



TOODOGGONE - McCONNELL PROJECT:

GEOLOGY OF THE McCONNELL RANGE - SERRATED PEAK TO JENSEN CREEK, PARTS OF NTS 94E/2 AND 94D/15

By L.J. Diakow and C. Rogers

KEYWORDS: Asitka Group, Takla Group, Black Lake intrusive suite, copper-gold porphyry, Kemess Mine, McConnell Range

INTRODUCTION

The Toodoggone-McConnell Project was initiated in 1996 to map and evaluate a tract of Early Jurassic plutons and surrounding arc volcanic successions of Paleozoic to Jurassic age for base and precious metal mineralization.

Bedrock mapping during the first year of the program focussed on a region south of the Finlay River and east of Thutade Lake, documenting local geology near known copper-gold porphyry targets - the Kemess South deposit and Kemess North and Pine prospects (Diakow and Metcalfe, 1997). The current 1:20000 scale mapping program expands this geology to the east and south into the McConnell Range, between latitudes 57°06' and 56°39' north, and longitudes 126°39' and 126°25' east (Figure 1).

The McConnell Range was divided into two contiguous map areas along the drainage line of Jensen and Thorne creeks. The northern map segment, described in this report, ties into geological work completed in 1996 in the vicinity of the Kemess South mine. It illustrates the extent of older, Paleozoic strata as far south as Jensen Creek, and also provides a glimpse of strata low in the overlying Upper Triassic succession. Geology in the southern map segment of the McConnell Range between Jensen and Johanson creeks is reported by Legun (1998). The southern region is underlain by Upper Triassic strata that are progressively younger towards the south, which affords stratigraphic comparison to correlative rocks that host important stratabound copper deposits in the Upper Triassic Takla Group in the type-area to the west.

Staging for this program was the Kemess South minesite. It is situated along the northwestern periphery of the study area, and requires only a short helicopter ferry into the McConnell Range.

LITHOSTRATIGRAPHY

The McConnell Range was previously mapped in regional programs undertaken by the Geological Survey of Canada (Lord, 1948; Richards, 1976). Present detailed mapping and subdivision of Paleozoic and Mesozoic units build upon this excellent earlier work. Local geology of the McConnell Range and outlying areas is summarized in

Figure 2 with representative stratigraphic sections illustrated in Figure 3.

The oldest layered rocks in the McConnell Range are assigned to the upper Paleozoic Asitka Group based on lithologies and paleontology similar to those described by Lord (1948) and Monger (1977) in the adjoining region to the west. Upper Triassic strata belonging to the Takla Group unconformably overlie the Asitka Group. Volcanic rocks of the Lower Jurassic Toodoggone formation unconformably overlie probable Upper Triassic strata at the northernmost part of the study area, just south of the tailings impoundment at the Kemess South mine. Farther to the south, in the McConnell Range, these distinctive Lower Jurassic volcanic rocks are absent. It is possible that volcanic rocks of the Toodoggone formation once overlay older strata in the McConnell Range, but have been removed by subsequent erosion that has cut down, exposing the tops of comagmatic epizonal granitic rocks. The youngest strata exposed is a continental clastic assemblage assigned to the Upper Cretaceous Sustut Group. Several small exposures of these rocks are found along the lower west side of the McConnell Range in fault contact with, and possibly unconformable on older strata.

Mid-Pennsylvanian to Early Permian - Asitka Group

The Asitka Group was originally named for a sequence of interbedded silica bimodal volcanic rocks, chert, limestone and argillaceous strata exposed mainly between the Asitka and Niven rivers in northeast McConnell Creek map area (Lord, 1948). Monger (1977) remapped part of this area and although emphasis was on the overlying Triassic stratigraphy, he introduced a three-fold division for the Asitka Group, comprising a middle unit dominated by rhyolite, and some breccia and feldspar porphyry, which grade into underlying basaltic rocks. Basalts are also common in the uppermost and lowermost units, accompanied by limestone, in places tuffaceous and chert. Argillite is present in the lower unit.

New fossil and U-Pb isotopic data confirm that Paleozoic rocks are considerably more widely distributed than previously mapped in the southern Toodoggone River map area (Gabrielse, 1977). They underlie a broad region that extends from the northwestern side of Thutade Lake, southeastward across Duncan Ridge, through the Kemess mine area, and as far east as Serrated Peak. Near Serrated Peak they are folded and involved in west-directed thrust faulting. Southward from Serrated Peak, into the McConnell Creek map area, Paleozoic strata are uplifted

