GEOLOGY OF THE SWANNELL RANGES IN THE VICINITY OF THE KEMESS COPPER-GOLD PORPHYRY DEPOSIT, ATTYCELLEY CREEK (NTS 94E/2), TOODOGGONE RIVER MAP AREA

By Larry J. Diakow and Paul Metcalfe

KEYWORDS: Toodoggone River map area, Kemess South, copper-gold porphyry, Black Lake intrusive suite, Asitka Group, Stuhini Group, Toodoggone formation.

INTRODUCTION

The Toodoggone-McConnell project was intitiated in 1996. The main objective is to improve understanding of the geological setting of copper-gold porphyry prospects along the tract of Mesozoic volcanic and plutonic rocks in the Swannell Ranges that extends southeastward from the Toodoggone River (94E), through McConnell Creek (94D) into the Mesilinka River (94C) map areas. The Kemess South copper-gold porphyry deposit, situated along this belt in the southern Toodoggone River map area, was discovered in the late 1980's and currently is at an early stage of mine development with production anticipated in 1998. The Kemess South orebody has estimated reserves of 200 million tonnes grading an average of 0.224% copper and 0.63 g/t gold (Royal Oak Mines Inc., 1995).

During 1996, 400 square kilometres in the vicinity of the Kemess mine was mapped at 1:20 000 scale (Figure 1). This work refines and supplements earlier regional mapping in the Toodoggone River area (Gabrielse *et al.*, 1975; Diakow *et al.*, 1993). Also in 1996, a regional geochemical survey (RGS) program was conducted in McConnell Creek and Toodoggone River map areas, covering more than 18 500 square kilometers outside of Spatsizi and Tatlatui provincial parks. Survey results are scheduled to be released in July, 1997.

Access into the study area is by fixed wing from either Prince George or Smithers to an airstrip along the Sturdee River. A system of Forest Service roads originating at either Fort St. James or Windy Point on Highway 97, north of Prince George, join the Omineca Resource Access Road and together they serve as a seasonal transportation link to a number of active mineral prospects in the Swannell Ranges. The drive from either point of origin to the Kemess minesite covers more than 400 kilometres and requires about 10 hours.

The area has been glaciated and varies from subdued, rounded hills to steep terrain at elevations between 1200 metres and 2100 metres. Rock exposure is sporadic along the major drainages but improves significantly above tree line, at about 1600 metres elevation.

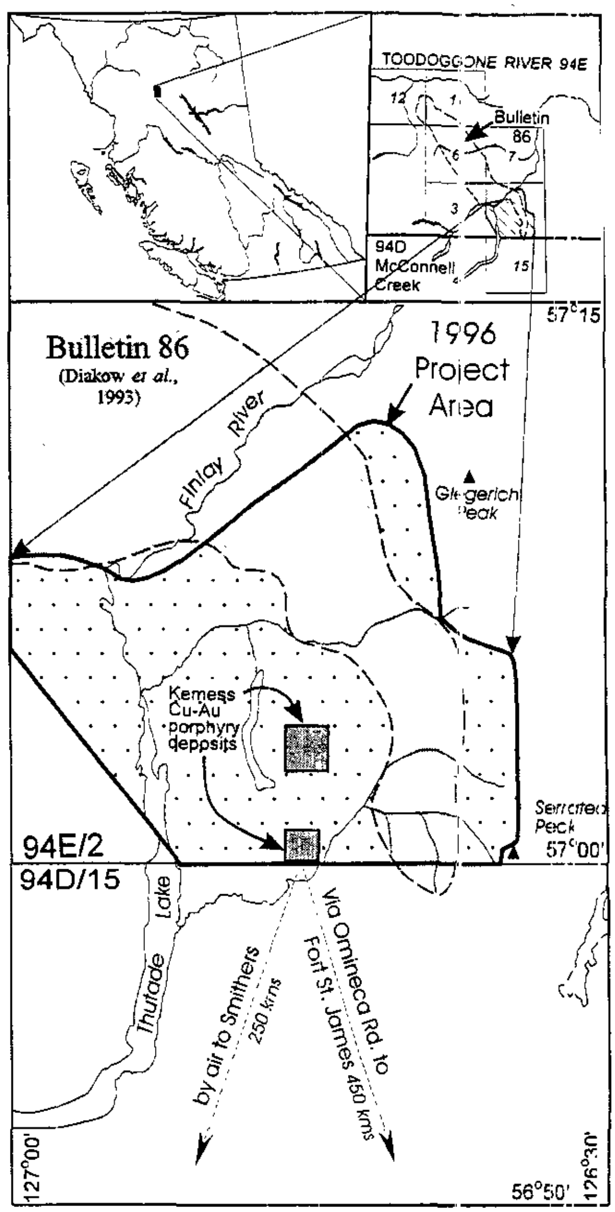

Figure 1. Location of the study within Attycelley Creek map area (94E/2).

LOCAL GEOLOGY

The study area is located near the eastern margin of the Intermontane Belt, where dextral strike-slip faults of the northerly trending Finlay-Ingenika fault system separate rocks in Stikinia to the west from slivers of Quesnellia to the east (Figure 2). These Late Paleozoic and Mesozoic volcanic arc terranes lie along the western border of older, comparatively more intensely deformed and metamorphosed pericratonic rocks of the Cassiar Terrane in the Omineca Belt. Farther west in the Stikine Terrane, the arc assemblages are largely concealed by Middle Jurassic to Late Cretaceous sedimentary strata that underlie the Bowser and Sustut successor basins.

Rock units underlying the southern part of the Toodoggone River map area at about 57° latitude are dominated by volcanic and lesser sedimentary rocks that range in age from Paleozoic to Early Jurassic. The general distribution of lithostratigraphic units in the study area comprises a relatively young, medial Jurassic belt that passes outward into bordering Triassic and Paleozoic strata. Towards the western border of the study area, the older units disappear beneath a thick cover of Upper Cretaceous sedimentary strata.

Paleozoic rocks along parts of the northeastern margin of Stikinia, which have been mapped as the Lower Permian Asitka Group (Gabrielse *et al.*, 1975; Monger, 1977), consist of andesitic and rhyolitic volcanic rocks with locally prominent sections of interbedded limestone and chert. Upper Triassic rocks of the Stuhini Group are more widespread and characterized by a proponderance of clinopyroxene-bearing basalts, andesitic volcanic rocks and associated epiclastic rocks. They are difficult to distinguish solely on lithology from some of the more mafic Paleozoic volcanic rocks. Locally the Lower Jurassic Toodoggone formation of the Hazelton Group rests directly on strata of the Stuhini Group. The contact, where exposed, is a gently inclined non-erosional unconformity. The Toodoggone formation is composed mainly of volcanic units readily distinguished by the presence of modal quartz, biotite and hornblende in rocks of andesite to dacite composition.

Most rocks in the study area display mineralogy typical of the zeolite grade of regional metamorphism. The exceptions are metavolcanic rocks of amphibolite and greenshist grade found in the thermal aureoles of several small Alaskan hornblende gabbro and pyroxenite bodies. Probable Early Jurassic intrusive rocks of the Black Lake suite underlie much of the Swannell Ranges in the eastern Toodoggone River (94E) and McConnell Creek (94D) map areas. In the Toodoggone River area, Early Jurassic calc-alkaline plutons and coeval volcanic rocks of the Toodoggone formation represent an important arc magmatic event. This event coincides with development of an elongated volcano-tectonic depression that is endowed with numerous precious metal-bearing occurrences. During the 1980's the Toodoggone mining camp was intensely explored for epithermal gold and silver mineralization, and resulted in production from the Baker and Lawyers mines. A general shift of exploration toward copper-gold porphyry targets related to Early Jurassic plutons is more recent.

LITHOSTRATIGRAPHIC UNITS

Paleozoic Rocks

Limestone, chert and volcanic rocks, mainly basalt and andesite, but with local rhyolitic ash-flow tuff are interpreted to be Late Paleozoic in age. In isolated outcrops the more basic rocks of this map unit are easily confused for lithologically similar rocks of the Upper Triassic Stuhini Group. Relatively undeformed Paleozoic rocks underlie much of the valley bottom adjacent to the northern end of Thutade Lake and extend eastward to the flat-topped ridge (herein called the Duncan Lake ridge) that borders Duncan Lake in the west. Near Serrated Peak, in the southeast part of the study area, Paleozoic strata are locally folded and presumably thrust over Jurassic volcanic rocks. Paleozoic rocks also crop out, generally at lower elevations in several valleys incising a mountain located between Attycelley Creek and the Finlay River. The upper contact of the Paleozoic succession is an unconformity with overlying rocks of the Upper Triassic Stuhini Group.

