GEOLOGICAL SETTING OF THE KEMESS SOUTH AU-CU PORPHYRY DEPOSIT AND LOCAL GEOLOGY BETWEEN KEMESS CREEK AND BICKNELL LAKE (NTS 94E/2)

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INTRODUCTION

The Kemess South gold-copper porphyry deposit is British Columbia's newest mine. With reserves of 170 thousand kilograms of gold and 441 million kilograms of copper, it is projected to be in production for sixteen years (Royal Oak Mines Inc., 1996). The deposit, discovered in 1983, is owned by Royal Oak Mines Inc. Production began from an open pit on May 19, 1998 and the first shipment of gold-copper concentrate was on June 23, 1998. The daily production in October, 1998 was 76 thousand tonnes of combined waste rock and ore per day.

During June and July of 1998 a detailed geological study of the Kemess South deposit and adjacent region was conducted by the principal author with the support of the B.C. Geological Survey Branch and Royal Oak Mines Inc. This study is part of a Master of Science thesis at the Ottawa-Carleton Geoscience Centre. The underlying purpose of this study is to determine the geological setting and genesis of the Kemess South gold-copper porphyry deposit. This objective will be approached as follows:

- Conduct detailed mapping at 1:10,000 scale in order to determine local stratigraphy and structure and their relationship to geology within the orebody;
- Study the orebody to identify important geological features: to determine their relationships to, or controls on distribution of ore; to characterize the alteration and zoning; and to define mineral zoning in both the hypogene and supergene ore zones.

In addition, study of the Kemess deposit and surrounding prospects and geology will establish it as a representative example for comparison and evaluation of other potential porphyry-related intrusions in the region.

The study area covers 36 km^2 and is bounded to the south and west by the Omineca Mining Access Road, to the north by a major valley that connects Kemess and Duncan lakes and to the east by Kemess Creek (Figure 1). It is located on the western margin of the Swannell Ranges, an area characterized by gentle mountainous terrain and wide valleys that range in elevation from about 1200 to 1800 metres. The area is covered for the most part by trees, and swampy ground characterizes lower elevations. Rock exposures are scarce, comprising less than 5% of the study area. With recent development of the open pit at Kemess South, new exposures of the orebody provide an excellent opportunity to map internal and external stratigraphic and structural relationships.

The field program involved mapping both regionally and within the open pit and re-logging of selected drill core from the deposit to augment the surface work. This report presents only the results of mapping in and adjacent to the Kemess South orebody. This mapping will be incorporated with regional 1:20,000 scale mapping that has been ongoing for several seasons (Diakow and Metcalfe 1997; and Diakow and Rogers 1998), and is scheduled for publication at 1:50,000 scale.

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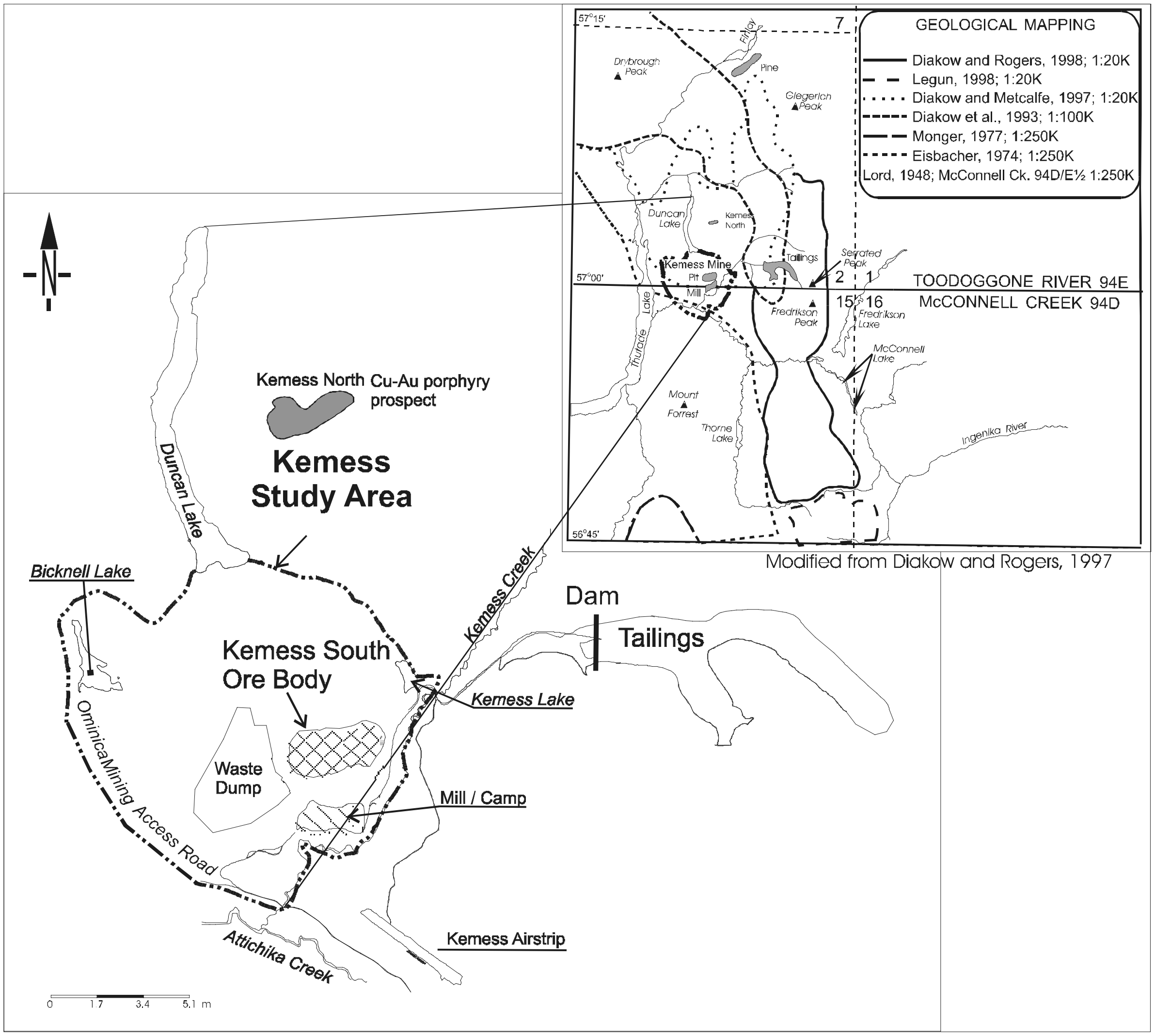

