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**Geological Setting of the Kemess South Cu-Au Porphyry
Deposit, British Columbia.**

By

Christopher Rogers

A thesis submitted to the Faculty of Graduate Studies and Research in partial
fulfilment of the requirements for the degree of Master of Science.

Department of Geology

Carleton University
Ottawa, Ontario
April 26, 2002

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The undersigned recommend to the
Faculty of Graduate Studies and Research acceptance of the thesis
**“Geological Setting of the Kemess South Cu-Au Porphyry Deposit, British
Columbia.”**

submitted by Christopher Rogers, B.Sc. (Honours),
in partial fulfilment of the requirements
for the degree of Master of Science

A handwritten signature in black ink, reading "Richard P. Taylor", written over a horizontal line.

Dr. Richard P. Taylor (Thesis Supervisor)

A handwritten signature in black ink, reading "George Dix", written over a horizontal line.

Dr. George Dix, Chairman Department of
Earth Sciences

Abstract

The geological setting of the Kemess South copper-gold porphyry was investigated principally by field mapping at a scale of 1:10,000. Methods used in the analysis of specimens collected in the field included: transmitted and reflected light microscopy, scanning electron microscope and electron microprobe analysis, x-ray diffractometry. The combination of field mapping and these analytical methods permitted the recognition of three distinct lithostratigraphic units, which 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 are: (1) the mid-Pennsylvanian to Lower Permian Asitka Group; (2) the Upper Triassic Takla Group; and (3) the lower Jurassic Hazelton Group, specifically the Toodoggone Formation. Two previously unmapped units are exposed as a consequence of the development of the open-pit at Kemess South. The lower unit, which rests directly on supergene ore, has been identified as part of the Saunders Member of the Toodoggone Formation. The uppermost unit is a distinctive, pyroxene-basalt flow that directly overlies and interdigitates the tuff-epiclastic unit. The supergene zone formed as a result of the weathering and oxidation of hypogene zone mineralization (disseminated chalcopyrite + pyrite), located in the upper part of the Maple Leaf pluton, which intrudes Takla Group, Savage Mountain Formation basalts. Supergene copper mineralization is distinguished from hypogene ore, and characterized by, the mineral assemblage: native copper $\pm$ chalcocite $\pm$ bornite $\pm$ covellite. The supergene copper mineralization is set in highly altered, clay- and hematite-rich rocks that preserve some original igneous and hypogene zone textures .

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Chapter 1: Introduction

Introduction

Discovered in 1983, the Kemess South deposit is one of British Columbia's newest mines, with reserves of 116,200,000 g (4,100,000 oz) of gold and 441,000,000 kg (972,200,000 lbs) of copper. Because of a very small strip ratio of 1:1.16, the Kemess South mine began production from an open pit on May 19th, 1998, only two years after commencing construction of the mine infrastructure, and produced its first shipment of gold-copper concentrate on June 23rd, 1998. Commercial production of gold-copper concentrate was achieved on October 7th, 1998, when Kemess met agreements set forth by the provincial government. With current¹ equipment the Kemess South mine is capable of mining 108,000 tonnes of rock per day. The Kemess South mine is projected to produce 7,100,000 g (250,000 oz) of gold and 27,200,000 kg (60,000,000 lbs) of copper annually. Currently owned by Northgate Inc., Kemess South has a permanent staff of 350 employees and will be a very important contributor to British Columbia's economy over the sixteen year projected mine life (Royal Oak Mines Inc., 1996; Jacques Houle, pers. comm., 1998).

The Kemess South mine is situated at the eastern margin of the Stikine terrane in the Toodoggone River map area (NTS 94E) of north-central British Columbia. The Cu-Au deposit is hosted by an early Jurassic subvolcanic calc-alkaline intrusion, of quartz-monzonite composition, informally named the

¹Current as of October 1998.

Maple Leaf pluton. By comparison, other early Jurassic gold-copper porphyry deposits elsewhere in British Columbia are located mainly in the Quesnel terrane and are associated with alkaline intrusions (Figure 1.1). After its emplacement, of the Maple Leaf pluton was rapidly exhumed and exposed at surface producing a copper-gold enriched, highly weathered supergene zone above the primary zone of hypogene mineralization (Rebagliati *et al.*, 1995).