Paleozoic rocks are most widespread and probably thickest in the region adjacent to Thutade Lake. The sequence there appears to be gently inclined towards the west with probable flextures causing strata to locally deviate from this general trend. Although no contacts were observed in the scattered outcrops west of Thutade Lake, a consistent spatial relationship implies a crudely bedded stratigraphy that comprises a lowermost rhyolitic ash-flow tuff overlain successively by andesite flows then limestone with interbedded chert. Conglomerate, which is sporadically exposed, marks the top of the Paleozoic unit and it stratigraphically underlies the first exposure of pyroxene phyric flows of the Stuhini Group. The conglomerate is between 3 and 20 metres thick and consists of subangular and angular pebbles and cobbles supported by a finer sandy matrix. The most abundant clasts are fine-grained feldspar porphyry; less common clast varieties include limestone, chert, siltstone, welded tuff, and rare biotite-quartz-feldspar phyric granitoid. With the exception of the granitic clasts, these lithologies resemble local outcrops of the Paleozoic unit. No mafic volcanic clasts were found.

Pyroclastic flows in the lower part of the succession near Thutade Lake are readily distinguished by flattened, chlorite-altered fragments between 1 and 8 centimetres long that are in a light green siliceous groundmass. Although other lithic pyroclasts are present they are recrystallized and silicified. Light green and maroon ash tuff, with rare intervals of accretionary lapilli tuff, form scarce, well bedded, air-fall tuff deposits up to 20 metres thick within otherwise massively bedded ash-flow tuff. The ash-flow member is conformably overlain by a unit with massively bedded andesite and some aphanitic basalt

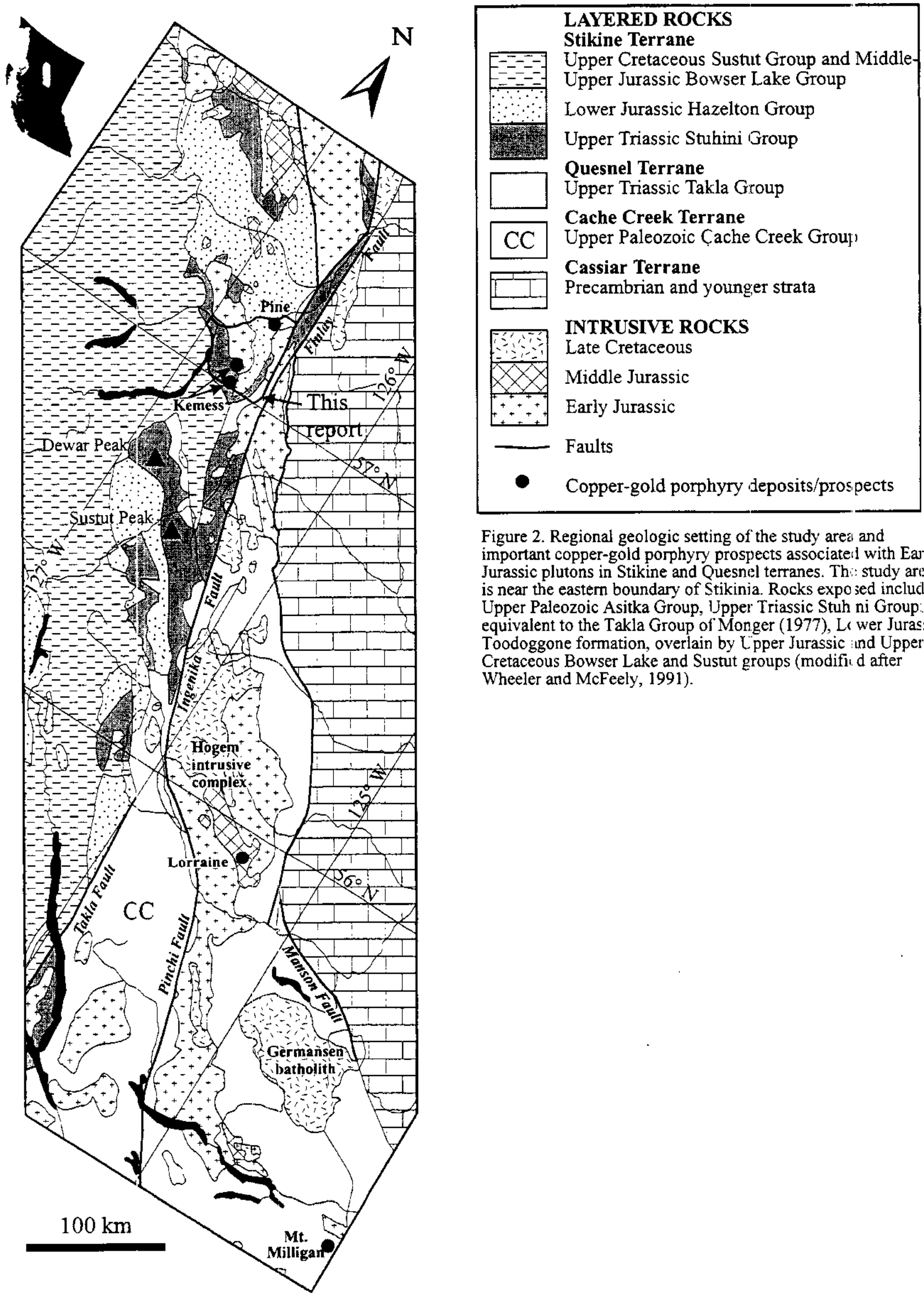

Figure 2. Regional geologic setting of the study area and important copper-gold porphyry prospects associated with Early Jurassic plutons in Stikine and Quesnel terranes. The study area is near the eastern boundary of Stikinia. Rocks exposed include: Upper Paleozoic Asitka Group, Upper Triassic Stuhini Group; equivalent to the Takla Group of Monger (1977), Lower Jurassic Toodoggone formation, overlain by Upper Jurassic and Upper Cretaceous Bowser Lake and Sustut groups (modified after Wheeler and McFeely, 1991).

flows that locally contain sandstone and granule conglomerate beds about 1 metre thick at the base. The andesite contains between 20 and 25% plagioclase phenocrysts up to 4 millimetres in diameter and microphenocrysts of clinopyroxene set in a medium green groundmass. East of Thutade Lake aphanitic basalt flows become more common and predominate along sections of the west facing slope on the Duncan Lake ridge. The basalt is a dark green, almost black rock with lustrous chloritic fracture and cleavage surfaces. At several localities similar aphanitic basalt flows occupy intervals up to 20 metres thick within an overlying limestone-chert member.

Limestones interlayered with chert are perhaps the most readily recognizable of the Paleozoic lithologies. They stratigraphically overlie the andesite-basalt flow member on Duncan Lake ridge, however, the actual contact has not been observed. Here, the limestone is more than 120 metres thick and forms rounded knolls across the ridge crest in the north; it thins dramatically southward in a series of bluff-forming exposures along the east-facing slope. West of Thutade Lake, where limestone underlies an area of 2.5 km^2 along a low-lying ridge, it appears to be bound on all sides by steeply dipping faults that juxtapose it against the andesite flow member. In this area the limestone is typically massive, weathering light grey or streaky grey-black and internally it is white with a recrystallized fine-grained texture. The relative proportion of chert and limestone is quite variable, ranging from isolated chert layers within massive limestone to chert-dominant sections more than 60 metres thick. Generally the chert, which is off-white, light green, or less commonly pink or purple, forms beds from several centimetres to 30 centimetres thick, sometimes alternating with limestone.

Solitary corals occur with bryozoans, crinoid and brachiopod fragments in a number of localities of the bedded limestone and chert unit. At a fossil site on the Duncan Lake ridge, massive carbonate is stratigraphically overlain by a steeply inclined section about 60 metes thick, composed of aphanitic basalt at the base that passes upward to alternating coral-bearing limestones, calcareous ash tuff and lesser lapilli tuff beds. The coral population appears to have been extinguished periodically during explosive volcanic episodes only to be reestablished during lulls in volcanism that are marked by deposition of limestone interbeds up to one-half metre thick. Fusulinids are well preserved locally within some reworked lapilli tuff beds. Microfossil collections for conodonts have been made from relatively scarce limy argillite interbeds in limestone and for radiolarians from a number of chert localities. Fossil identifications will facilitate age assignment and subdivision of Paleozoic rocks in the study area. In addition, the felsic welded tuff near Thutade Lake, which appears to be stratigraphically beneath limestone, was sampled for a U-Pb zircon date. At present, the presumed late Paleozoic succession in the study area is tentatively correlated with the Lower Permian Asitka Group. Monger (1977) describes three subdivisions in a stratotype of the Asitka Group near Dewar Peak, located about 50 kilometres south of the study area. There volcanics are also prominent in the section, varying in composition from basalt to rhyolite, and they are intercalated with cherts, limestones and some argillite. Fusulinaceans and sponges collected from the Dewar Peak area all indicate that the Asitka Group was deposited during Early Permian time (Ross and Monger, 1978; Rigby, 1973).

Triassic Rocks

Following current usage, rocks of presumed Triassic age in the area are assigned to the Stuhini Group, although the closest Triassic rocks which occur south of the study area and in the same tectonostratigraphic province are assigned by Monger (1977) to the Takla Group of Quesnellia. It is these which will be used for comparison and regional correlation.