Figure 1. Location of the study area centered on the Kemess South deposit.

GEOLOGY BETWEEN KEMESS CREEK AND BICKNELL LAKE

Three distinct lithostratigraphic units are recognized in the Kemess map area and they can be correlated with major rock units that have been mapped regionally by Diakow and Metcalfe (1997) and Diakow and Rogers (1998). These major stratigraphic divisions include: the mid-Pennsylvanian to Lower Permian Asitka Group; the Upper Triassic Takla Group; and the Lower Jurassic Hazelton Group, specifically the Toodoggone Formation. In the study area the oldest rocks, the Asitka Group, consists of a sequence of rhyolitic to basaltic volcanic rocks that are succeeded by a limestone-chert succession. The Takla Group is dominated by augite-plagioclase phyric basalts. Pyritic mudstone locally marks the bottom of the Upper Triassic sequence, and volcanic sandstones comprise relatively minor, but diagnostic interbeds in an otherwise monotonous basalt flow sequence. Rocks of the Toodoggone Formation are mainly dacitic tuffs. Two previously unmapped units are exposed as a consequence of development of the open pit at Kemess. The lower unit, which rests directly on supergene ore, is composed of friable tuffaceous rocks and interspersed epiclastic beds. These were encountered in early definition drilling of the deposit, but are unlikely to be Upper Cretaceous Sustut Group as interpreted by Rebagliati and co-workers (1995); we tentatively correlate them with the Toodoggone Formation. The uppermost unit is an olivine basalt flow that directly overlies the tuff-epiclastic unit.

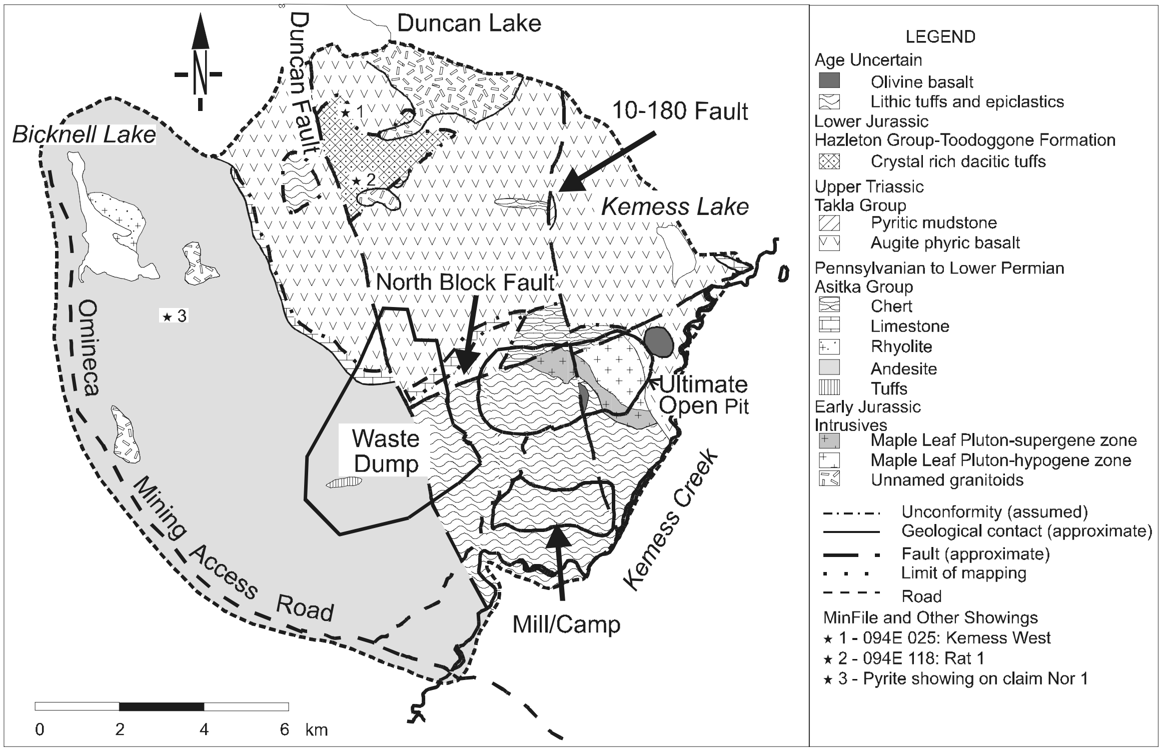

Figure 2. Geological sketch map of the Kemess map-area showing the location of the Kemess South mine.