The Kemess South orebody is thus composed of two ore types, comprising:

1. Native copper, bornite, chalcocite, native gold and Fe-oxides (e.g. hematite) in the supergene zone; and
2. Pyrite, chalcopyrite, and native gold in the hypogene zone.

Location and Access

The Kemess South open-pit is located approximately 440 km north of Prince George, in north-central British Columbia. Kemess South is located on the western margin of the Swannell ranges of the Ominica mountains, north-east of the Bowser basin (Rebagliati *et al.*, 1995). The topography is characterized by gently rolling hills and wide valleys, ranging in elevation from 1200 to 1800 metres (3950 to 5900 feet). Vegetation consists of lowland coniferous trees and marshy vegetation at lower elevations, and sub-alpine grasses and shrubs at higher elevations. Rock exposure is scarce, comprising less than 5% of the Kemess study area, where it is concentrated near the crests of the two major ridges. The study area covers thirty-six square kilometres and is confined in the west by the Ominica Mining Access road, in the north by a major valley that connects Kemess and Duncan lakes, and

Overlap Assemblages
 BL - Bowser Lake Gp.
 CPC - Coast Plutonic Complex

Island Arc Terranes
 QN - Quesnellia
 ST - Stikinia

◆ Early Jurassic Calc-Alkaline related porphyry deposits
 ★ Early Jurassic Alkaline related porphyry deposits
 ✱ Red Chris may be a Alkaline/Calc-Alkaline Hybrid
 (although its predominately alkaline)

Oceanic Terranes
 CC - Cache Creek
 SM - Slide Mountain
 BR - Bridge River

Displaced North America
 KO - Kootenay
 CA - Cassiar

Figure 1.1 Shows the location of important porphyry deposits in their respective terranes within the province of BC.

in the east-southeast by Kemess creek (Figure 1.2). With recent development of the open pit, new exposures of the orebody provide excellent evidence of the internal and external stratigraphic and structural relationships.

Access to the Kemess South mine site is *via* a charter flight, originating in Smithers or Prince George, to an all-weather airstrip owned and operated by Northgate Inc. Flight-time is approximately forty five minutes. Road access is *via* a network of forestry roads that covers approximately 400 kilometres. The ground route originates either in Fort St. James or Windy Point near Mackenzie, on highway 97. From either direction the drive covers approximately 400 km and can take between 6-10 hours depending on road and weather conditions.

Objectives and Fieldwork

The purpose of the Kemess project was to expand the understanding of the geology that surrounds the Kemess South gold-copper deposit. The study therefore attempted to accomplish three main objectives.

The first objective entailed regional mapping at a scale of 1:10,000, in order to facilitate a better understanding of the country rocks that surround the Kemess South deposit, and place them into an appropriate regional context (for example see Diakow and Metcalfe, 1997, Diakow and Rogers, 1998); the second objective was to map the stratigraphic and structural relationships of the footwall and hangingwall rocks to the Kemess South deposit and its host, the Maple Leaf pluton; and the third objective was to examine and sample the supergene ore.

Fieldwork for this project was carried out in 1998, from mid-June to

Figure 1.2 Location of study area and the Kerness South deposit with respect to regional mapping in the southern Tooodoggone River map area (94E). The inset on the right shows the location of the Kerness South deposit in the province of BC, marked by a circle. The inset on the left is a representation of all the mapping in the area and where this study area is located in relation to previous work (modified from Diakow and Rogers, 1998).

early-August and involved the following:

1. Twenty days of mapping the stratigraphic and structural relationships of the country rocks that lie above and below the orebody. From this mapping a representative suite of rock samples was collected for petrography and lithogeochemistry;
2. Ten days of mapping the stratigraphic and structural relationships of the footwall and hangingwall rocks to the Kemess South deposit. From this mapping two samples were collected for geochronology; 1 sample for Ar-Ar and 1 sample for zircon U-Pb zircon age dating.
3. Ten days of logging diamond drill-core (over 2400 metres) from thirteen drill holes that were each spaced approximately 200 metres apart. Over 150 representative samples of the supergene and hypogene ore types, as well as many samples of the footwall and hangingwall rocks were collected from drill core.