Volcanic rocks in the study area, that are interpreted to be part of the Stuhini Group, are lithologically similar to those described by Monger (1977). They form an assemblage at present unconstrained by paleontological data or by isotopic age measurement and grouped entirely on the basis of their lithological homogeneity. A complete section is not present in the area and the thickness of the unit is therefore not known. Their outcrop distribution, shown in Figure 3, is peripheral to overlying units identified by Diakow *et al.* (1993) as the Lower Jurassic Toodoggone formation. The package is underlain by the presumed Paleozoic stratigraphic assemblage described above. The lower contact with the limestone-volcanic sequence of inferred Paleozoic age is apparently disconformable and is exposed on the Duncan Lake ridge. In this section, a limestone-chert unit with associated volcanic siltstones is overlain by a relatively thin bedded unit of clastic sedimentary rocks which are probably volcanogenic and are in turn overlain by a thick succession of fragmental units, incorporating blocks exclusively of volcanic material. This transition in depositional style is identified as the contact, in the absence of paleontological data. Elsewhere, the contact is not exposed. The upper contact of the Stuhini Group is exposed in the centre of the study area, east of the Saunders-Wrich fault and south of Attycelley Creek. The contact is another disconformity, marked by the occurrence of an extremely coarse Triassic volcanic conglomerate, overlain by a distinctly different conglomerate of the Toodoggone formation. Elsewhere the upper contact is covered or faulted.

The main exposures of Stuhini Group rocks are to the north and west of Thutade Lake; immediately south of the Firesteel River; on an unnamed peak immediately southeast of the confluence of the Firesteel and Finlay rivers; to the east along the margin of the Giegerich pluton; on the Duncan Lake ridge and in the immediate vicinity of the Kemess North and Kemess South deposits. Rocks which may also correlate with this Stuhini succession are exposed in the southeast, near Serrated Peak.

The Stuhini Group is dominated by mafic volcanic rocks and by significant thicknesses of derived volcanogenic clastic rocks. Diagnostic phenocryst phases

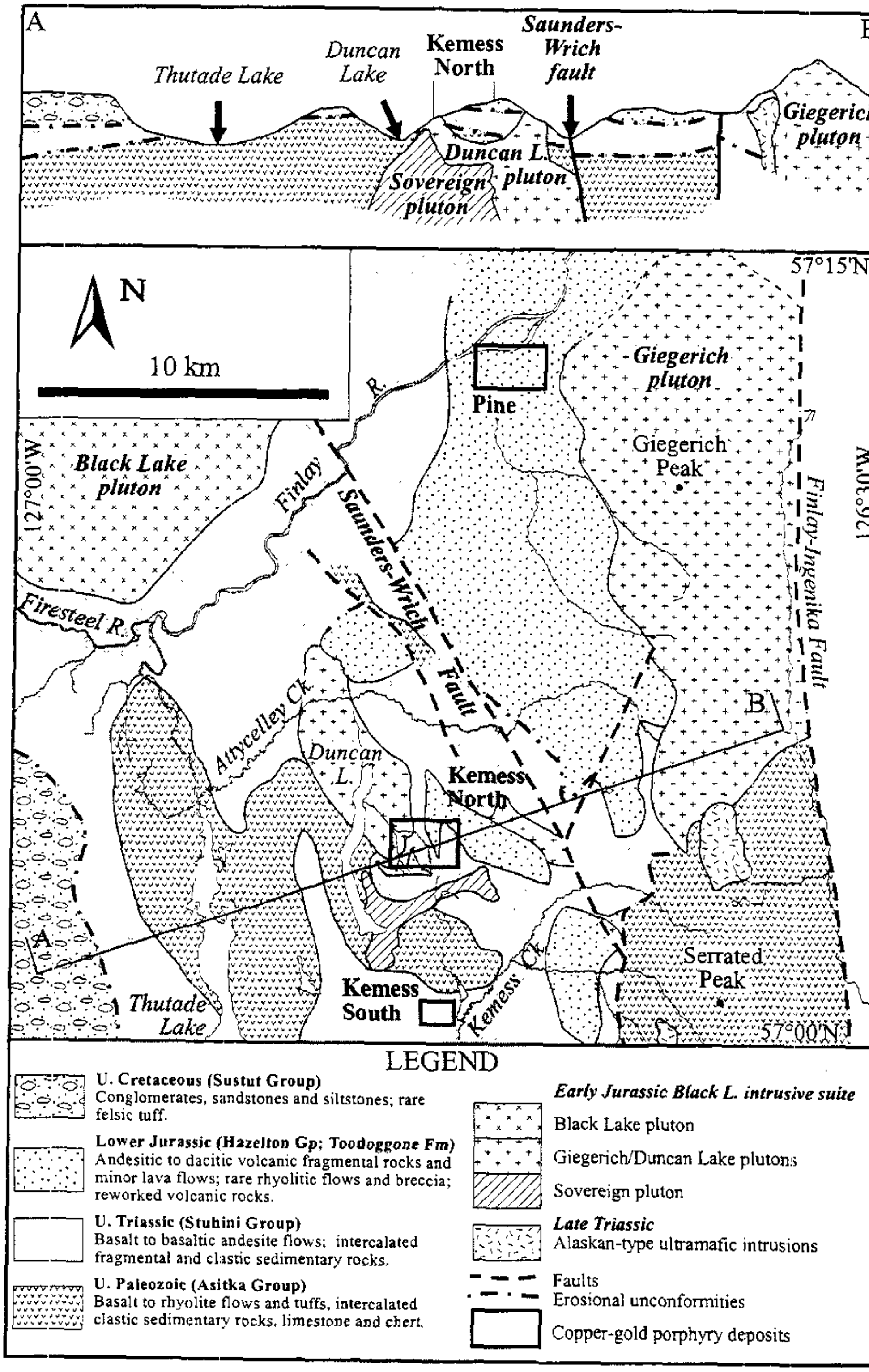

Figure 3. Generalized geology of the Attycelley Creek map area.

for this assemblage are clinopyroxene and plagioclase; the volcanic rocks are characterized by an absence of quartz phenocrysts. Plagioclase and augite are also the dominant detrital minerals in the immature clastic sedimentary rocks and frequently show subhedral crystal forms; this easily leads to misidentification of the rocks as volcanic flows, especially where lichen obscures sedimentary textures that are often visible on clean, weathered outcrops. Similarly, the monomictic nature of both matrix and clasts, together with the occurrence of very large clasts in massive breccias and conglomerates, may cause misidentification of these units as flows.

Basaltic flows in the Stuhini Group are typically dark green or greenish grey on fresh surfaces, maroon or dark green on altered surfaces and weather to a medium grey, grey-green or brown. The flows are commonly porphyritic, containing euhedral to subhedral phenocrysts of plagioclase and/or augite. Olivine is rare or absent. Either phenocryst phase may be as abundant as 15%, but total phenocryst content rarely exceeds 25%. Both phases are 1 to 3 millimetres and rarely exceed 6 millimetres in size. Tabular subhedral plagioclase is generally more abundant and commonly shows weak to moderate epidote alteration; euhedral to subhedral prismatic augite is characteristically very fresh, even in moderately altered rocks. Although traces of olivine may also be present in the phenocryst assemblage (Monger, 1977), these are partially or completely replaced.

Flows may be weakly to locally moderately vesicular; vesicles are subrounded to irregular, as much as 1 centimetre in size and may be partially filled with iron hydroxides. A distinctive lithology, characteristic of the Triassic rocks in the vicinity of Sustut Peak (Monger, 1977) also occurs in the present study area. It comprises lava flows containing large bladed phenocrysts of plagioclase. These are as much as 2 centimetres in length and as abundant as 25% of the rock. Augite phenocrysts are locally present. Monger noted that this rock type occurred as pillowed lava flows, as well as being represented by abundant fragments in volcanic-derived coarse clastic rocks elsewhere. Bladed plagioclase porphyry flows in the study area lack pillows, hyaloclastite or other evidence of hydromagmatic brecciation and are, moreover, very fresh. They are interpreted to be subaerial equivalents of the plagioclase-megaporphyritic pillow lavas to the south.

A large part of the Stuhini Group in the study area consists of coarse reworked volcanic material. This material comprises clasts and crystals derived almost exclusively from basaltic volcanic rocks and is included as the dominant component of massive breccias, cobble conglomerates and boulder conglomerates. Clasts are typically homolithic or monomictic, subrounded and as large as 50 centimetres across. These coarse fragmental rocks are matrix-supported or, less commonly, clast-supported. Matrix and clasts are difficult to distinguish except on clean, weathered surfaces. The rocks are interpreted as forming from reworked pyroclasticentimetresaterial or the distal, brecciated portions of basaltic lava flows. In either case, their large clast size and lack of sorting indicates that they are proximal.