Asitka Group

Rocks assigned to the Asitka Group underlie much of the topographically low part of the study area east of the Omineca road and west of the Duncan fault (Figure 2). In the region of the Kemess deposit, which is situated between two major faults - the Kemess fault and the Duncan fault, strata of the Asitka Group are scarce but sufficiently widespread to suggest they comprise basement. Good exposures of the Asitka Group, particularly, the upper sedimentary part comprise the foot-wall of the North Block fault, whose trace cuts across the highest benches of the open pit. The lower contact is not exposed either in the study area or regionally. However, the upper contact, which is probably an unconformity, is overlain by rocks of the Takla Group. At the contact, augite-phyric lavas lie above either distinctive andesite or limestone known to be Lower Permian and older. This contact can be traced along the south-facing slope of Duncan Ridge, southwest of Duncan Lake.

Lower Volcanic Unit

The stratigraphic subdivisions proposed for the Asitka Group in this report are based on similar rocks mapped adjacent to the study area (Diakow and Metcalfe, 1997; Diakow and Rogers, 1998). In general, the Asitka Group comprises a lower, volcanic-dominated package that passes upward into a comparatively thinner unit composed of sedimentary rocks. Within the study area, rhyolitic tuffs, which are exposed only at a solitary site in the waste rock area, are believed to represent some of the oldest deposits in the Asitka Group. They are light greenish grey and contain flattened lithic fragments that range in size from lapilli to blocks. The lithic fragments are generally crystal poor and rhyolitic in composition. Regionally, similar lithic tuffs accompany rare, thin rhyolite flows that have been sampled at several widely spaced localities and have yielded U-Pb zircon ages of about 308 Ma (Diakow, personal communication, 1998).

Up section from these tuffs is a thick and widespread light green porphyritic andesite unit. Andesitic flows underlie the entire region between the Omineca road and the Duncan fault. These andesites contains 10 to 30% blocky plagioclase crystals approximately 1 to 3 millimetres in diameter, and trace amounts of quartz as subrounded phenocrysts about 1 millimetre in diameter. The andesite flows are generally light green and contain variable amounts of epidote. Thinly bedded tuff and fine-grained sandstone layers are locally interbedded with these andesites. The tuffs are a few metres thick at two localities. They are light green and contain chloritized rhyolitic fragments. Sandstone beds interlayered locally with andesitic flow may be up to 2 metres thick. Exposed in a single location along the Omineca road, they are fine grained, light green, internally graded, and thinly to thickly laminated.

Massive basalts that are found stratigraphically beneath the andesites regionally appear to be absent in the study area. However, on the west side of the open-pit there are several outcrops of massive basalt that exhibit characteristics of both Asitka Group and Takla Group basalts. These basalts crop out slightly upslope from a small isolated exposure of Asitka Group limestone. Because the intervening area between exposures is vegetated the contact relationship is equivocal. A sample of this basalt was collected for lithogeochemical analysis, and will be compared to other basalts representative of the Takla and Asitka groups, regionally.

Upper Sedimentary Unit

Limestone and chert, with or without black argillite interbeds comprise the upper, sedimentary division of the Asitka Group in the area (Diakow and Rogers, 1998). These rocks are easily recognized and regionally are typical lithologies comprising the top of the Asitka Group below an unconformable contact with the Takla Group. West of the Duncan fault, a discontinuous 50-metre thick band of limestone that is intermittently exposed for about 6 kilometres, stratigraphically overlies porphyritic andesite and local maroon tuff on the south-facing slope of Duncan Ridge. Neither chert nor argillite occurs with the limestone in this region. East of the Duncan fault, there is a solitary exposure of limestone that lies between the open pit and waste rock area. Around the open pit, chert interlayered with black argillite is the dominant Asitka Group unit exposed. Northeast of the pit, between Kemess Lake and Kemess Creek, limestone is once again exposed, presumably brought up along a strand of the Kemess fault that trends northwest through a major valley between Kemess Lake and Duncan Lake.

Limestone of the Asitka Group is typically white, recrystallized and weathers light grey. Limestone that is exposed between Kemess Lake and Kemess Creek has an uncharacteristic light green color and contains fine grained impurities. This limestone is adjacent to several mafic, hornblende-bearing hypabyssal dykes and carries some pyrite, chalcopyrite and sphalerite mineralization. A solitary outcrop at the south end of Duncan Ridge, exposes chert interbeds in the limestone. However, in the study area, chert is generally found in thick sections without associated limestone. The best exposures of chert are in the upper benches of the Kemess open pit where it is light to dark grey and thinly bedded. The chert has partings of black mudstone and local siliceous mudstone interbeds. In pit exposures the chert-argillite beds are intensely folded adjacent to the North Block fault. Graphitic argillite with polished slip surfaces marks the fault plane in places. Indeterminate bivalves have been found in strongly sheared siliceous and graphitic mudstone adjacent to the fault.

Takla Group

Lower Sedimentary Unit

Pyritic mudstone with or without volcanic sandstone comprises the base of the Takla Group. A solitary outcrop of the pyritic mudstone is exposed on the northeast side of the ridge, behind the Kemess open pit where it was brought up along a fault that is interpreted to represent the northern extension of the 10-180 fault, which cuts the Kemess orebody. It in turn is overlain by volcanic sandstone then basalt. The mudstone is friable, light to dark brown and contains rusty sections where disseminated pyrite is oxidized. This mudstone contains fossils that resemble the Upper Triassic bivalve *Halobia*.

Volcanic sandstone is found in two localities within the map area. The first is on the east side of the ridge immediately behind the Kemess open pit, where it rests directly on top of pyrite mudstone; the second is on the west side of the same ridge where the sandstone is surrounded by Takla basalt. These two relatively thin beds average six metres in thickness. Sections are characteristically graded from light green sandy beds at the base to darker green siltstone that exhibit fine cross-laminations near the top. Volcanic sandstone and siltstone containing pyroxene grains are diagnostic of sedimentary interbeds derived by erosion of local Takla Group basaltic rocks (Diakow and Rogers, 1998).