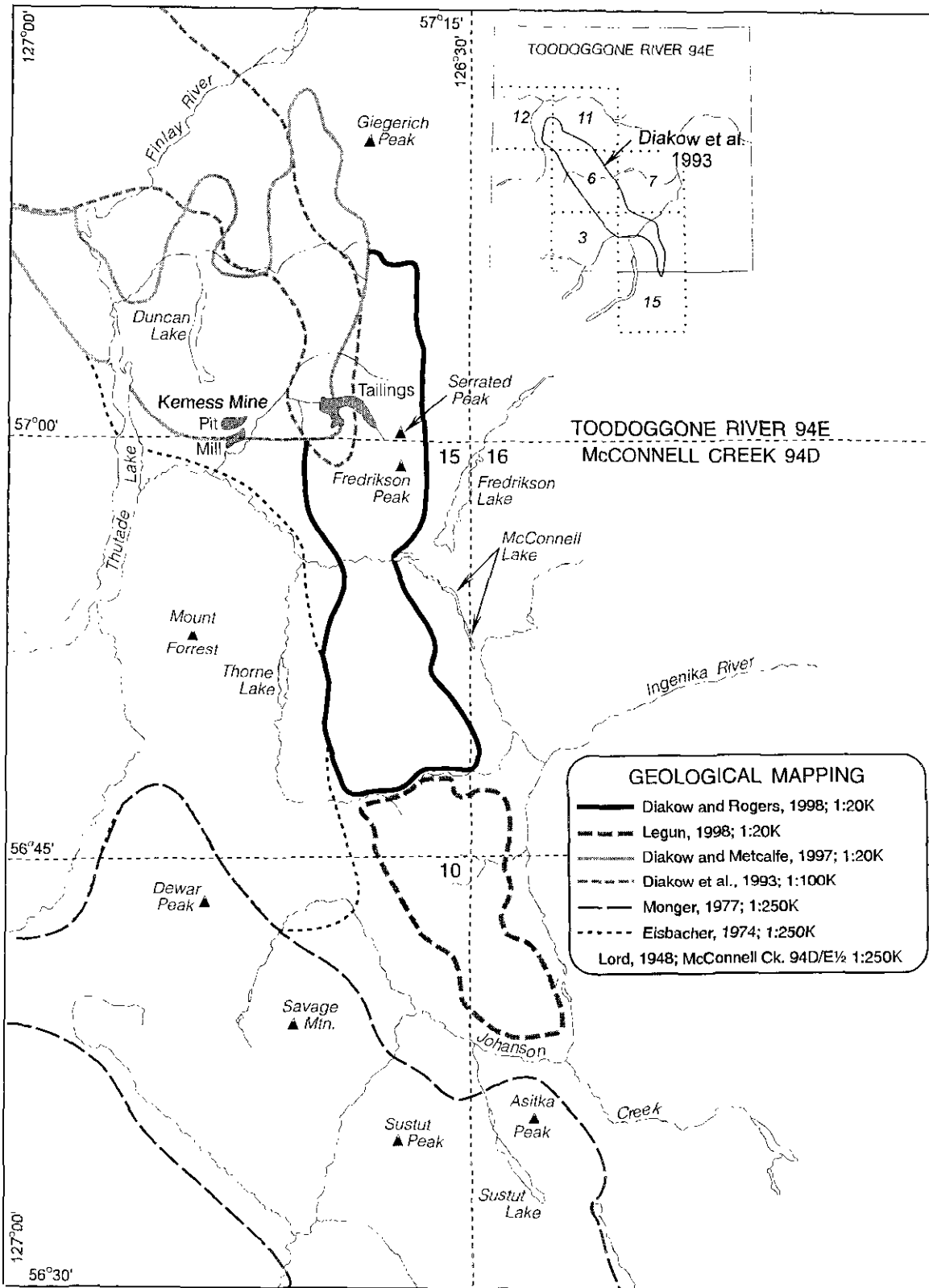


Figure 8.1. Location of recent and previous mapping in the southern Toodoggone River (94E) and northeastern McConnell Creek (94D) map areas.

and exposed mainly along the west side of the Fredrikson pluton where they are affected both by thermal contact metamorphism and numerous steep faults. The most southerly exposures are scattered along a creek that marks the trace of a major north-trending fault located immediately north of a drainage divide separating Thorne Creek from Jensen Creek.

The thickness of the Paleozoic sequence is not known since the base has not been observed. Chert and lesser argillite comprise the youngest unit of the Paleozoic sequence. The upper contact is placed at the first occurrence of grey-black platy weathering limestone containing the distinctive Late Triassic fauna, *Halobia*. These fossiliferous beds are observed at four widely spaced localities, where they are either faulted against or stratigraphically overlying the Paleozoic succession. However, the upper contact may be an unconformity. This is indicated where there are local folds in immediately underlying Paleozoic strata but planar beds in overlying Triassic strata.

Paleozoic stratigraphy south of Serrated Peak is informally subdivided into two units that have a consistent relative stratigraphic position and are in gradational contact. The lower unit is dominated by basaltic flows, lesser andesite, both as flows and as fragmental deposits, and rare rhyolite was exposed in a single section. Sedimentary rocks may occur in intervals up to 100 metres thick within this predominantly mafic succession. The upper unit consists of a varied sedimentary assemblage that includes: chert, limestone, siliceous and pyritic black shale, and tuffaceous siltstone and sandstone.

Lower Volcanic Unit

The volcanic unit is typified by dark green basalt and basaltic andesite flows that form massive sections devoid of obvious layering. Flows representative of this unit are best observed outside the map area on the southwest-facing slope immediately to the north of a small lake adjacent to the lower camp at Kemess Mine. Most flows are aphanitic, imparting a massive appearance. Subordinate varieties may contain several percent pyroxene phenocrysts, fine plagioclase phenocrysts, and rare amygdaloidal members. The latter have elliptical chlorite and lesser silica-filled amygdules. Due to their massive nature, these flows sustain an irregular pattern of fractures that may be lined with epidote and a chalky mixture of silica and carbonate.

Fragmental and felsic rocks constitute a volumetrically minor component within the mafic flow unit. A 50-metre-thick pyroclastic unit bounded by flows is well exposed on a ridge located 3.7 kilometres at 287° azimuth from Fredrikson Peak (section D in Figure 3). The base of this section comprises aphanitic basalt overlain by bedded and laminated andesitic to dacitic meta-tuffs. The tuffs are composed mainly of layers of mixed ash and crystals that pass upwards into predominantly lapilli-rich layers containing finer grained, graded interbeds. Flattening of pyroclasts along a narrow horizon suggest incipient welding, possibly as a result of compaction of hot subaerial fallout. Above a sharp, conformable contact with the tuffs is rhyolite about 60 metres thick; it is grey and aphanitic with thin, faint flow laminae. A sample of this rock has

been collected for U-Pb geochronometry. Conglomerate composed of matrix-supported cobbles derived from the underlying rhyolite marks the base of an overlying recessive 30-metre-thick sedimentary interval. Rusty pyritic black mudstone dominates the sedimentary unit but there are subordinate interbeds composed of well sorted feldspathic sandstone immediately above the conglomerate, and grey-black limestone lenses containing solitary corals, near the top of the sequence. More than 150 metres of aphanitic basalts, not unlike those found beneath the pyroclastic unit, stratigraphically overlie the sediments.

Sedimentary rocks also occur within the basaltic flow unit at a lower stratigraphic level. This sedimentary section consists of alternating light and dark metasedimentary layers that occupy an interval between 15 and 75 metres thick traceable for more than 3 kilometres along a west-facing cliff dominated by basalt. This banded section consists of recrystallized siltstone and fine-grained sandstone interbedded with more distinctive laminated black mudstone that contains some feldspathic sandstone.