Well-bedded sections of finer grained volcanogenic sedimentary rock are neither common nor laterally persistent in the area. Bedding is usually planar and graded bedding is common in the bedded sections. The composition of the finer grained clastic rocks is lithic arkose or wacke and feldspathic siltstone; quartz is rare. The wackes and siltstones are crystal-rich, often massive and show only vestigial rounding of crystal grains, resembling volcanic rocks. Near-aphanitic siltstones, except where bedded, resemble aphanitic basalts. The composition of the finer clastic rocks is lithic arkose or wacke; quartz is rare. The composition of the finer clastic rocks is lithic arkose or wacke; quartz is rare.

The thickest bedded section of Stuhini Group epiclastic rocks crops out on the east-facing slope of the Duncan Lake ridge. Two to three hundred metres of massive reworked volcanic material overlie a partially bedded section approximately 50 metres thick. The bedded section comprises massive to thinly bedded lithic arkose and thinly bedded to thickly laminated siltstone, immediately overlying a limestone-chert sequence of presumed Paleozoic age. The basal bedded units are volcanic sedimentary rocks and are overlain by coarse reworked volcanic fragmental rocks, with subrounded clasts of augite basalt as large as 25 centimetres, clast and matrix supported in a matrix rich in subhedral plagioclase crystals. The top of this unit was not observed, nor is the unit present on the west side of the ridge; either it is not laterally persistent or terminates against a fault.

Another well exposed section of Stuhini Group clastic volcanogenic sedimentary rocks is found on the banks of the Firesteel River, approximately 2 kilometres upstream from its confluence with the Finlay River. The section is about 100 metres thick and consists of relatively flat-lying thinly to medium bedded, graded, matrix-supported conglomerates and probable reworked lapilli tuffs intercalated with more massive cobble and boulder conglomerates. Overlying rocks consist of coarse augite-phyric basalts, sporadically exposed to the south of the river.

Argillaceous rocks rarely occur in the Stuhini Group in the study area; the finest-grained clastic rocks are usually siltstones. Southwest of the headwaters of Kemess Creek, on a ridge extending northwest from Serrated Peak, a black, thickly laminated pyritic shale unit, approximately 20 metres thick, underlies massive augite-bearing volcanic and subordinate clastic sedimentary rocks.

Rocks south of Attycelley Creek in the centre of the study area, which we assign to the Stuhini Group, have an upper unconformable contact with the basal member of the Toodoggone formation. The top of the Stuhini Group exposed in this area comprises approximately 150 metres of coarse clastic sedimentary rocks, including clast-supported boulder conglomerates containing clasts derived exclusively from the underlying Stuhini Group flows. Boulders are as large as 50 centimetres in diameter, most are subrounded to subangular. The matrix is distinctively maroon weathering; it contains grains of plagioclase and augite but quartz is absent, distinguishing these rocks from similar rocks in the Toodoggone formation, where quartz is ubiquitous.

A fragmental unit, locally marking the top of the Stuhini Group is exposed east of the Saunders-Wrich fault and south of Attycelley Creek. The unit is generally massive, with rare interbeds of normally graded coarse sandstone. It has a regional strike ranging from east-southeast to southeast and dips are moderate. The unit youngs to the northeast and is overlain by a Toodoggone conglomerate containing clasts of quartz-bearing dacite and grains of quartz in the matrix. This contact between the Stuhini Group and the Toodoggone formation is not well exposed.

A probable variant of the Stuhini Group is found to the south of Kemess Creek, in low country initially planned as the site for the Kemess South mill and also along Kemess Creek, immediately south of the Kemess South deposit. The two areas are separated by a low ridge that is underlain by massive augite-porphyritic basalt of the Stuhini Group. Rocks underlying the initial mill site area are highly friable, non-foliated and maroon-weathering volcanogenic fragmental rocks. Conglomerates containing plagioclase-phyric clasts are part of this unit; phenocrysts in clasts, or reworked subhedral grains in the matrix include 10-15% plagioclase, 1 to 4 millimetres in size. Both equant and elongate mafic phenocrysts are present in amounts as great as 10% in clasts and matrix. Complete replacement by chlorite is common, but subvitreous hornblende is present in some samples. The sequence contains, near its top, a non-calcareous fine-grained sandstone and siltstone unit of indeterminate thickness; neither top nor base are exposed. The unit is cream or pale green weathering, thinly bedded to thickly laminated and contains small delicate bivalves, at least one vertebrate fossil and plant debris. Rocks exposed along Kemess Creek are intensely oxidized and are interpreted as reworked pyroclastic units, containing subrounded pebbles or cobbles of plagioclase-porphyritic volcanic rocks. Clasts are monomictic, of similar composition to that of the friablematrix and both clasts and matrix contain relic subhedral plagioclase, partially replaced by zeolite.

Upper Triassic strata are regionally extensive and have been locally mapped in detail near Sustut Peak, south of the study area (Monger, 1977; Figure 2). Monger subdivided the Triassic stratigraphy into three formations. The basal Dewar Formation, comprises well-bedded volcanic sandstone, tuff and argillite; the middle Savage Mountain Formation, comprises augite and plagioclase porphyritic basaltic flows, volcanic breccias and minor volcanogenic clastic sedimentary rocks. In either formation, both the sedimentary and volcanic rocks are characterized by grains of augite and plagioclase. Overlying these units is the Moosevale Formation, it contains volcanic breccias and derived coarse clastic sedimentary rocks dominated by intermediate feldspar porphyry and augite basalt clasts. The sedimentary rocks contain diagnostic Triassic, late Carnian and early Norian, fossils.

The sections of augite- and plagioclase- phyric flows in the study area are correlated with Monger's (1977) Savage Mountain Formation because of the dominance of augite in the rocks. It is possible, however, that the basal, clastic sedimentary beds of this succession, which overlie the chert and limestone sequence west of Duncan Lake, correlate with the Dewar Peak Formation; finer grained lithologies are less common than in the type area but, as Monger notes, the Dewar Peak Formation is probably the distal, basinward equivalent of the Savage Mountain Formation, therefore a range of clastic sedimentary rocks will be present in the region. Units correlative with Monger's (1977) uppermost pyroclastic Moosevale Formation are either poorly represented or absent from the study area. Correlative rocks in the study area might be represented by the hornblende-bearing lithologies described above, in the initial mill site area and, friable volcaniclastic epiclastic rocks exposed along Kemess Creek.

The abundance of extremely coarse clastic sedimentary rocks, the lack of pillowed or hyaloclastic successions and the prevalence of maroon-weathering sequences suggest that most if not all the volcanism associated with the Stuhini Group in the study area was subaerial.

Jurassic Rocks

Lower Jurassic rocks underlie a northwest trending belt in the central part of the Toodoggone River map area. They are unconformable on volcanogenic rocks of the Upper Triassic Stuhini Group and in turn are overlain unconformably by continental sedimentary rocks of the middle and Upper Cretaceous Sustut Group. Part of the Jurassic succession in the Toodoggone River map area was mapped at 1:50 000 scale and subdivided into six members that comprise the Toodoggone formation (Diakow *et al.*, 1993); a stratigraphic division of the Hazelton Group. The Toodoggone formation records two major eruptive cycles separated by deposition of epiclastic rocks during local uplift and erosion of Triassic volcanic and earliest Jurassic plutonic rocks. The formation records subaerial arc volcanism in an extensional setting along the leading edge of the Stikine Terrane between 196 and 193 Ma.

Within the map area, Toodoggone stratigraphy is most complete south of the Finlay River, between the Saunders-Wrich fault and the Giegerich pluton. In this region, three, relatively flat lying members of the Toodoggone formation disconformably overlie a locally eroded surface on Upper Triassic strata. The Adoogacho member, which is the bottom of the formation, the Metsantan member, erupted at the end of the lower volcanic cycle, and the Saunders member, which comprises the uppermost division of the formation. In the immediate area of Attycelley Creek, a substantial thickness of pyroclastic rocks, conservatively estimated at greater than 500 metres thick, crop out between distinctive ash-flow tuffs units of the Adoogacho and Saunders members. However, because this volcanic pile is composed of numerous varieties of crystal-rich tuffs that exhibit only small compositional and mineralogic variations, it is difficult to subdivide the unit. Previously they have been mapped as the Attycelley member, however, this member is now considered to comprise a lower subdivision of the Saunders member. Together they record highly explosive eruptions that culminated volcanism of the Toodoggone formation. The Toodoggone formation apparently thins southwest of the Saunders-Wrich fault, where the uppermost, Saunders member rests directly on uplifted Upper Triassic volcanic rocks.