Upper Volcanic Unit

Where present, the Lower Sedimentary unit of the Takla Group is conformably overlain by a thick monotonous succession of augite-plagioclase phyric flows. Although the basalts of the Asitka and Takla groups are very similar, Asitka Group basalts are generally aphyric, whereas Takla Group basalts typically contain approximately 5 to 20% pyroxene crystals and 15 to 35% plagioclase crystals. Confusion arises locally because some Takla basalt members may also be aphyric and some Asitka basalts are porphyritic, containing pyroxene phenocrysts.

Takla basalts cover the two highest points of land within the study area, the ridge north of the Kemess South open pit, and the south end of Duncan ridge. Although exposure is spotty, there is enough evidence to indicate that Takla basalts form dip slopes on those ridges. Because no submarine features, such as pillowed basalt, have been recognized these basalts appear to have been subaerially deposited.

HAZELTON GROUP - Toodoggone Formation

Volcanic rocks of the Toodoggone Formation underlie a small area east of the Duncan fault. They consist of a grey-green, dacitic crystal-rich ash-flow tuff. Bounded on the west by the Duncan fault, these tuffs unconformably overlie Takla basalts and are cut by unnamed Early Jurassic ? intrusive rocks. The tuffs contain diagnostic quartz phenocrysts (2-5%) and approximately 30% plagioclase crystals that are 1 to 3 millimetres in size. Alteration in the tuffs is weak, identified by sericite, chlorite and pyrite.

INTRUSIVE ROCKS

The Black Lake suite consists of a series of Early Jurassic calc-alkaline intrusions (Diakow and Metcalfe, 1997). Within the Kemess map area there are five intrusions that are thought to be part of the Black Lake intrusive suite. They include the Maple Leaf, which hosts the Kemess South gold-copper porphyry mineralization, and four other unnamed, very poorly exposed intrusions. One is located east of Bicknell Lake, another is south of the lake, and two are at the western end of the prominent ridge immediately to the south of Duncan Lake. The contacts of the intrusions have not been directly observed but some of the country rocks are recrystallized indicating an intrusive contact. The Maple Leaf pluton is discussed in a later section that deals with the Kemess South orebody.

Granitic plutons near Bicknell Lake

The largest of the intrusions, which covers less than 1 square kilometre on a knoll south of Bicknell Lake and east of the Omineca road, is near the south end of the map area west of the Duncan fault. Although no contact has been observed, andesite of the Asitka Group crop out both east and west of this intrusion. The intrusion has an equigranular texture of interlocking 2-4 millimetre crystals. It weathers light tan to buff and is pinkish white on a fresh surface. The intrusion is composed of roughly 15% quartz, 40% plagioclase, 25% potassium feldspar, 15% hornblende and 5% biotite. This mineral assemblage places the intrusion in the quartz-monzodiorite field on the Streckeisen ternary diagram.

A second intrusion approximately 1 kilometre east of the southern tip of Bicknell Lake is exposed over a distance of about 200 metres. It intrudes porphyritic andesite of the Asitka Group. The intrusion is reddish brown and weathers tan to buff. It consists of 10 to 15% quartz, 10 to 15% plagioclase, 50 to 60% potassium feldspar, and 10 to 15% biotite, placing it in the quartz syenite field of the Streckeisen ternary diagram.

Granitic plutons south of Duncan Lake

Approximately 1 kilometre south of Duncan Lake, on the northwest end of the ridge that is immediately behind the Kemess South open pit, a granitic intrusion and a megacrystic quartz porphyry crop out. The granitic rock covers an area of approximately 1 square kilometre, while the quartz porphyry is only 500 square metres in size. Disseminated pyrite is widespread in both intrusions and throughout adjacent country rocks of the Toodoggone formation and Takla Group. The intrusions cut distinctive quartz-phyric dacitic rocks of the Toodoggone formation. Also associated with these intrusions are magnetite veinlets that cut dacitic tuffs near the contact.

The granitic rock consists of 5 to 10% quartz, 50 to 60% plagioclase, 10 to 15% potassium feldspar, 10% hornblende and 5% biotite. Approximately 5% pyrite and 1 to 2% magnetite are disseminated through the intrusion. The mineral assemblage plots in the quartz-monzodiorite field of the Streckeisen ternary diagram.

The quartz porphyry contains 15 to 25% quartz crystals that are up to 15 millimetres across. The rock is altered; the original groundmass has been changed to a light green to beige mixture of clay minerals and silica that gives it a porcelaineous texture.

STRUCTURE

Two major high angle brittle faults have been mapped within the study area; the Duncan and Kemess faults. The assumed traces of these structures correspond with major valleys and have been located on the basis of significant discontinuities of lithostratigraphic units. Other important faults that provide evidence for more than one deformational event at the Kemess South deposit are well exposed in the open pit.

The trace of the most significant fault in the study area, the Duncan fault, projects to the north up the axis of Duncan Lake and presumably abuts the Early Jurassic Duncan pluton. To the south, the fault is covered by overburden for the most part, but it is believed to closely approximate the axis of a broad valley that also marks a significant change in the character of the Paleozoic rock units across the valley. West of the fault is a broad region underlain by andesitic rocks, whereas east of this structure mainly limestone and chert from the upper sedimentary division of the Asitka Group are exposed. Farther north, near the south end of Duncan Lake, the fault forms a prominent linear cleft in the slope. Here the fault places basalt of Late Triassic age west of the fault, against dacitic tuff of Early Jurassic age to the east. Juxtaposition of differing rock units along the Duncan fault is consistent with a normal fault having east-side down displacement. The actual amount of displacement is not known.