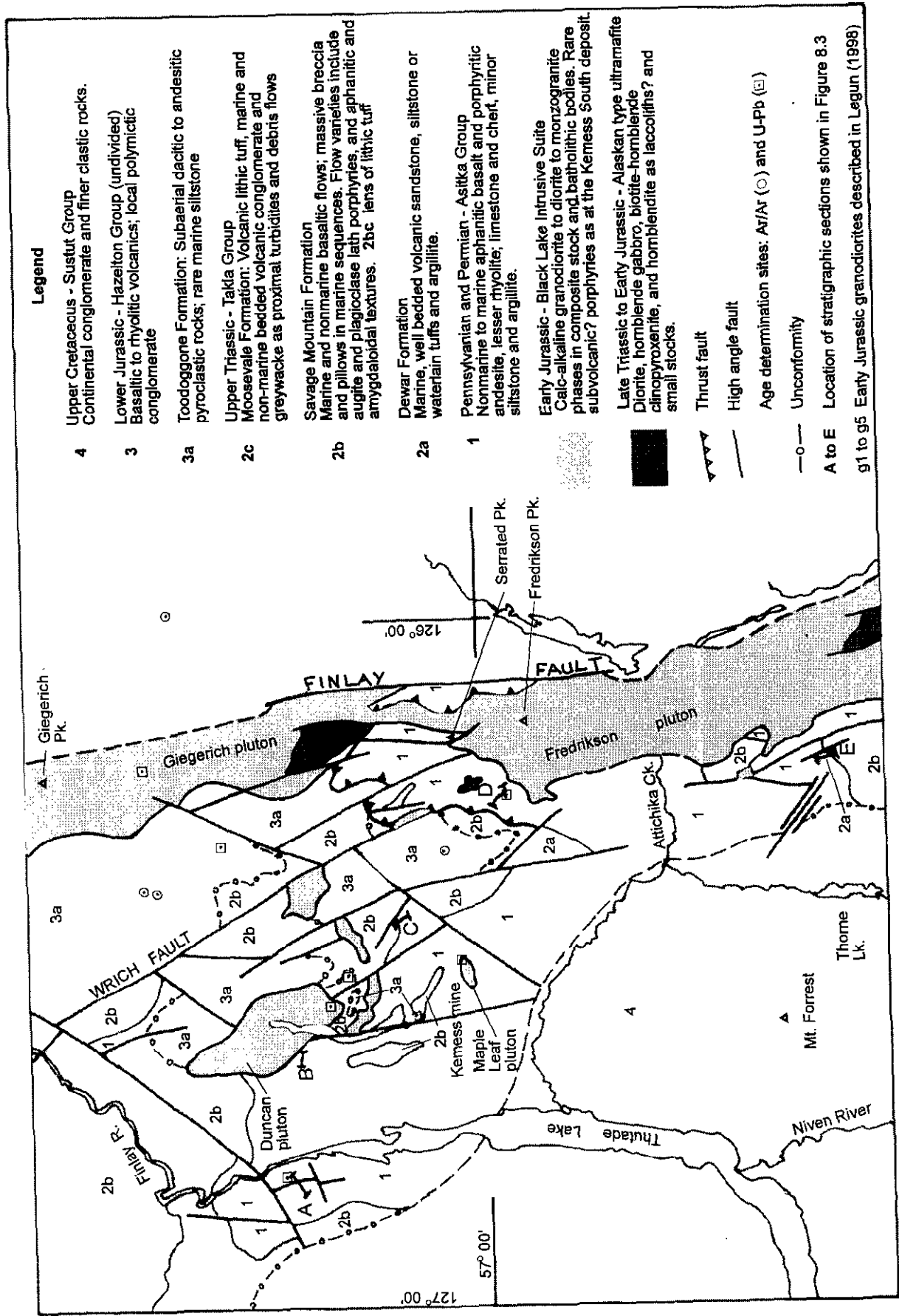
The top of the volcanic unit is placed where bedded sedimentary rocks predominate. The change from underlying volcanic to overlying sedimentary units is typically abrupt with the exception of several localities where limestone interbeds in basalt mark a gradational upper contact.

Upper Sedimentary Unit

The upper sedimentary unit of the Asitka Group is characterized by thinly bedded chert and diagnostic massive limestone. Limestone, which generally occurs nearest the base, is locally interleaved with basalt. This passes upsection into cherts with or without thin limestone, tuffaceous siltstone and sandstone interbeds, then finally into an uppermost sequence dominated by black chert and siliceous mudstone. Various combinations of these lithologies are present in the northern McConnell Range, where they are generally tilted and complicated by steeply dipping faults. Possibly the most complete sequence is a composite section reconstructed from outcrops exposed sporadically along the north slope of an unnamed mountain in the central part of the study area (see section E in Figure 3). At this locality, the lower contact of the sedimentary unit consists of limestone found both as lenses within, and beds depositionally overlying, aphanitic basalts. The upper contact of the sedimentary unit is between locally folded siliceous mudstone and interbedded black chert, representative of the uppermost Paleozoic stratigraphy, and grey-black micritic limestone containing Upper Triassic macrofossils.

Limestone Facies

Limestone occupying the lower part of section E is about 5 metres thick and consists of tan and grey beds 5 to 20 centimetres thick. Along strike they are interlayered with subordinate calcareous green siltstone and medium grained sandstone that locally rest directly on aphanitic basalt. This differs from the more typical limestone of the sedimentary unit observed in isolated structural blocks throughout the northern McConnell Range. The typical