The unconformable contact that separates underlying Stuhini Group strata from some of the oldest rocks of the Toodoggone formation crops out at several localities in the vicinity of Kemess Creek. At the most southerly exposure of the Toodoggone formation, recessive, crumbly weathered reddish crystal-ash tuffs underlie a flat-topped plateau. The morphology of this plateau is believed to reflect a relatively thin capping of gently inclined bedded pyroclastic units from the basal Adoogacho member. Although there is a 10 metre gap in outcrop, underlying rocks of the Stuhini Group consist of aphanitic basaltic flows with moderate north dipping interbeds of calcareous siltstone and rare, thin, grey limestone. Rocks of the Adoogacho member are most widespread northeast of the Saunders-Wrich fault between Kemess and Attycelley creeks. They consist exclusively of fragmental rocks dominated by crystals admixed with lapilli-size accessory lithics and, in places, blocks. Thin, well bedded intervals with concentrations of crystal and lithic fragments may be due to reworking of the tuffs near their original site of deposition. Although most of the tuffs lack welding, there are weak to moderately welded zones that commonly form resistant bluffs, characterized internally by flattened and aligned pyroclasts.

Regionally, the Adoogacho member is sharply overlain by the Metsantan member. The Metsantan member is composed mainly of trachyandesite flows, intercalated debris flows, finer intraformational epiclastic beds, and some thinly bedded maroon ash and crystal tuffs. Rocks resembling the Metsantan member underlie a series of interconnected ridges southwest of Giegerich Peak. They cover an area of about 10 square kilometres, and are in fault contact with the western margin of the Early Jurassic(?) Giegerich pluton. Lava flows predominate. They are relatively homogeneous light grey-green andesites containing up to 35% phenocysts. The phenocrysts, listed in order of abundance, include: 20 to 30% subhedral plagioclase between 2 and 4 millimetres, 3 to 7% prismatic chloritized hornblende up to 6 millimetres long, scarce chloritized biotite, up to 3 millimetres in diameter, and rare quartz. A variety of epiclastic rocks and fine tuffs comprise sporadic crudely bedded intervals of variable thickness between the monotonous massive flows. The coarsest epiclastic deposits are typically unstructured and contain poorly sorted subangular and subrounded monolithic fragments up to one-half metre in diameter, that are derived from the enclosing andesite flows, supported by a matrix of plagioclase grains and mud. These deposits may have originated as debris flows, however, because there are conglomerate layers dominated by well rounded clasts and also interspersed sandstone and siltstone beds; they evidently attest to periodic reworking of loose debris mantling the flows. Tuff beds are uncommon, but those present consist of relatively thin, ash and crystal-rich varieties.

Strata of the Metsantan member apparently wedge out across a broad valley to the west and southwest from the main area of exposure. The most southerly outcrops of the Metsantan member are sporadically exposed on the lower, north-facing slope of the east trending ridge immediately north of Attycelley Creek. Here it is represented by cobble and boulder conglomerate composed of clasts that closely resemble the texture and composition of flows diagnostic of the Metsantan member. These deposits appear to pass topographically upwards into overlying tuffs assigned to the Attycelley member.

The Attycelley member, as stated previously, resembles conformably overlying rocks of the Saunders member in mineralogy and genesis; both are products of a presumably continuous explosive eruptive event. In this report, however, the Attycelley member is considered to be a subdivision of the Saunders member, comprising the lower of two divisions.

The lower division of the Saunders member is a heterogeneous succession of tuffs and reworked tuffs that crop out adjacent to the central part of Attycelley Creek. Locally they rest with angular discordance on a thick succession of bedded conglomerates and finer clastic rocks that directly overlie the Stuhini Group. Where the lower division is apparently thickest, north of central Attycelley Creek, it is conformably overlain by ash-flow tuffs characterizing the upper division of the Saunders member. Farther west and southwest, towards Duncan Lake and Kemess Creek, the lower division is absent, presumably due to a depositional pinch-out. However, ash-flow tuffs of the upper division apparently thicken, forming a resistant caprock directly overlying the Stuhini Group. In the vicinity of the Kemess North deposit, these rocks are intensely altered adjacent to the Early Jurassic Duncan Lake granodiorite.

The stratigraphic base of the lower Saunders division is locally exposed in the area northeast of the Saunders-Wrich fault between Attycelley and Kemess creeks. The contact is placed at the first occurrence of tuffs that locally have an angular unconformable relationship with the underlying oxidized red conglomerates, sandstone and siltstones that mark a major erosional surface developed on the Stuhini Group. The conglomerates along this paleosurface may be absent, in which case biotite and quartz-bearing tuffs of the lower division disconformably overlie pyroxene phyric flows of the Stuhini Group. Elsewhere correlative epiclastic rocks which are particularly well exposed locally along a northeast striking fault that intersects the Saunders-Wrich fault in the southwest, occupy an intact section more than 250 metres thick. It is composed of two lithologically distinct conglomeratic units. The lower conglomerate, approximately 30 to 50 metres thick, and massively bedded consists exclusively of red oxidized rounded clasts, some as large as 1.5 metres in diameter, in a relatively scant, but well indurated matrix. The clasts are predominantly basalts resembling those of the Stuhini Group, and include bladed feldspar porphyry, aphanitic and amygdaloidal varieties and pyroxene-plagioclase porphyry. This conglomerate is sharply overlain above a sharp disconformable contact by a sequence composed of planar bedded alternating conglomerates, sandstones and siltstones more than 175 metres thick. This sequence is distinguished from the lower conglomerate by its pronounced stratification and the ubiquitous presence of small amounts of quartz, with or without biotite in both the fragmental volcanic clasts and the matrix. Typically the clasts are well rounded, ranging from granules to cobbles and rarely up to 2 metres across. They are dominantly crystal tuffs and lithic-rich tuffs similar to rocks of the Toodoggone formation. Near the base of the upper conglomerate, rare reworked clasts of the underlying Stuhini Group conglomerate are present. Large boulders are sometimes concentrated in lenses that occupy broad channels cut into the underlying planar beds. The conglomerates are generally poorly sorted, alternating or grading upwards into finer grained clastic beds. The upper contact of this sedimentary section is a profound angular unconformity locally with fragmental rocks of the lower Saunders division.

Between Attycelley and Kemess creeks, the lower division of the Saunders member is predominantly recessive, dark grey-green to maroon lapilli tuff, crystal-lithic tuff, tuffite and a subordinate volume of volcanic breccia. Lava flows are virtually absent from the succession. Most of the rocks are rich in crystals, dominated by plagioclase with much less abundant hornblende, biotite and quartz. In rocks containing both mafic minerals, hornblende generally exceeds biotite and together they may account for 5 to 7 volume percent of the rock. Quartz in the rock rarely exceeds 3 volume percent; typically it forms angular grains 1 to 2 millimetres in diameter. Lithic fragments are commonly of lapilli size and make up less than 20 volume percent of most tuffs. They consist mainly of brick red-brown aphanitic and green to maroon porphyritic andesites. The porphyritic fragments generally contain either hornblende or biotite and quartz, and most are dacitic. Rare bedding in the tuffs is generally defined by a change in pyroclast volumes or a variation in grain size, or, in some instances, incipient welded textures. Epiclastic interbeds locally provide superb stratigraphic markers within the monotonous tuffs. For example, south of central Attycelley Creek an interval of volcanic sandstones, siltstones and fine grained conglomerate 30 metres thick is traceable continuously for about 4 kilometres.

The recessive, crudely bedded friable tuffs of the lower division readily distinguish it from more competent, cliff-forming ash flows of the upper division. The contact between divisions is abrupt and best observed north of central Attycelley Creek. There tuffs of the lower division form pink weathering scree capped by ash-flow tuffs of the upper division which form craggy cliffs. Regionally the ash-flow tuff appears to be a single homogeneous cooling unit which is characterized by uniform incipient welding and devitrification that weathers to yield well indurated angular blocks. The rock is dacitic, composed of 30 to 35% broken crystals and comparatively few lithic clasts. The crystals include plagioclase, sanidine, hornblende, biotite and quartz in varying proportions; most are 2 to 4 millimetres in diameter. Quartz, one of the more diagnostic components in the ash flow is commonly resorbed or bipyramidal; abundance varies from 1 to 7 volume percent. The grey-green groundmass of the rock is composed of a fine grained anhedral quartz and feldspar, formed as product of devitrification, along with vestiges of primary glass fragments devitrified to coalescing spherulites. The "classic grey dacite", as it is called in the field, contains cognate vitrophyric pyroclasts which are typically compressed to define a distinctive compaction fabric in the ash flows. Moderately welded rocks containing these fragments crop out mainly north of central Attycelley Creek. In less welded exposures to the west and southwest accidental lithic pyroclasts predominate, consisting mainly of basaltic lithologies derived from the Stuhini Group and lesser pink granitoids. The lithic fragment have subrounded to subangular outlines, form blocks up to one-half metre in diameter and occur in concentrations that range from sporadic to up to 30% of the rock. Rare bedded sandstones and siltstones conformably overlie the upper division These were seen at a single locality on the southwest side of the Saunders-Wrich fault, at Kemess Creek. Detritus in these rocks suggest a nearby Toodoggone formation source.