The Kemess fault, located along the northern margin of the study area, is also aligned parallel to a major valley that extends northwest from Kemess Lake to the southeast corner of Duncan Lake. On the northeast side of this structure, a thick section of aphanitic basalt and rare argillite and some chert comprising part of the Asitka Group crops out (Diakow and Rogers, 1998). A series of en echelon, valley-parallel normal faults with south-side down motion have been documented cutting these rocks (Diakow, personal communication, 1998). To the southwest, across the fault, pyroxene basalt and rare *Halobia*-bearing mudstones that form part of the lowermost sedimentary division of the Takla Group are exposed along the ridge crest north of the Kemess pit. The northeast-facing slope below these Takla exposures was not traversed, but presumably is underlain, in part, by rocks of the Asitka Group. Projection of the Takla Group toward the southwest from the ridge crest suggests they form a dip slope, and could explain the distribution of stratigraphically underlying chert and argillite of the Asitka Group, which crops out in topographically lower areas in the immediate vicinity of the Kemess South deposit.

GEOLOGY OF THE KEMESS SOUTH OREBODY

The Kemess South gold-copper porphyry deposit is a recent discovery (Rebagliati *et al*., 1995). Production began in 1998 and the projected mine life is 16 years. Kemess South is associated with an Early Jurassic sub-volcanic, calc-alkaline porphyritic quartz monzonite intrusion called the Maple Leaf pluton (Figure 3). Drill information indicates that the intrusion is a gently inclined sheet (Rebagliati *et al*., 1995) that was intruded into Takla Group basalt and is in fault contact with Asitka Group chert. Its age, based on a U-Pb zircon analysis, is 199±0.6 Ma (Diakow and Rogers, 1998). The majority of the mineralization is within the Maple Leaf intrusion. After emplacement and uplift, exposure and oxidation of the mineralized sill caused the supergene zone to form. This took place before deposition of a tuff-epiclastic sequence which directly rests on the supergene zone.

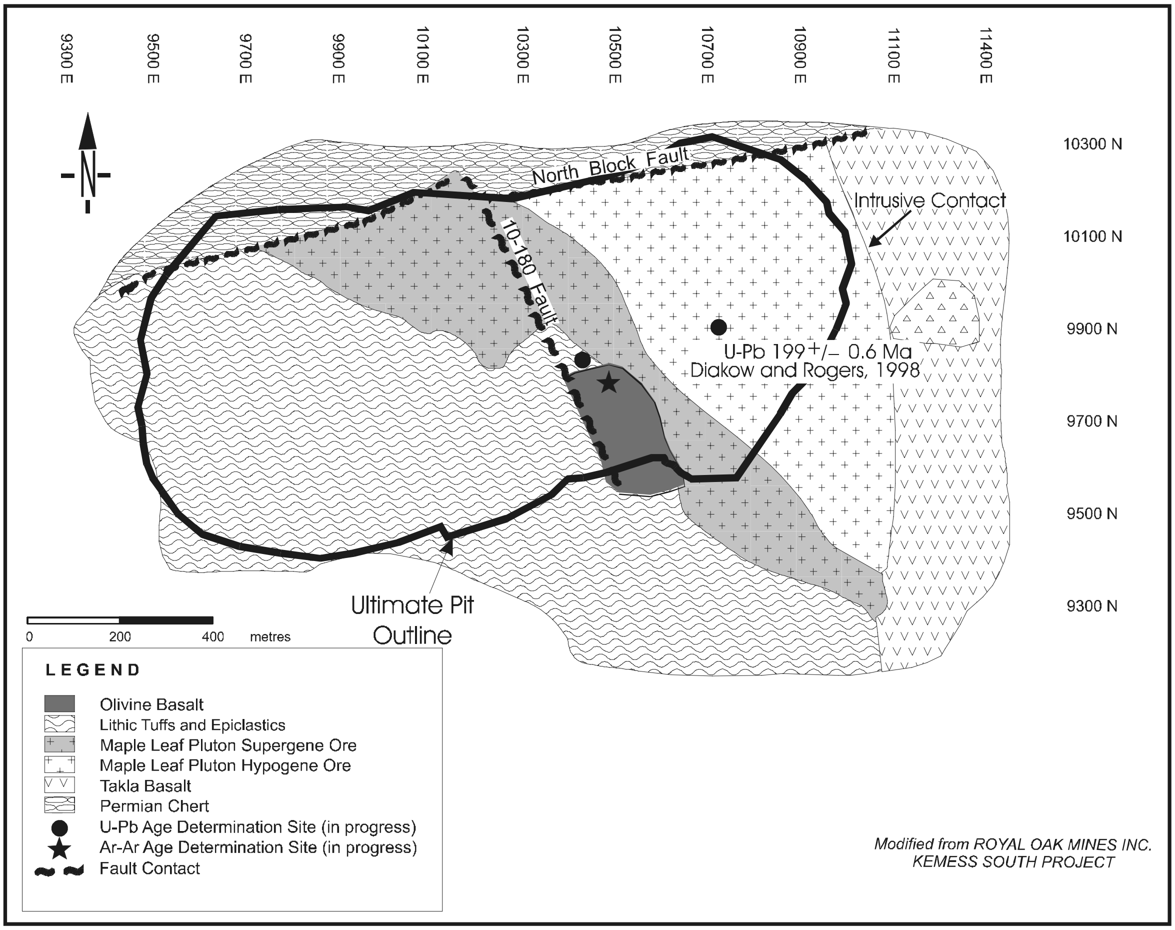

Figure 3. Simplified surface projection of major lithostratratigraphic units and ore zones at Kemess South. The U-Pb date of 199±0.6 Ma represents the emplacement age of the Maple Leaf intrusion (Diakow and Rogers, 1997).