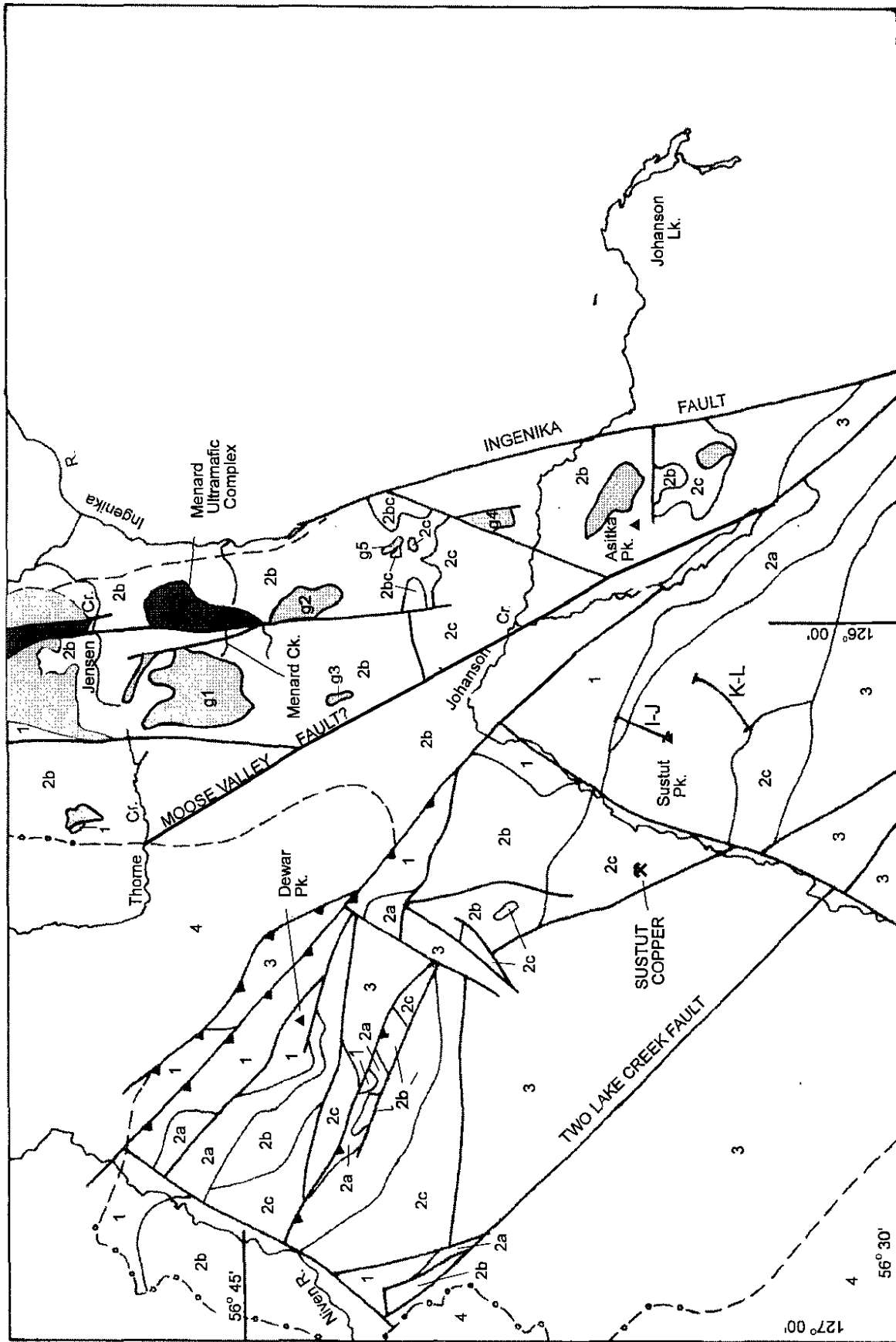


Figure 8.2 Geology of the McConnell Range showing major lithostratigraphic divisions and plutonic rocks. Geology in outlying regions to the south, northwest and west by Legun (1998), Diakow and Metcalfe (1997) and Monger (1976) respectively, are incorporated.

limestone is massive, weathers light grey or streaky grey-white, and is recrystallized. Fossils in the limestone include solitary corals, bryozoans and shell debris usually too recrystallized for specific identification. Underlying opposing slopes of a mountain immediately to the south of Attichika Creek, this limestone forms a distinctive band that is locally interlayered with aphanitic basalt. At this site massive grey, recrystallized limestone comprises several lenticular bodies; the thickest is estimated at more than 100 metres. It is either overlain by (?) or passes laterally into a distinctly laminated and bedded section about 25 metres thick which is composed of light green limestone that weathers grey with protruding siliceous laminae. Elsewhere, particularly east of Serrated Peak, strongly-folded massive grey limestone, presumed to be quite thick, is repeated in a series of imbricated thrust panels.

Chert Facies

Regionally, a chert dominant succession containing variable quantities of fine-grained clastic beds gradationally overlies carbonate rocks. The transition is seen where chert layers form scarce interbeds in massive limestone then pass into sections dominated by chert containing lenses and thin beds of carbonate. In several areas, limestone is missing and chert beds directly overlie basalt. At section E, bedded siliceous mudstone, siltstone and medium to coarse-grained feldspathic sandstone are interlayered with the chert. In general, clastic rocks diminish upsection where only scarce mudstone or light green siltstone interbeds occur within the chert. Chert is mainly light grey-green or clear and translucent. However, local ribbon jasper causes colorful alternating green, red and maroon layers. Individual chert layers are typically between 1 and 15 centimetres thick. Near the top of the chert subunit, black mudstone predominates. Mud combines with silica forming siliceous mudstone which contains scarce lenses and thin layers of black micritic limestone. Pyrite disseminated throughout these black beds oxidizes to produce rusty exposures readily distinguished from a distance.

Age and Correlation

A representative locality of the Asitka Group is located along the northeastern side of Duncan Ridge, an informal name given to the flat ridge bounding Duncan Lake in the west (section B in Figure 3). This locality contains massive grey limestone originally interpreted to be overlain by interbedded limestone, calcareous ash tuff and lapilli tuff stratigraphically above a base of aphanitic basalt (page 104 in Diakow and Metcalfe, 1997). Based on field relationships in the McConnell Range, this bedded sequence probably underlies the massive grey limestone and represents stratigraphy low in the upper, sedimentary subdivision of the Asitka Group. Solitary, rugose corals collected from the lowest bedded interval above basalt suggest that the stratigraphic lowest carbonates recognized in the study area are probably Early Permian; Asselian or early Sakamarian (Collections GSC C-143728, 143729, 143732 and 143734; E.W. Bamber, internal report 1-EWB-1997). Associated fusulinaceans identified as *Schwageina*

sp. ex. gr. *S. sustutensis* (Ross) confirm an Early Permian age; Sakamarian or early Artinskian [Collection GSC C-143733 (corresponds with coral collection GSC C-143732); L.Rui, internal report 1-Rui-1997]. Identical fusulineans are reported from limestone north of Sustut Peak (Ross and Monger, 1978) that was assigned to Monger's (1977) lowest stratigraphic subdivision of the Asitka Group. The age of basaltic flows dominating the lower subdivision of the Asitka Group in the McConnell Range is presently unknown. However, a sample of the aphanitic rhyolite from west of Fredrikson Peak, which interfingers similar basaltic flow members, has been collected for U-Pb geochronometry.

Outside of the current map area, west of Thutade Lake, a locally prominent fragmental member composed of rhyolitic ash-flow tuff underlies an andesite-basalt flow member (section A in Figure 3). It also includes sporadic exposures of intermediate variegated maroon and green ash tuff, lapilli tuff and rare accretionary tuff. Lithic-rich ash-flow tuff dated by U-Pb on zircons at 308.4 ± 0.7 Ma [(mid-Pennsylvanian to Moscovian); R.M. Friedman, U.B.C. Geochronology Laboratory, written communication, 1997] indicate this felsic interval represents the oldest known strata of the Asitka Group. The bottom of this sequence has not been recognized, implying that older stratigraphic components of the Asitka Group may exist.