The range of isotopic ages determined for the Toodoggone formation are summarized in Diakow *et al.*, (1993). Within the study area, previous K-Ar dates indicate the duration of volcanism extended from roughly 204 to 182 for the Adoogacho and upper division of the Saunders member, respectively. Subsequent $^{40}Ar/^{39}Ar$ dating compressed this timing somewhat to 196 and 193 Ma. Additional samples have been collected to better determine the onset of Saunders volcanic activity and to constrain the duration of an Early Jurassic erosional event which separates the two discrete volcanic cycles that regionally comprise the Toodoggone formation.

MAJOR INTRUSIONS

Figure 2 shows the regional distribution of Mesozoic intrusions along the eastern margin of Stikinia and adjacent Quesnellia. The economic importance of these suites is illustrated by their association with copper-gold porphyry deposits. Known mineralized prospects include the Mount Milligan deposit (299 Mt; 0.45 g/t Au; 0.22% Cu; Sketchley *et al.*, 1995), the Lorraine deposit (10 Mt; 0.34 g/t Au; 0.7% Cu; Bishop *et al.*, 1995) and, in the study area, the Kemess South (200 Mt; 0.63 g/t Au; 0.224% Cu) Kemess North (no mineral inventory; Rebagliati *et al.*, 1995a) and Pine (40 Mt; 0.57 g/t Au; 0.15% Cu) deposits (Rebagliati *et al.*, 1995b).

The Kemess and Pine deposits are associated with Early Jurassic (*ca.* 202 to ~190 Ma) calc-alkaline intrusions of the Black Lake intrusive suite, which cut Triassic and older strata along the eastern margin of Stikinia (Woodsworth *et al.*, 1992). Diakow *et al.* (1993) described the Black Lake stock as a pink granodiorite to quartz monzonite with coarse to medium grained hypidiomorphic-granular texture. Modal mineralogy of the rock comprises plagioclase, orthoclase, quartz, hornblende and biotite with accessory apatite, zircon and magnetite. The important Kemess South copper-gold porphyry deposit is associated with a monzonitic intrusive body, the Maple Leaf intrusion, of presumed Early Jurassic age. The Kemess North porphyry deposit occurs between the Duncan Lake pluton and the Sovereign pluton; intrusive bodies of similar composition. The absolute ages of these intrusions is integral to interpreting the age of mineralization and alteration at Kemess North. By contrast, copper-gold porphyry mineralization at the Mount Milligan and Lorraine deposits to the south occurs in alkaline intrusions, at or near the western margin of Quesnellia (Figure 2; McMillan *et al.*, 1995). Mount Milligan is hosted by small monzonite intrusions that yield U-Pb dates of about 182 to 183 Ma. (Sketchley *et al.*, 1995). Like Mount Milligan, the Lorraine deposit (Bishop *et al.*, 1995) is associated with alkalic intrusions which are phases of the Hogem batholith, an intrusive complex that yields Early Jurassic to Early Cretaceous radiometric dates (Garnett, 1978).

Giegerich Pluton

The Giegerich pluton is a dominantly granodioritic intrusion which forms craggy topography throughout the north-eastern part of the study area. Many smaller intrusions in the study area have very similar texture and modal mineralogy, but there is no evidence to indicate that they are comagmatic. Stock and batholith-size intrusions have apparently intruded structurally prepared country rocks, indicated by elongate bodies with steeply dipping faulted contacts.The Giegerich pluton itself cuts Stuhini Group sedimentary and volcanic rocks in this area (Figure 3). The trend of the contact is rectilinear, with alternating 020° and 140° azimuth orientations, progressing northward; these directions are subparallel to the general trends of regional fault sets, the latter direction typified by the Saunders-Wrich fault. Faults with these trends host and may have, to some extent, channelled mineralizing fluids. Rebagliati *et al.* (1995b) noted a northeasterly elongation of an induced polarization anomaly on the Pine property, interpreted as the effect of a northeasterly trending fault, approximately 1.5 kilometres from the margin of the Giegerich pluton.

The Giegerich batholith is an homogeneous biotite-hornblende granodiorite. The rock is typically equigranular, with a grain size of 2-3 millimetres. It contains 10-15% mafic minerals, dominantly subhedral hornblende and subordinate, euhedral to subhedral biotite. Subhedral plagioclase forms as much as 15% of the rock; crystals are as large as 5 millmetres. The equigranular interlocking groundmass consists of 30% plagioclase, 15% intersertal potassium feldspar and as much as 10% intersertal quartz. A more mafic, finer grained rock contains as much as 30% anhedral hornblende and is a possible border phase. Texturally and compositionally, the intrusion is very similar to the Black Lake stock, north of the Finlay River. The intrusion is unfoliated, except along its western contact, where aligned hornblende crystals locally define a weak fabric that is commonly perpendicular to the orientation of the contact.

A sample of granodiorite collected near the centre of the pluton is being analysed for a U-Pb zircon date.

Duncan Lake Pluton

The area immediately east and west of the northern end of Duncan Lake is underlain by intrusive rocks very similar in texture and composition to that of the Giegerich pluton. The Duncan Lake pluton apparently extends northward, across the valley of Attycelley Creek; exposed below treeline on the southwest facing slope of a mountain. The pluton is faulted against Paleozoic rocks west of Duncan Lake and to the east, the intrusion appears to plunge southeastward beneath the Kemess North deposit; altering adjacent dacitic ash-flows that form the stratigraphic top of the Lower Jurassic Toodoggone formation. Similar alteration in both the intrusion and the Jurassic country rocks, co-spatial to the deposit, suggests the mineralizing hydrothermal fluid system may be a syn to post 193 Ma event. This event is inferred from previously published K-Ar and $^{40}Ar/^{39}Ar$ dates determined for cooling of the Duncan Lake pluton (Cann and Goodwin, 1980) and crystallization of correlative ash-flow tuffs (Diakow et al., 1993). During this study samples from both the Duncan Lake pluton and the ashflows were collected for U-Pb zircon age determinations in order to refine the timing of events at Kemess North.

The Duncan Lake stock is an homogeneous, equigranular to weakly porphyritic hornblende-biotite granodiorite that weathers to crumbly talus with a distinctive salmon pink to sandy brown colour. It is composed of 40-45% subhedral tabular plagioclase; including rare phenocrysts up to 7 millimetres long, 10-15% subhedral prismatic hornblende, with rare phenocrysts as large as 7 millimetres, and 5-10% subhedral to euhedral, tabular to prismatic biotite that form rare phenocrysts as large as 6 millimetres. The mafic minerals usually do not exceed 20% of the whole rock and although they appear to be first-formed, smaller hornblende crystals are also intergrown with plagioclase. The mafic minerals are commonly replaced by felted aggregates of chlorite; less commonly, plagioclase is partially epidotized. Intersertal phases consist of 15-20% white potassium feldspar and 5-10% grey quartz. Trace amounts of prismatic apatite and 5-10% microcrystalline magnetite occur in the groundmass of the granodiorite.

Sovereign Pluton

The Sovereign pluton crops out sporadically to the south of the Kemess North deposit. It is a hornblende-biotite granodiorite with a U-Pb date of 202.7 +1.9 -1.6

Ma. (J.K. Mortensen, personal communication, 1996). The age of this intrusion is important because of altered and mineralized rocks of the Saunders member (*ca.* 193 Ma) adjacent to the Kemess North deposit. This suggests that the mineralizing episode may be unrelated to the Sovereign intrusion or possibly, there are overprinting hydrothermal events. The Sovereign intrusion is unaltered except for a moderately strong envelope of epidote and pyrite alteration present near its intrusive contact with volcanic rocks of the Stuhini Group.

The composition of the Sovereign pluton is very similar to that of the Giegerich and Duncan Lake intrusions, described above. The rock is porphyritic and light brownish grey on fresh surfaces, weathering to light brown or beige. Phenocrysts comprise 25-30%, 1 to 6 millimetre subhedral plagioclase; 5-10%, 1 to 4 millimetre subhedral to doubly terminated quartz, and 10% euhedral to subhedral hornblende and biotite. Potassium feldspar occurs entirely as a microcrystalline phase in the groundmass.

The only significant petrographic difference apparent in hand specimen between the Sovereign pluton and the Giegerich and Duncan Lake intrusions is the presence of quartz phenocrysts in the former; quartz also occurs in abundance in the other intrusions; but, as an intersertal phase. The possibility of a comagmatic origin cannot therefore be rejected on the basis of modal mineralogy alone. The chemical variations and petrogenesis of the three intrusions lie outside the scope of this report, but Cann and Godwin (1980) noted that the single sample taken from the quartz-phyric Sovereign pluton did not lie on the Rb-Sr isochron obtained for the Duncan Lake stock, strongly suggesting that the Sovereign pluton is part of a discrete isotopic and chemical system.

Maple Leaf Sill at the Kemess South Deposit

The Kemess South deposit is hosted by the Maple Leaf sill, which intrudes Stuhini Group volcanic rocks. The intrusion is completely covered by overburden, encountered only in diamond drilling. Rebagliati *et al.* (1995a) describe the Maple Leaf intrusion as a plagioclase-porphyritic quartz monzodiorite to quartz monzonite, containing 40-60% plagioclase, 5-10% potassium feldspar, and 5-15% quartz, and, with scarce mafic minerals and accessory sphene, rutile, zircon and apatite.