The hypogene ore zone consists predominantly of pyrite, chalcopyrite, magnetite-hematite, bornite, with local molybdenite and important amounts of native gold. Weathering in an arid environment of the time produced the supergene cap where the overall grade is the same as that in the underlying hypogene zone (Rebagliati *et al*., 1995). The supergene blanket is 10 to 70 metres thick (Rebagliati *et al*., 1995) and contains native copper, native gold, chalcocite and oxides.

MAPLE LEAF PLUTON

The Maple Leaf quartz monzonite intrusion is a tabular body that dips to the south-west at approximately 30 degrees. The South Kemess ore zone measures 1.7 kilometres east to west, 650 metres north to south and varies in thickness from approximately 50 metres in the south to over 250 metres near the North Block fault (Rebagliati *et al*., 1995). Gold-copper mineralization extends beyond the intrusion but is uneconomic at present metal prices.

Samples of the Maple Leaf pluton seen on surface and in drill core are strongly altered. The least altered section of the deposit is near the east side of the open pit. At this locality the intrusion consists of approximately 10 to 15% quartz, 45% plagioclase, 10 to 15% potassium feldspar, and 20 to 25% mafic minerals, now mostly replaced by chlorite and local hydrothermal biotite. Also at this locality quartz veins make up approximately 5% of the rock.

One mafic dike cuts the Kemess orebody and therefore post dates mineralization at the Kemess South deposit. It is located on the east side of the deposit (herein called the East dike). The East dike was not detected in any of the four surrounding drill holes; it is assumed to be near vertical in its orientation. The dike is dark green and porphyritic in texture. It contains approximately 10 to 15% pyroxene phenocrysts that are 2 to 4 millimetres in diameter and 15 to 20% plagioclase less than 2 millimetres.

Hypogene Zone

The hypogene zone makes up approximately 75% of the Kemess South deposit and is mineralized with gold and copper. The Maple Leaf intrusion contains approximately 1 to 5% disseminated pyrite, chalcopyrite, magnetite-hematite and bornite, with minor amounts of molybdenite and traces of gold and other minerals (Rebagliati *et al*., 1995). The sulphides are hosted mainly within the Maple Leaf sill. They occur on fractures, in veins and interstitial to the feldspar crystals.

Sericite is the dominant alteration mineral associated with Kemess mineralization. Locally it comprises up to 25% of the rock. It gives the intrusion a light greenish pink color but a dirty white appearance when associated with silica alteration. As the sericite content increases in the deposit there also tends to be an increase in silica content and greater destruction of the primary minerals and original textures.

The second most abundant alteration type is pink potassium feldspar. Potassic alteration with minor sericite forms selvages on the quartz veins that can range from several millimetres to 3 centimetres in width. Sulphide veins also have pink potassium feldspar alteration envelopes and these tend to be proportionally thicker than those associated with the quartz veins.

According to Rebagliati *et al*. (1995) drilling has shown alteration patterns that are subparallel to the contact of the Maple Leaf intrusion. In cross section, a lower hematite-clay-carbonate-silica zone gives way upward to a quartz stockwork zone with associated potassium feldspar alteration which gives way upward to a strong quartz stockwork zone with potassium feldspar selvages and interstitial sericite alteration. The highest copper and gold grades occur in the intense quartz stockwork zones.

As part of this study, alteration related to Kemess mineralization will be examined in detail. Samples have been taken at approximately 25 metre intervals from 13 individual drill holes across the deposit. These samples will be analyzed to study geochemical trends, and polished thin sections will be made to study the silicate and ore minerals and their chemistry.

Supergene Zone

The supergene zone is a red oxidized zone. It contains chalcocite and two forms of native copper, as large sheets, and as tiny disseminated flecks of native copper termed “pin prick copper” by workers at the Kemess South mine, who have subdivided the supergene zone into three sub-zones. The lowest zone overlies hypogene ore and contains the “pin prick” copper, in which flakes are less than 2 millimetres in diameter and disseminated throughout the oxidized, highly clay and hematite altered intrusive rock. This zone also contains secondary sulphides, consisting of chalcocite and minor hypogene sulphides - chalcopyrite and bornite. The middle zone contains slightly larger leaves of native copper, some of them reaching 10 centimetres in diameter, and 3 millimetres in thickness. Near the top of this zone the copper is associated with planes of weakness and sheets more than 3 metres long and 50 centimetres wide have been found. This zone is more highly altered and contains up to 30% hematite-stained clay. The upper zone has been termed the “Leach Cap” by the mine geological staff. It contains elevated levels of gold, and very little copper and is characterized by the intense alteration, and contains 5 to 10% quartz and relict plagioclase crystals.

Typical rocks from the supergene zone are reduced to a hematitic mud in drill core making an in-depth study difficult. However, 12 sample were collected from the Kemess South open pit for petrographic analysis. The samples were collected approximately 10 metres apart; three representative samples from both the top and bottom units, and three from the upper and three from the lower section of the middle unit.

POST-ORE LAYERED ROCKS

Tuff-epiclastic Unit

The supergene zone of the Maple Leaf pluton is overlain by poorly indurated lithic tuffs, and interbedded epiclastic rocks. This unit does not crop out at surface near the orebody, however, drilling has shown that it is widespread in the subsurface, thickening towards the southwest to more than 200 metres. Similar rocks also crop out along Kemess Creek, south of the mine site, where cut banks up to 60 metres high are dominated by reddish brown to maroon epiclastic rocks. Farther downstream these rocks are covered by glacial till. West of the Duncan fault, bedded epiclastic rocks with similar lithologic characteristics crop out sporadically in a small area, approximately 100 by 200 metres. They consist of a relatively flat lying bedded sequence more than 25 metres thick exposed along an unnamed creek. The lower contact is not exposed, however, basalts of the Takla Group crop out nearby and suggest a probable unconformity.