In summary, the oldest rocks assigned to the Asitka Group are felsic volcanics of mid-Pennsylvanian age. The contact of these rocks with overlying porphyritic andesite is apparently stratigraphic, but this is not proven. The andesites west of Thutade Lake extend toward the east into the McConnell Range where they have been included in a predominantly basaltic volcanic succession which also contains volumetrically minor rhyolite flows and pyroclastic rocks that are designated as the lower volcanic unit. Sedimentary rocks in this succession are not common but clearly occupy several intervals. An upper sedimentary sequence composed mainly of chemical sedimentary rocks gradationally overlies the volcanic unit. Limestones near the base of the sedimentary succession contain Early Permian fauna; they pass upsection into chert which is capped by a stratiform, rusty pyritic zone.

Environment of Deposition

Earliest strata of the Asitka Group record Pennsylvanian felsic and intermediate volcanic activity during an explosive subaerial event. Subsequently, the buildup of monotonous basaltic lavas, at times interrupted by deposition of comparatively thin shale, siltstone and sandstone, took place in a shallow marine basin. As mafic volcanism waned, carbonate rocks, locally accompanied by influx of fine-grained clastic rocks dominated. Limestone appears to have accumulated in small patch reefs upon a low-relief volcanic platform. Carbonate deposition was supplanted by chert and by periodic influxes of fine grained clastic rocks in response to increasing sea level or basin subsidence. Anoxic conditions led to deposits of black pyritic siliceous mudstone and chert near the top of the Early Permian sequence.

Upper Triassic-Takla Group

Upper Triassic strata overlie Permian stratigraphy in the McConnell Range. In general, the Triassic strata pass from lowest to highest stratigraphic levels in a north to south transect along the axis of the range. Starting south of Attichika Creek to the Thorne Creek-Jensen Creek divide, recessive micritic limestone, representing the lowest stratigraphic member, is recognized at three localities where it is either faulted against or depositionally overlies locally deformed black pyritic siliceous mudstone and chert of the Asitka Group. The contact may be unconformable. This lower sedimentary unit is in turn abruptly overlain by a middle unit characterized by a massive accumulation of basaltic flows containing subordinate pyroclastic and volcanic epiclastic rocks. South of the Thorne Creek-Jensen Creek divide, where the geology is described in a separate report (Legun, 1998), the middle, mainly mafic succession apparently thickens and changes with the principal addition of coarse feldspar phyric mafic volcanic members and increased reddish oxidation of the volcanic pile. Near the southern limit of mapping, north of Johanson Creek, the mafic succession is conformably overlain by a volcanoclastic succession composed mainly of red oxidized tuffs interspersed with sedimentary rocks. These strata are tentatively designated as the topmost unit of the Upper Triassic sequence.

Marine Sedimentary Rocks

Marine, dark grey to black micritic limestone that weathers to platy angular fragments comprises the base of Upper Triassic succession. At four localities where these rocks crop out, the closest underlying strata are rusty weathering black siliceous mudstone and black chert from the uppermost Asitka Group. Distribution of these rocks ranges from the most northerly exposure on a ridge crest immediately above the open pit at Kemess Mine to a cluster of sites in the south, four to seven kilometres due east of Thorne Lake. These rocks weather recessively and appear to be relatively thin, probably less than 20 metres. In section E, these rocks directly overlie Permian strata composed of thinly bedded black chert layered with pyritic and siliceous mudstone which outline tight Z-style folds. A similar unconformable relationship between identical rock units also exists about 2 kilometres to the southeast of section E. Upslope, and slightly obscured by scree, is a pod of black limestone surrounded by black, friable mudstone which passes upsection over about 4 metres into a one-half-metre thick bed of undeformed platy black micritic limestone. This limestone contains the diagnostic Late Triassic bivalve *Halobia* and associated scarce belemnite and ammonoid fragments.

Augite Phyric Basalt and Associated Epiclastic Rocks

The Takla Group is characterized by pyroxene-bearing basalt flows and associated epiclastic and volcanoclastic deposits that form castellated physiography where thickest. The predominant volcanic component typically weathers

dark green in fractured blocky exposures that rarely reveal clear indications of layering or significant compositional variability. Consequently, subdivision of the unit and reliable thickness determination are difficult. In the southwestern part of the map area, north of Thorne Creek, massifs are underlain almost entirely by lavas, estimated to be at least 400 metres thick, a calculation estimated from a rough measure of maximum relief, and assuming nearly flat layering in a presumably unfaulted section. The actual lower contact of the volcanic rocks has not been observed. However, an abrupt topographic rise corresponds with a change from the underlying recessive limestone, described above, into overlying competent volcanic sections. This probably reflects a conformable stratigraphic relationship.

Massive lava flows dominate the volcanic sequence. They are composed for the most part of distinctive basaltic porphyries with blocky augite phenocrysts. Augite phenocrysts range in size from several millimeters to sub-equant grains up to 5 millimetres in diameter in concentrations varying from a few sparse grains to 25 volume percent. Usually basalt flows containing only augite have a very dark green color which becomes lighter as randomly oriented, slender feldspar phenocrysts increase in abundance in rocks that are designated augite-plagioclase porphyry. A distinctive variety of porphyritic basalt containing plagioclase laths as long as 2 centimetres in a dark green or maroon aphanitic groundmass have been observed in a few places. These may represent thin flow members or sills and dikes. They become a significant mappable unit in the region south of Thorne Creek (Legun, 1998). Epidote, quartz, calcite and laumontite line fractures that cut the basalts.

Significant accumulations of pyroclastic rocks are notably absent in the Triassic volcanic sequence north of the Thorne Creek-Jensen Creek divide. Where present, they consist of aphanitic basaltic lapilli in a dark green groundmass.

Erosion of the volcanic pile occurred throughout volcanism resulting in scattered epiclastic interbeds. At one locality, more than 160 metres of sandstone and siltstone apparently rest on chert of the Asitka Group. Elsewhere, similar sedimentary rocks occur at a higher stratigraphic level within the basaltic volcanic sequence. There they range from individual beds a few metres thick to sequences over 100 metres thick. Everywhere they are immature and dominated by broken pyroxene and plagioclase grains in alternating dark and medium green layers 1 to 10 centimetres thick. The beds characteristically display parallel lamination and internal grading from sandstone to siltstone, with delicate cross laminations in the finer, upper parts of beds. Conglomerates are more restricted, but are well exposed in large talus blocks spalling from cliffs immediately north of the headwaters of Jensen Creek. The conglomeratic deposits locally occupy discontinuous layers up to 20 metres thick bounded stratigraphically by massive augite phyric basalts. Rounded clasts up to one-half metre in diameter and composed exclusively of pyroxene phyric basalt are suspended in a matrix of similar, smaller clasts and pyroxene-bearing sandstone.