The intrusion from the hypogene ore test pit, located at the eastern margin of the orebody was sampled for zircons and a U-Pb age determination. The sampled rock displays strong replacement of original minerals by aphanitic potassium feldspar. Because of the intensity of alteration primary textures in the supposed plutonic rock are obscured and, in places the mineralized rock resembles sparsely quartz-phyric volcanics of the Toodoggone formation.

Quartz Monzonite North of Serrated Peak

Near Serrated Peak a quartz monzonite intrusion, which is coarser grained and more potassic than other plutons in the study area, forms an elongate body with subvertical faulted contacts that are roughly parallel to the Finlay-Ingenika fault, immediately to the east. The western margin is a steep, north trending fault which brings the intrusion against a foliated, amphibolite grade metavolcanic border to an Alaskan-type hornblende gabbro stock. The eastern margin is also a steeply dipping fault that juxtaposes the intrusion against a greenstone-chert-limestone sequence of probable Paleozoic age. These faults are evident as distinct linear features on airphotos.

The rock is coarse grained, equigranular and non-porphyritic. Mottled purplish pink and grey on fresh surfaces, it weathers to pale pink or white. All mineral phases are anhedral with a grain size of 3 to 5 millimetres in interlocking non-foliated fabric. They comprise 45-50% plagioclase, 30-35% potassium feldspar, 10-15% quartz and 2-5% chloritized hornblende. Weak, to locally moderate pervasive epidote alteration is present near the contacts.

The quartz monzonite is intruded by two types of dikes. Most are between 2 and 20 metres wide, but on the ridge immediately north of Serrated Peak, a dike is up to 100 metres wide. The older phase of dikes are porphyritic; phenocrysts comprise 25-30% subhedral plagioclase between 3 and 6 millimetres in diameter, 5-10% subhedral hornblende between 1 and 2 millimetres and several percent chloritized biotite. In turn these dikes are locally cut by weakly augite-porphyritic to aphanitic basaltic dikes up to 1.5 metres in diameter. Isotopic age measurements are not available for the quartz monzonite, but we speculated it may be as young as Cretaceous.

Hornblende Gabbro and Hornblende-Biotite-Olivine Clinopyroxenite Near Serrated Peak

Coarse grained mafic and ultramafic rocks that closely resemble Alaskan-type ultramafic bodies intrude Stikinian Upper Triassic and Paleozoic rocks 4 kilometres to the north and on a ridge 2 kilometres southwest of Serrated Peak (Figure 3). The northernmost and larger of these mafic plutons underlies an area greater than 2 km^2. It comprises coarse to medium-grained hornblende gabbro, composed of anhedral plagioclase occupying irregular interstices between randomly oriented subhedral to euhedral prismatic hornblende phenocrysts. Grain size is usually between 2 and 4 millimetres, but an almost pegmatitic variant of the pluton contains hornblende phenocrysts as long as 6 centimetres. The southern and southwestern parts of the pluton are in intrusive contact with amphibolite facies metavolcanic rocks. Based on the preponderance of pyroxene-bearing mafic flows and sparse, coarse bladed plagioclase phyric flows in the metavolcanic assemblage bordering the pluton, the protolith is believed to be the Upper Triassic Stuhini Group.

The mafic intrusion exposed at the southern locality may underlie a much larger area, since it was only briefly examined along the crest of a northwest trending ridge. On this ridge, the northwest contact appears to be a steep fault with a chert-limestone-argillite succession of probable Paleozoic age. Amphibolite facies metavolcanic rocks, similar to those described above, locally form a narrow border to the intrusion. The intrusion is classified as wehrlite, comprising 50-55% anhedral to subhedral clinopyroxene, 20% relict olivine and up to 30% antigorite, pseudomorphous after the olivine. Biotite is present as minute grains ranging from trace to 2%. Grain size is approximately 4 millimetres.

DIKES

Dikes of mafic to felsic composition are more commonly solitary, although swarms may be present, particularly near the northwest margin of the Giegerich pluton. Most of the dikes have either a northwest or northeast trend and dip steeply, parallel to the main structural fabric of the study area. The dikes are grouped roughly on their bulk composition and/or phenocryst assemblage.

Feldspar ±Quartz Porphyry

Volumetrically, feldspar porphyry dikes, with or without quartz phenocrysts are the most common small intrusion and bear a strong resemblance to larger granodiorite plutons (*e.g.*, Giegerich, Duncan Lake and Sovereign) in the map area. The density of these dikes is highest cutting the Toodoggone formation near the northwestern contact of the Giegerich pluton and transecting ridges underlain by the Stuhini Group east and southeast of the Kemess North deposit. In both areas they typically intrude along vertical extensional faults that trend northwest.

The dikes are typically light pink to red and vary in width from 1.5 to 8 metres. Phenocrysts comprise up to 35 volume percent of the rock, dominated by subhedral plagioclase 2 to 6 millimetres in diameter. Two to seven percent subhedral hornblende up to 6 millimetres long and several percent biotite, averaging 2 millimetres in diameter, are nearly always present and partly replaced by chlorite. Potassium feldspar is found locally as scarce phenocrysts. Quartz, which commonly occurs as small sparse phenocrysts, may locally be present as grains averaging 3 millimetres in diameter, in volumes up to 7%.

Basaltic Dikes

Dark green basaltic dikes consist of aphanitic and porphyritic varieties that locally cut the feldspar-quartz porphyry dikes. Typically they are narrow, between 0.5 and 2 metres wide and intruded along structures with general trends of 030° and 140° azimuth. Porphyritic dikes characterized by euhedral augite phenocrysts intrude the Paleozoic and Upper Triassic sequences. Because of the close mineralogic resemblance of these dikes to augite phyric flows of the Stuhini Group they may represent feeders for the basaltic volcanism. The youngest mafic dikes have an aphanitic texture and locally intrude strata of the Toodoggone formation. They are aphyric with plagioclase microlites and a chloritized mafic phase which was probably small anhedral augite.

Megaphyric Quartz Porphyry

Dikes containing conspicuous quartz phenocrysts as large as 1.5 centimetres in diameter are exposed in the cirque headwall south of the Kemess North deposit, immediately to the north of the Kemess South deposit, and at two isolated localities near the northern end of Thutade Lake, and along the Firesteel River. With the exception of the dike at Thutade Lake which is about 15 metres wide, dikes at the other localities vary from 30 metres to more than 100 metres wide. The rock contains as much as 20% subhedral grey quartz phenocrysts in a pale grey or pale green porcellaneous groundmass.

The largest of these intrusives near Kemess North intrudes along a fault that separates ash-flow tuffs of the Toodoggone formation from bladed plagioclase-phyric and clinopyroxene phyric basalts of the Stuhini Group. The dike is mineralized with as much as 5% disseminated pyrite and is locally pervasively epidotized which suggests that it predates mineralization at Kemess North, but postdates some northerly faults that may have channelled the mineralizing solutions.

STRUCTURE

Structures within the map area are dominated by a system of high-angle normal faults, and possibly contractional faults that are mapped mainly in the vicinity of Serrated Peak. The magnitude of motion on most faults is believed to be minor. Minor dislocations within solitary map units are indicated by abrupt changes in bedding attitudes and lateral discontinuity of lithologically distinct rocks. The most prominent high angle faults trend between 120° and 150° azimuth with conjugate sets of secondary faults trending from 20° to 40° and 60° to 80° azimuth. This pattern of faulting is documented regionally in the Toodoggone River map area where it has locally imparted primary control on the deposition and distribution of the Lower Jurassic Toodoggone formation, aided high-level emplacement of comagmatic plutons and provided sites for precious metal-bearing epithermal deposits (Diakow *et al.*, 1993).

Several major faults in the map area are associated with topographic lineaments, as in the case of the Saunder-Wrich fault. The Saunders-Wrich fault is a regional-scale structure traceable imtermittantly for over 30 kilometres northward to the Toodoggone River valley and possibly beyond (Diakow *et al.*, 1993). South of the Finlay River this structure coincides with three valleys aligned to the northwest but separated by Attycelley and Kemess creeks. This fault places the youngest rocks of the Toodoggone formation against Upper Triassic and older strata. Similar granodiorite bodies exposed across the fault near Kemess Creek are interpreted to represent displaced segments of a solitary intrusion. If this assumption is correct, up to 4 kilometres of right lateral strike-slip movement is indicated. The southeastern extent of the Saunder-Wrich fault presumably occurs at an inferred intersection with a younger thrust fault(?)west of Serrated Peak that carries Permian and Triassic rocks and places them against the Toodoggone formation. This is contrary to an earlier interpretation (Diakow *et al*, 1993), in which the trace of the Saunders-Wrich fault was extrapolated to the southeast through the valley southwest of Serrated Peak and beyond, to its terminus at the northerly trending Finlay-Ingenika fault.