At Kemess South, copper and gold assays from drill core indicate that the lower contact of the tuff-epiclastic unit is sharp against the supergene enrichment zone. Gold assays average 1 ppb in the tuff-epiclastic unit but 45 ppb in the supergene zone. Copper assays behave similarly, averaging 0.015% in the tuff-epiclastic unit but 0.3% in the supergene zone. Native copper is notably absent in the tuff-epiclastic unit. In the field the contact looks more gradational. This gradation occurs over approximately one metre with a decrease of quartz grain content from approximately 5% in the supergene zone to trace amounts in the tuff-epiclastic unit. Plagioclase increases from virtually none in the supergene zone to more than 5% in the tuff-epiclastic unit.

The tuffs form crudely layered, very thick beds that are maroon to brick red. The concentration of lithic fragments in the tuff ranges markedly, from 5 to 50%. The dominant fragments are aphanitic, very light green and scale-like, between 5 and 20 centimetres long and 1 to 4 millimetres thick. A diagnostic feature is their greasy feel and swelling habit when exposed to the atmosphere, suggestive of replacement by a clay mineral. A sample of one of these fragments has been collected for X-ray diffraction analysis. Locally the tuff contains rare quartz and biotite crystals. There are also a few sub-angular to sub-rounded basaltic-looking clasts. These clasts make up 1% of the unit and are dark green; some have pyroxene phenocrysts.

Grey-green and maroon epiclastic rocks comprise distinctive bedded intervals within the comparatively more massively bedded maroon tuffs. They are typically medium to thickly bedded with thinner, parallel laminated and graded sections. The epiclastic layers are composed mainly of sandstone and siltstone. Rounded pebbles and cobbles, varying in composition from basalt to andesite, are randomly dispersed in some sandstone beds or form clast-supported conglomeratic interbeds. Pyroxene occurs as discrete grains and crystals in basaltic clasts. The provenance of this detritus is thought to be nearby basaltic rocks of the Takla Group. Despite the proximity of older Paleozoic chert and mudstone, clasts of these lithologies are not evident in the epiclastic beds.

The thin section of tuffs and epiclastic rocks exposed in an unnamed creek west of the Duncan fault are lithologically similar to those that overlie the supergene zone. Light grey epiclastic rocks dominate this section with approximately 20% broken plagioclase in the matrix. The sedimentary components are very similar to the reddish grey and brick red epiclastics and the tuffs are similar and although finer grained, and the lithic fragments have the same greasy texture as those found in the open pit. The rocks in Kemess Creek are tentatively assigned to the tuff-epiclastic unit despite the generally rubbly appearance of bedrock exposures that masks distinguishing features.

Rebagliati and co workers (1995) correlated the tuff-epiclastic unit at Kemess South with the Sustut Group. However, there are significant lithologic differences between typical rocks of the Sustut Group and those overlying the deposit that make this correlation improbable. The Sustut Group nearby is characterized by diagnostic well-rounded chert, vein quartz, and granitic clasts in thick, parallel bedded conglomerate-sandstone beds. In contrast, the maroon colored rocks found above the Kemess deposit are mainly subaerial tuffs with subordinate immature epiclastic rocks, more like rocks of the Toodoggone formation. Toodoggone tuffs typically contain quartz and quartz is present, albeit as rare grains, in the Kemess tuff-epiclastic unit. A tuff sample from this unit has been collected for a U-Pb zircon age determination. Because this unit overlies the supergene zone, a date from these rocks would aid in bracketing the time of uplift and oxidation of the Maple Leaf pluton that resulted in the development of the supergene blanket.

Olivine Basalt

A fresh olivine-bearing basalt, more than 30 metres thick, sharply overlies the tuff-epiclastic unit and represents the youngest rock unit in the study area. It contains approximately 30 to 35% plagioclase, up to 10% glassy olivine, and pyroxene phenocrysts. Unlike any basalt mapped regionally, a sample is being processed for a whole rock ^{40}Ar-^{39}Ar age determination.

LOCAL STRUCTURE

The North Block fault is the most prominent fault exposed in the open pit. The fault strikes roughly east and dips at about 70 degrees towards the south. It truncates the north side of the Kemess orebody and juxtaposes it against deformed chert and argillite of the Asitka Group. Some of the best grades reported in the hypogene zone are against the North Block fault. The fault also truncates the supergene zone and the overlying tuff-epiclastic unit. Fault gouge zones 5 to 10 metres wide are developed along the North Block fault. Other than milled pyrite, the fault zone is unmineralized. This is consistent with data from the exploration drill core logs, which show that mineralization is cut off by the fault. Offset on the fault is normal and sinistral, but the absolute amount of offset is not known.

The 10-180 fault, another important structure mapped within the open pit, cuts both the orebody and the North Block fault. Extrapolated to the north, the 10-180 fault connects with a fault that apparently uplifted and mildly folded Upper Triassic sedimentary rocks on the ridge crest north of the pit. This structure strikes due north and dips east at 80 degrees. Like the North Block fault, the fault zone is unmineralized, and most of the displacement apparently post-dates supergene enrichment. The 10-180 fault truncates both the tuff-epiclastic unit that overlies the supergene zone and the olivine basalt that conformably overlies the tuffs. It also cuts the orebody near the south wall of the open pit. The 10-180 fault also crosses and displaces the trace of the North Block fault by approximately 250 metres; offset is dextral. Approximately 150 metres north of the North Block fault, near the ring road around the open pit, the 10-180 fault crosses deformed chert layers that contain native copper mineralization. This mineralization may have deposited from groundwater that moved along the fault from where it cuts the supergene zone. The 10-180 fault also has a rotational component; the east block rotated clockwise relative to the counterclockwise movement of the west block. Adjacent to the 10-180 fault, the tuff-epiclastic unit changes inclination. West of it the dip is approximately 60° southwest; to the east the dip is 20°southwest.