Environment of Deposition

The preponderance of angular pyroxene and plagioclase detritus comprising the sedimentary rocks indicates derivation from the proximal basaltic volcanic sequence. Lithologic features and structure in the sediments resemble those of volcanic wackes and possibly represent mass flow turbiditic re-sedimentation.

Interpretation of the environment of deposition for volcanic and associated sedimentary rocks in the northern McConnell Range is conjectural. Shallow marine conditions prevailed prior to the outpouring of volcanic rocks. These are represented by fossiliferous mudstone and limestone that locally mark the basal unit of the Upper Triassic succession. In the overlying basalts, features that are common in submarine mafic sequences do not occur; for example, pillow lavas and pillow fragment breccias. In some marine sequences, massive lava flows have been documented which represent proximal facies that pass laterally to more distal facies dominated by pillows (McPhie *et al.*, 1993). However, because the basaltic rocks in the study area lack submarine features and locally contain interbeds of fluviatile conglomerate and finer clastic rocks, the mafic sequence is therefore interpreted to be deposited mainly in a subaerial setting. Contemporaneous erosion of the flows is indicated by sections of well sorted, immature pyroxene-bearing clastic rocks. Consequently, these sediments could record deposition in either shallow marine or lacustrine environments. However, there is an absence of marine fauna.

Correlation

Upper Triassic rocks in the northern McConnell Range are represented by two lithostratigraphic divisions - marine sediments conformably overlain by subaerial basaltic volcanic and associated sedimentary rocks. They are equivalent in age and lithologic character to the Dewar and Savage Mountain formations of the Upper Triassic Takla Group (see Takla Group stratotype in Figure 3). The Dewar Formation is a time stratigraphic equivalent of the Savage Mountain Formation. They are interpreted as a distal, sediment-dominated facies and volcanic-dominated facies, respectively (Monger, 1977). Stratigraphic relationships are well documented in a series of representative sections between Sustut Peak and Dewar Peak, about 6 kilometres west-southwest of the McConnell Range (columnar sections in pocket of Monger, 1977). Evidently, both marine and subaerial facies of the Takla Group are traceable outside the type area, underlying a broad area towards the north and northeast between the Kemess South minesite and the northern McConnell Range. Farther north in the Toodoggone River map area, similar facies have been mapped at Castle Mountain, west of the Baker Mine (Diakow *et al.*, 1993). Regional distribution of the marine facies is not well defined. It may be more extensive than presently known, but is overshadowed by the more resistant and easily recognized subaerial mafic volcanic unit.

Upper Cretaceous-Sustut Group

Sedimentary rocks of the Sustut Group are exposed at two localities along the lower west slope of the McConnell Range, marking the present erosional edge of conglomerates and sandstones deposited in the Sustut Basin (Eisbacher, 1974; Lord, 1948). At the latitude of the study area, they possibly extended farther toward the east, blanketing older rocks, as indicated by outliers mapped to the north in Toodoggone River map area (Gabrielse *et al.*, 1977; Diakow *et al.*, 1993). The Sustut Group underlies much of Moose Valley, west of the McConnell Range, where it is largely concealed by cover but exposed along incised creeks. Exposure improves to the west toward Mount Forrest where westerly-inclined, uniformly-bedded sedimentary rocks hundreds of metres thick comprise east-facing cliffs.

Three kilometres east of Thorne Lake, conglomerate and sandstone beds are nearly horizontal in several creek exposures near treeline on the lower mountain slope at about 1500 metres elevation. The contact separating topographically lower Upper Cretaceous sediments from Upper Triassic volcanics upslope is concealed by a vegetated interval several hundred metres wide. The contact relationship might be an angular discordance or a major fault. At the same elevation on a southwest facing slope several kilometres to the north, flat-lying Sustut Group are clearly faulted against the Asitka Group. However, because this fault zone is oblique (*i.e.* 140° azimuth) to the general northerly trend of faults that are prominent in the McConnell Range, it is highly unlikely that an extension can be projected southward to account for distribution of the Sustut Group adjacent to Upper Triassic strata.

From a distance, the conglomerates appear to be relatively well bedded. However, up close they are typically crudely-layered aggregates composed of rounded cobbles and randomly distributed boulders, present both as a supporting closed framework or suspended largely in a finer clastic matrix. The clasts, particularly augite porphyry, chert and granitic rocks, closely resemble locally exposed map units. White vein quartz is also an abundant clast type. Coarse sandstone cemented by calcium dominates the matrix in conglomerates and occupies thinly-bedded, sometimes graded intervals between conglomeratic beds.

PLUTONIC ROCKS

Plutons in the McConnell Creek map area were originally assigned to a single batholithic body comprising part of the Omineca intrusions (Lord, 1948). Woodsworth (1976) subdivided granitic rocks mainly in the Swannell Ranges north of the Hagem batholith, but also examined in reconnaissance fashion the continuation of this plutonic belt westward into the northern McConnell Range at Fredrikson Peak.

Two intrusive suites have been mapped in the McConnell Range. They include: a composite body of probable Early Jurassic age composed of unfoliated

monzogranite, coextensive and probably comagmatic with a dominantly quartz monzodiorite phase; and smaller, Alaskan-type diorite-gabbro-ultramafic complexes that locally intrude Upper Triassic volcanic strata and are faulted against the intermediate plutons.

Early Jurassic - Intermediate Plutons

The Fredrikson pluton is named for a north-south elongated body, exposed the length of the current map area from approximately Serrated Peak in the north to Jensen Creek in the south. Between Jensen and Johanson creeks, a number of similar but smaller stocks and plug-sized bodies coincide with a characteristically strong aeromagnetic response, similar to that over the main body to the north. These smaller granitic bodies may represent apophyses of a southward-plunging extension of the Fredrikson pluton, which may be concealed by Upper Triassic strata. The Fredrikson pluton possibly extends well into the Toodoggone River map area to the north, where granitic rocks, informally named the Giegerich pluton (Diakow and Metcalfe, 1997), appear to be similar, suggesting they are part of a homogenous batholithic body stretching from at least the Finlay River in the north to Johanson Creek in the south. The best estimate of the age of the Giegerich pluton is 197.5 ± 2.0 Ma based on a concordant titanite fraction from a sample collected near Giegerich Peak (R.M. Friedman, U.B.C. Geochronology Laboratory, written communication, 1997). A sample of monzogranite from the vicinity of Fredrikson Peak has been collected for U-Pb geochronology.