Other important northwesterly trending faults are mapped along the cirque headwall of the Kemess North deposit. Here steeply dipping faults with slickenslides that indicate dip-slip movement place locally intensely oxidized and altered rocks of the Stuhini Group against comparatively unaltered rocks of the Toodoggone formation. Steep faults oriented towards the northeast are also numerous in the map area; however, their timing relative to the northwest faults is generally ambiguous, suggesting periodic reactivation of one or the other structures.

Together these more or less orthogonally oriented extensional faults provide structural control for a variety of intrusive rocks in the map area. There importance as a fundamental control for larger plutons is exemplified by the Giegerich pluton. The western contact of this pluton is essentially an interconnected series of steeply dipping faults juxtaposed with slivers of the Stuhini Group, which in turn are faulted against more widespread stratigraphic units of the Toodoggone formation. The contact displays a pronounced rectilinear configuration that approximates the regional structural fabric. Moreover, this inherent control in the country rocks bordering the pluton is manifest in local dike swarms of pink, feldspar phyric, with of without, quartz porphyry and aphanitic basalt, which maintain a consistent northwest trend.

Prominent north striking faults delimit the eastern margin of the Giegerich pluton and juxtapose it against presumably younger quartz monzonite and Paleozoic strata near Serrated Peak (Gabrielse *et al.*, 1977). These faults represent probable en echelon strands of the right lateral strike-slip Finlay-Ingenika fault system. The Finlay-Ingenika fault presumably coincides with the broad valley trending north, in part, along the eastern margin of the Giegerich pluton and, farther north, along the north flowing segment of the Finlay River. It marks a tectonic boundary along the eastern side of the study area that separates mainly brittly deformed, zeolite grade rocks in Stikinia to the west from penetratively deformed greenschist to amphibolite grade rocks in Quesnellia and ancestral North America to the east. Movement along this and other interconnected major right-lateral faults in the northern Canadian Cordillera occurred in Cretaceous and Early Tertiary time (Gabrielse, 1985).

Paleozoic and Triassic rocks, near Serrated Peak, comprise a structural panel apparently thrust locally to the west-northwest onto relatively flat lying Lower Jurassic rocks of the Toodoggone formation. Axial planes in locally folded Lower Permian(?) chert generally trend to the northeast, and dip moderately to the southeast. Bedding attitudes in the hanging wall strata vary markedly, disrupted by numerous high-angle faults that strike to the northeast, subparallel to a prominent regional set of older extensional faults. The outcrop area of the Adoogacho member of the Toodoggone formation narrows south of Kemess Creek, possibly the consequence of local contraction faults.

COPPER-GOLD PORPHYRY DEPOSITS

Copper-gold porphyries related to Early Jurassic plutons are the principal exploration target in the study area and along the tract of Mesozoic arc volcanic and plutonic rocks that extend southeastward into the McConnell Range. The Kemess South and Kemess North deposits are significant examples of this style of mineralization and both deposits are located within the study area. A history of development of the deposits is described in detail by Rebagliati *et al.* (1995a); a brief synopsis of these deposits is given here in addition to observations made during this study.

Kemess South (MINFILE 94E 094)

The Kemess South deposit consists of a supergene zone, containing native copper in a hematite-rich hostrock and hypogene ore zone, with pyrite, chalcopyrite and minor molybdenite lining fractures in variably clay altered and potassium enriched rocks.

The deposit is hosted mainly by the Maple Leaf monzodiorite sill which underlies an area of about 2 square kilometres, but is concealed by a thin veneer of glacial till. The sill is 75 to 175 metres thick in the vicinity of the deposit, with a base that is gently undulose in its eastern part and gently inclined towards the southwest at its western edge. To the south it thins to less than 30 metres and to the north the North Block Fault truncates and juxtaposes the sill against probable Paleozoic chert and argillite overlain by Stuhini Group volcanic rocks. Further study of the fault and its motion is integral to future exploration for a possible northern extension of the ore body.

Rocks exposed in the hypogene test pit, located near the eastern edge of the orebody contain subtle quartz phenocrysts, which has led to the possible presence of altered and mineralized volcanic rocks resembling the Toodoggone formation. The closest rocks of the Toodoggone formation are exposed 5 kilometres north at the Kemess North deposit. They are sparsely quartz phyric ash-flow tuffs which represent the stratigraphic highest unit of the Toodoggone formation that yields Ar-Ar dates of about 193 Ma, elsewhere to the north. Uranium-lead zircon geochronometry on a sample from the hypogene zone will provide a relative age date for mineralization at the Kemess South orebody and test its contemporaneity with intrusive and mineralizing events at Kemess North.

Chert-bearing clastic sedimentary rocks of the Cretaceous Sustut Group, exposed as a thick succession west of the study area, may have extended to cover the Kemess South deposit, but no supporting field evidence was found during the course of the study. Our work indicates that the hanging wall strata exposed to the south of the deposit are friable maroon weathering volcanic rocks, covered to the south and west by progressively greater thicknesses of Pleistocene fluvioglacial boulder- and cobble-bearing gravels.

Kemess North (MINFILE 94E 021)

The Kemess North porphyry prospect is six kilometres north of the Kemess South deposit. Copper and minor molybdenum mineralization is centred on a northeast trending swarm of porphyritic dikes of intermediate composition concealed by a broad gossan which lies along the periphery of two isolated granodiorite intrusions that locally cut and alter volcanic rocks of the Stuhini Group and Toodoggone formation.

The gossan is crudely defined by an oxidized halo with pyrite and inner , alternating argillic and phyllic zones, dominated by clay minerals, quartz, sericite and pyrite. Pervasive alteration has overprinted all primary minerals in the country rocks near the deposit. The Stuhini Group volcanic and sedimentary rocks are moderately to strongly epidotized and chloritized, and have patchy areas of complete replacement by fine-grained grey silica. The altered Toodoggone volcanic rocks contain pervasive argillic and phyllic alteration but can still be distinguished by their infrequent quartz phenocrysts. To the south, the alteration becomes patchy in Stuhini and Toodoggone rocks underlying the headwall of the Kemess North cirque and to the north, an area of poor exposure separates the alteration zone from the Duncan Lake stock.

The Sovereign pluton located south of the deposit has a U-Pb zircon age of 203 Ma. Emplacement of this intrusion may predate the hydrothermal event at Kemess North. Hornblende-biotite granodiorite of the younger(?) Duncan Lake stock is exposed to the north of the deposit. It apparently plunges southeastward beneath the mineralized zone and gossanous country rocks. The Duncan Lake intrusion yields a Rb-Sr isochron date of 190±4 Ma, which is interpreted as the time of cooling and hydrothermal alteration (Cann and Goodwin, 1980). The Saunders member of the Toodoggone formation is about 193 Ma old and the dacite is pervasively altered and locally mineralized with chalcopyrite near the deposit. Field relationships coupled with geochronology indicate that hydrothermal alteration and hypogene mineralization events at Kemess North postdate deposits of the Toodoggone formation, supporting the contention of Cann and Goodwin (1980) for a circa 190 Ma mineralizing event.

SUMMARY

Regional mapping in the Attycelley Creek map area documents three main lithostratigraphic successions. The oldest unit, widely exposed between Thutade Lake and the Kemess minesite, consist of probable Upper Paleozoic chert, limestone, basaltic and rhyolitic volcanic rocks. Upper Triassic augite phyric volcanic and associated sedimentary rocks of the Stuhini Group are extensively exposed but remain undivided; they represent mainly subaerial deposits. Lower Jurassic volcanic rocks of the Toodoggone formation unconformably overlie Upper Triassic strata. They are readily distinguished by fragmental dacitic volcanic rocks containing quartz,with or without, hornblende and biotite. The distribution of the Toodoggone formation narrows to the south where they locally appear to be overridden by a west-northwest verging thrust fault carrying Paleozoic and Upper Triassic rocks in the hangingwall. Elsewhere in the map area the structural fabric is defined by prominent high-angle extensional faults trending northwest and conjugate structures trending north-northeast.

Copper-gold porphyry mineralization is associated with an Early Jurassic plutonic suite of granodiorite to monzonite composition. The Maple Leaf intrusion, a sill-like body which hosts the Kemess South deposit, intrudes probable Upper Paleozoic chert and Upper Triassic volcanics, the latter locally form a deeply weathered profile gradational at depth into supergene ore. The protolith of potassically altered and mineralized country rocks, exposed in the hypogene ore test pit, at the eastern margin of the deposit may be correlative with the Toodoggone formation. The Kemess North deposit is situated between two granitic bodies, the Duncan Lake granodiorite and the Sovereign granodiorite. Field relationships suggest that the Duncan Lake stock may be younger, altering the youngest, Saunders member of the Toodoggone formation near the main zone of mineralization. U-Pb zircon dating of the various plutons is in progress.

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