138**) from the base of the fossiliferous sediments of unit **lJbs**, which overlies unit **lJbv**, closely constrains the position of the Triassic-Jurassic unconformity; the placement of the unconformity at the base of unit **lJbv** is arbitrary. To the southeast, south of McEwan Creek and between South Fork and Cullivan faults, green tuffaceous sediments (unit **uTRw**) of the Upper Triassic Stuhini Group contain three fossil localities (**F155, F160** and **F162**) with fossils of the Amoenum Zone of middle Late Norian age. Because the overlying 2000 m thickness of red and green, sparsely porphyritic (plagioclase) volcanics (**TRJrv, TRJgv**), rhyodacite (**TRJvr**), and maroon and green sediments (**TRJs**) are unfossiliferous, they are designated as Triassic and/or Jurassic rock units. In the absence of fossils, but based on the presence of maroon coloured sediments and sparsely porphyritic (plagioclase) volcanic rocks, and rhyodacite flows in the Triassic and/or Jurassic rocks, the unconformity between the Stuhini Group and Cold Fish Volcanics probably lies at the top unit **uTRw**.

In the map area, conglomerate, in part of latest Jurassic age, dominates the clastic sediments of the Bowser Lake Group, and its dominance implies proximity to the basin edge. Only 20 km to the north, Middle Jurassic rocks of units **mJs** to **mJvp**

are largely volcanic rocks of early Middle Jurassic age. The lower Middle Jurassic rocks, now lie only on the north side of Pitman fault. Their former southern extension, may have been removed by erosion, due to uplift of the south side of Pitman fault, prior to deposition of the Bowser Lake Group along the northern margin of the basin.

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TABLE 3
STRATIGRAPHIC COLUMNS ADJACENT TO PITMAN & McEWAN CREEK FAULTS*

Stratigraphic Unit	North of Pitman fault		Between Pitman and McEwan Cr. faults		South of McEwan Cr. fault
Bowser Lake Group	Absent	? ?	Absent	U D	4000+ m
Middle Jurassic units	2000 m	D U	Absent	? ?	Absent
"Brock Volcanics"	Probably present	? ?	4000 m	D U	Probably absent
Spatsizi Group	Absent	U D	0 to 600 m	? ?	Present
"Cold Fish Volcanics"	Probably present as ŦJ units	? ?	Present	U D	Probably present as ŦJ units
Triassic and/or Jurassic units	Up to 3000 m	? ?	Absent	U D	3500+ m
Stuhini Group	Absent	U D	0 to 100 m Stikine Suite	U D	3000+ m
"Tsaybahe Group"	up to 3000 m Stikine Suite	D U	Absent	U D	Present?
Carboniferous and(?) older units	Present	? ?	Present	? ?	Absent?

*U D = Implied apparent relative Up/Down motion across fault