Monzogranite is the dominant phase of the Fredrikson pluton. The main body crops out over an area more than 23 kilometres long by 4 kilometres wide between Jensen Creek and Serrated Peak. In general, the monzogranite forms a more differentiated quartz-rich core zone that passes outward into a more mafic-rich, probable comagmatic, quartz monzodiorite phase. East of Serrated Peak and north along the eastern side of the range, a number of parallel, north trending steep faults have been mapped and coincide with a change from dominantly monzogranite on the west to quartz monzodiorite in the east. The contact between phases, which tends for the most part to be near vertical and abrupt, is traceable for kilometres between a series of ridge transects. Some contacts are clearly faults with polished surfaces. However, many are simply abrupt changes in lithology with no evidence of chilled or faulted margins. Parallelism of these abrupt lithological boundaries with demonstrable high-angle faults suggests that emplacement of these intrusive phases was controlled to a large degree by these structures.

Where monzogranite and quartz monzodiorite phases are both found in the same outcrop, the contact is typically abrupt with no clear indication of temporal relationship. However, north of Serrated Peak, narrow, isolated bodies of monzogranite are faulted against and, in places, cut quartz monzodiorite. If this relationship holds regionally, then monzogranite represents the slightly younger phase, although textural evidence indicates that both were hot when they were juxtaposed.

The contact of the monzogranite intrusive into Upper Triassic and older rocks is steep and traceable along most western and southern exposures of the pluton. Alteration of country rocks adjacent to the intrusive margin is restricted to a zone tens of metres wide, in which mafic country rocks may be weakly bleached and are contact metamorphosed to a uniformly fine-grained hard hornfels. At several localities, where limestone is exposed near the pluton, skarn alteration produced garnetiferous marble. The intrusive contact is particularly well exposed along a ridge about 3.4 kilometres due west of Fredrikson Peak, where pendants and smaller xenoliths of dioritized mafic country rocks are included in the monzogranite. Dikes composed mainly of light pink aplite and lesser pegmatite commonly project outward into the hornfelsed country rocks. Immediately north of Jensen Creek, narrow diabasic dikes, not seen elsewhere, comprise a north-northeast trending set cutting monzogranite. Contact features of the monzogranite suggest epizonal emplacement. An exception may be rare biotite-garnet schist adjacent to the pluton that may represent a deeper zone of the pluton emplaced into a probable sedimentary protolith.

Monzogranite of the Fredrikson pluton is texturally and compositionally uniform. Light pink, coarse grained and equigranular, it is composed of between 25 and 30 percent quartz, nearly equal amounts of potassium and plagioclase feldspar, and between 10 and 15 percent mafic minerals. Fresh hornblende generally exceeds the modal abundance of biotite by a factor of two to three times. Titanite and apatite are ubiquitous as minute prisms. In contrast, quartz monzodiorite is typically off-white weathering, medium grained and composed of less than 10 percent quartz, 50 to 60 percent plagioclase, less than 10 percent potassium feldspar and between 20 and 30 percent mafics. Hornblende is the dominant mafic mineral and is present as relatively unaltered grains, unlike biotite that is commonly replaced in part by chlorite. Like monzogranite, titanite and apatite are common accessory minerals.

Late Triassic to Early Jurassic - Alaskan-type Mafic-ultramafic Complexes

Four small mafic-ultramafic intrusions have been mapped along the eastern margin of the study area in the McConnell Creek and Toodoggone River map areas. These bodies extend the distribution of Alaskan-type complexes more than 30 kilometres northward from the Menard Creek complex, which is part of a belt that extends farther southeast into the Mesilinka River map area (94C). There, many of the larger complexes have been studied in varying detail and evaluated for their potential to contain platinum group elements (Irvine, 1976; Nixon *et al.*, 1997).

In the study area, the size of the intrusions ranges from roughly four to less than one square kilometre in area. Except for one body that is a flat-lying sill or laccolith, the bodies are elongated and bounded for the most part by steep faults which are part of the north-northwest regional structural fabric. Lithologies comprising these bodies have not been mapped in detail although certain features are common to all. Diorite-gabbro is volumetrically dominant, containing hornblende and abundant magnetite. Diorite-

gabbro pass imperceptibly into less voluminous clinopyroxenite, with or without biotite and hornblende. However, it is uncertain whether this is part of a regular internal zonation. At the largest body in the north, late differentiates, rich in prismatic hornblende and feldspar, are locally associated with magnetite-rich layers. These form pegmatitic segregations in hornblende gabbro and also late dikes. Fine-grained felsite and feldspar porphyry comprise the youngest dikes cutting the northernmost body.

Regionally, Alaskan-type complexes have a close spatial association with mainly volcanic rocks of Upper Triassic age. Irvine (1976) postulated a genetic relationship with at least some compositionally similar Upper Triassic volcanic rocks. This hypothesis is supported in part by age determinations for some of the major Alaskan-type complexes in British Columbia (Nixon, 1997). Alaskan-type complexes have a broad range of ages in the Canadian Cordillera, varying from the oldest, Lunar Creek complex, at 237 ± 2 Ma to the youngest, Polaris complex, at 186 ± 2 Ma. No emplacement ages for the small bodies in the study area have been determined. The age and distribution of these complexes in Toodoggone River, McConnell Creek and Mesilinka River map areas is intriguing. They comprise a unique suite of similar intrusions distributed in a continuous belt that straddles adjacent tectonostratigraphic terranes (*i.e.* Quesnellia and Stikinia), and is apparently little affected by postulated dextral motion (Gabrielse, 1985) along the Ingenika-Finlay interterrane fault.

STRUCTURE

The structural fabric of the McConnell Range is broadly similar to that documented to the north in adjacent southern Toodoggone River map area (Diakow and Metcalfe, 1997). The pattern is dominated by north trending, high angle brittle faults. Unlike the area to the north, conjugate subsidiary faults that trend northeast were not recognized in the central and northern McConnell Range. Farther to the southwest, across Moose Valley, significant facies and thickness trends in Upper Triassic strata presently coincide with major northeast trending valleys that may approximate the location of early syndepositional faults. One such fault is presumed to parallel the Sustut River between Sustut Peak and Savage Mountain (Monger, 1977); it may extend to the northeast across Moose Valley, cutting obliquely across the southern McConnell Range, north of Johanson Creek. Interestingly, in the southern McConnell Range, the youngest depositional unit of the Upper Triassic sequence is exposed only in the massif immediately south of this assumed northeasterly structure.