In the open pit, intensely folded chert and argillite of the Asitka Group are present in the foot-wall section of the North Block fault. Folded Permian chert in the foot-wall of the deposit is cut by the North Block fault. The folds are asymmetric and verge east-northeast. The axial planes strike on average 132 degrees and dip approximately 70 degrees southwest, oriented roughly 30 to 60 degrees relative to the strike of the North Block fault. Fold axes trend 145 degrees and plunge 16 degrees. Fold axes within the chert display small reverse faults that parallel axial planes of the folds.

Minor folds are also documented in a rare exposure of Takla Group mudstone that is located on the ridge crest north of the open pit. The mudstone unit is less than 5 metres thick and apparently faulted into place against augite-phyric basalts. Upright, open folds in these rocks have axial planes that strike north and dip east at approximately 80 degrees. The orientation of these folds is almost perfectly parallel to the projection of the 10-180 fault and the folds are interpreted as drag structures related to faulting.

MINFILE AND OTHER PROSPECTS

Kemess West (Minfile 094E 025)

The Kemess West showing was first explored in the late 1960s. The showing is situated along the west central portion of a broad positive IP chargeability anomaly which covers the 6 by 4 kilometres area between and including the Kemess North and South deposits. This anomaly is likely caused by pervasive disseminated pyrite mineralization in augite phyric basalts of the Upper Triassic Takla Group and dacitic ash flows of the Toodoggone formation, which have been intruded by quartz monzonite bodies of the Early Jurassic Black Lake Suite. Dominant structures in the area are steeply dipping faults which define a northerly fabric. Extensive gossanous, pyritic and potassically-altered outcrops contain occasional quartz-carbonate-magnetite-pyrite shear-hosted veins with up to 5% sphalerite and traces of chalcopyrite and galena. Assay results of up to 252.5 g/t Ag, 9.9% Zn, 0.7% Cu, 0.18% Pb and 2.0 g/t Au have been reported from selected grab samples.

Rat 1 (Minfile 094E 118)

The Rat showing is situated 0.5 kilometres southwest of, and in a similar geological environment to, the Kemess West showing. Like the Kemess West showing, the Rat 1 showing is mainly hosted in dacitic ash flows of the Toodoggone formation and basalts of the Takla Group. In addition, quartz-feldspar porphyry bodies form locally gossanous and potassically-altered outcrops that host fractures, quartz veins and stockworks with 1 to 2% disseminated pyrite and traces of chalcopyrite. Assay results of up to 7.1 g/t Ag, 0.109% Cu, 0.005% Zn, 0.002% Pb and 0.315 g/t Au have been reported from selected grab samples.

Pyritic Showing on Nor 1 Claim (UTM 632360, 6321546)

This showing is located 5 kilometres west-northwest of the Kemess South deposit, and is hosted by relatively unaltered rhyolite of the Asitka Group. The rhyolite is underlain by light green andesitic flows. The showing consists of an outcrop approximately 5 metres in diameter of semi-massive pyrite, which appears to be replacing the rhyolite. A grab sample of the pyrite yielded an anomalous value of 530 ppm As.

SUMMARY

The map area is underlain by three major stratigraphic units. The oldest, the mid-Pennsylvanian to Permian Asitka Group consists of rhyolitic and andesitic tuffs and flows, chert, mudstone and limestone. It is mainly exposed west of Duncan Lake valley and in the Kemess South open pit. The Upper Triassic Takla Group consists mainly of dark green augite-plagioclase phyric basalts. The Toodoggone Formation of the Lower Jurassic Hazleton Group consists of dacitic ash flows, lithic tuff and epiclastic rocks. The youngest rocks are olivine basalt that overlie the tuff-epiclastic unit, tentatively correlated with the Toodoggone formation, in the Kemess South open pit.

The lithic tuffs interbedded with epiclastic sediments that overlie the supergene zone of the Kemess South deposit were originally correlated with the Upper Cretaceous Sustut Group. However, deposits of the Sustut Group in the region are predominantly pebble and cobble conglomerates composed of well-rounded chert, vein quartz and granitic clasts. This contrasts markedly with the constituents of the reddish brown tuff-epiclastic unit in which conglomerates are relatively scarce, composed of volcanic-derived clasts.

The deposit is cut off to the north by the east-west striking, south-dipping North Block fault. It has sinistral and normal motion; the magnitude of the offsets is uncertain. The deposit is also cut by a north-south fault named the 10-180. This fault, discovered during stripping of overburden in the open pit cuts and therefore post dates the North Block fault. There is approximately 250 metres of dextral offset and approximately 30 degrees of rotation on the 10-180 fault.

In the Kemess South open pit three subzones have been identified within the supergene zone. The lowest, above the hypogene ore contains “pin prick” native copper flakes. Locally the percentage of copper can be up to 5%. Rare hypogene sulphides can also be found in this zone. The middle zone is a redder color and contains approximately 50% hematite-stained clay altered material. This zone is characterized by small leaves of native copper at the base that become larger and more sheet-like upward.

As a new producing mine in British Columbia, the South Kemess Mine will have a significant impact on the economy of the province. A better understanding of the mine geology and the character of the deposit will have regional applications in the search similar porphyry copper-gold deposits elsewhere.

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