Several major north-northwest faults, parallel to the western margin of the Fredrikson pluton, are mapped between Attichika and Thorne creeks. These structures are nearly vertical and defined by a series of interconnected fault segments that juxtapose Paleozoic and Upper Triassic stratigraphic units. As distinctive bedded rocks of the Asitka Group are traced into fault zones comprised of one

or more en echelon structures, the beds typically become tilted to near vertical, folded and locally overturned by drag. Surprisingly, the brittle chert is generally not granulated along major faults planes. Typically, zones of breccia and gouge are rare along these structures, and seldomly more than a few centimetres wide.

The Moosevale fault or Moose Valley fault is a regional-scale structure that was proposed to delimit the McConnell Range in the west (Monger, 1977; Richards, 1976). No field evidence was found to support such a structure along the lower slope of the northern part of the range. In the south, sparse outcrops of a granitic plug are flanked on the west by a small area underlain by recrystallized Paleozoic limestone. Although the contact is buried, absence of deformation argues against a major fault. Projection of a hypothetical fault from this site toward the north is also unlikely, since exposures along strike consist of Upper Cretaceous strata which appear to unconformably overlie Upper Triassic rocks. Still farther north, correlative Upper Cretaceous sediments have clearly been faulted against Paleozoic limestone along a fault zone with azimuth about 140° , that presumably post dates regional north-trending faults. Finally, there is no indication of a major fault extension north beyond Attichika Creek into the Toodoggone River map area where recent detailed mapping was conducted between Thutade Lake and the Kemess South minesite (Diakow and Metcalfe, 1997).

A series of northerly trending, steeply dipping faults, similar to structures west of the Fredrikson pluton, also mark much of the eastern border of the pluton. The faults locally juxtapose Alaskan-type mafic-ultramafic complex lithologies against phases of the Fredrikson pluton. For example, parallel high-angle faults north of Jensen Creek bound a probable extension of the Menard Creek ultramafic complex in a narrow band of diorite-gabbro and lesser pyroxenite that is less than 1 kilometre wide and 4 kilometres long. To the north, steep faults also separate the Fredrikson pluton from other ultramafic bodies.

Along the lower slope east of Serrated and Fredrikson peaks, Paleozoic and Upper Triassic strata are folded and the stratigraphy repeated and inverted by a series of west-verging thrust panels. Deformation is most prevalent in a thick greyish white carbonate, part of a bedded Paleozoic succession with chert and aphanitic basalt. The carbonate layers locally outline large amplitude isoclines and other tightly appressed folds. These contractional structures are in turn cut by high-angle brittle faults that place the deformed rocks against unstrained monzodiorite of the Fredrikson pluton. A similar style of deformation is recognized west and northwest of Serrated Peak where deformed Paleozoic sequences occur in west-directed thrusts that are segmented by later high-angle faults.

The timing of the contractional deformation is unknown. However, west of Serrated Peak, basal strata of the Toodoggone formation, presumed to be around 200 million years old, apparently occupy the footwall to a thrust fault carrying overriding Paleozoic rocks (Diakow and Metcalfe, 1997). This relationship is equivocal since, although the Paleozoic rocks are in faulted contact with the

Toodoggone formation, it is not certain that they overlie the younger rocks.

The McConnell Range passes immediately to the east into a broad U-shaped valley oriented roughly north-south. This valley supposedly marks the trace of the major dextral Ingenika-Finlay fault which corresponds with separation of the tectonostratigraphic terranes Stikinia and Quesnellia (Wheeler and McFeely, 1991). Except for the odd traverse along the west side of this valley, an objective comparison of adjacent terranes and an evaluation of their common boundary requires further mapping and analysis.

MINERAL POTENTIAL

Early Jurassic magmatism manifest in stocks and smaller hypabyssal plutons of the Black Lake calc-alkaline suite and comagmatic volcanic rocks of the Toodoggone formation are important host rocks for both copper-gold porphyry and epithermal precious metal deposits in the Toodoggone mining district (Diakow *et al.*, 1993). The Kemess South gold-copper porphyry deposit is near the southern end of this district. Based on a limited view of the deposit in a test pit that exposes hypogene ore, the host rocks bear a striking resemblance to crystal-rich dacitic volcanic rocks of the Toodoggone formation. Pervasive replacement of plagioclase by fine-grained potassium feldspar accompanies disseminations of pyrite and chalcopyrite and cross-cutting quartz-pyrite-chalcopyrite veins in hypogene ore. A sample of this rock, returned a U-Pb date of 199.6 ± 0.6 Ma (R.M. Friedman, U.B.C. Geochronology Laboratory, written communication, 1997), dating crystallization of the host rock, but not necessarily the age of hypogene mineralization. Nearby volcanic rocks of the Toodoggone formation yield equivalent U-Pb dates of 199.1 ± 0.3 Ma and 200.4 ± 0.3 Ma (R.M. Friedman, U.B.C. Geochronology Laboratory, written communication, 1997). The equivalence of these dates implies that either mineralized rocks sampled at the Kemess South deposit are strongly altered and mineralized country rock in the aureole of the main pluton or the sampled material is an evolved crowded porphyritic subvolcanic intrusion.

Recent mapping of the Fredrikson pluton showed that it is like biotite-hornblende bearing intermediate epizonal plutons typical of the Early Jurassic Black Lake suite found elsewhere in the Toodoggone River map area. It is composed of differentiated monzogranite and quartz monzodiorite phases that probably represent the southern segment of a larger batholithic body that includes granitic rocks mapped farther north near Giegerich Peak (Diakow and Metcalfe, 1997). Contact alteration, with sporadic narrow rusty zones containing minor pyrite as well as quartz veinlets that may contain malachite is localized near the margin of the intrusion. This, coupled with the notable absence of hydrothermal alteration, diminishes the likelihood of associated economic mineralization in the Fredrikson pluton. This is supported by typically low copper and gold stream sediment geochemistry from watersheds sourced in the main granitic body (*Cf.* B.C. Regional Geochemical Survey; Jackaman, 1997). West of

the intrusion, samples from several watersheds draining mainly Paleozoic and lesser Upper Triassic rocks display multielement base metal and several gold anomalies. These anomalies were not followed up during the course of mapping.

ACKNOWLEDGMENTS

We are exceedingly grateful to Royal Oaks Mines and particularly staff at the Kemess South mine who have, in the midst of their own busy schedules, always offered tremendous support to this program. It was also a pleasure to fly once again with Canadian Helicopters and their professional, courteous pilots. This manuscript has benefitted from the editorial comments of W.J. McMillan and A. Legun.

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