Chapter 2: Regional Geology

Introduction

The Canadian Cordillera is classified as a classic orogenic belt that has accreted from more than 50 suspect terranes. The suspect terranes that make up the Canadian Cordillera are internally homogeneous, and have similar tectonic settings that cannot be explained by simple facies change or unconformities. In addition, many terranes juxtapose differing fauna, stratigraphy, and structural styles indicating a different evolutionary history than that of the neighbouring terrane (Coney *et al.*, 1980).

The Cordillera has a very complex tectonic history that represents the interplay of geological processes from the middle Proterozoic to the Cenozoic (Patchett, 1998; Coney *et al.*, 1980; Gabrielse *et al.*, 1992; Gabrielse, 1991). Extending from the coast to the western side of the Rocky Mountain fold and thrust belt, the Canadian Cordillera is composed of five morphological belts. From west to east they are: the Insular belt; the Coast belt; the Intermontane belt; the Omineca belt; and the Foreland belt (Gabrielse *et al.*, 1992; Marsden and Thorkelson, 1991; Coney, 1980).

Intermontane Belt and Continental North America

The North American craton or ancestral North America, is represented in central British Columbia by predominately sedimentary strata that range from Proterozoic to early Mississippian in age (Gabrielse, 1990; Coney, *et al.*, 1980).

Northern areas have thicker successions of carbonate and sandstone that may represent a near-shore environment. These lithologies suggest a passive miogeoclinal depositional environment. From the late Triassic to early Jurassic the tectonic setting of the miogeoclinal terrace changed from that of a passive one to a convergent one, leading to subduction of oceanic crust beneath the North American craton and the creation of allochthonous terranes. Accretion of terranes outside the passive continental margin of North America took place during the late Mesozoic and early Cenozoic (Coney *et al.*, 1980).

The largest of the five terranes, the Intermontane belt, is characterized by subdued relief, and is bounded by the high rugged mountains of the Coast belt and the Omineca belt on the west and the east respectively (Gabrielse *et al.*, 1991). The Intermontane, Coast, and Omineca belts are overlapped by sediments of the Sustut and Bowser basins. The Intermontane belt is composed of a variety of metamorphic, plutonic, and sedimentary rocks. Metamorphic rocks rarely reach greenschist grade. Plutonic rocks are predominately those of I-type intrusions (following the terminology of Chappell and White, 1974), and are associated with four distinct periods of volcanism and/or plutonism, occurring in the late Triassic, early Jurassic, late Cretaceous, and early Tertiary respectively. Sedimentary rocks are generally widespread and occur in thick successions (Gabrielse *et al.*, 1991). Structurally, the Intermontane belt is traversed by northwesterly-trending, late Cretaceous and Tertiary, dextral strike-slip faults. Mesozoic terrane assemblages are represented by the volcanic arcs of the Stuhini, Nicola and Hazleton groups of the Stikine and Quesnel terranes, together with oceanic assemblages from the

Cache Creek and Slide Mountain terranes. In general, the structural style of the Cordillera can be characterized by oceanic, island-arc, foredeep, and clastic wedge assemblages related to the development of accretionary prisms and subduction zones in the early Mesozoic (Gabrielse *et al.*, 1992).

The major terranes involved with the development of the Stikine terrane are the oceanic Cache Creek and Slide Mountain terranes and the ocean-island arc terranes of Quesnellia and Wrangellia. The Quesnel terrane is confined between the Thibert and Klinkit faults and is typified by the presence of massive augite-porphyry basalts. These porphyries are intruded by early Jurassic quartz monzonites, granodiorites, and granites. The augite-porphyry volcanic rocks are overlain by limestone, greywacke, and shale of lower Jurassic age (Gabrielse, 1990).

The Cache Creek terrane is composed of three assemblages, two of which may be overlap assemblages (Gabrielse, 1990). The oldest formation of the Cache Creek terrane comprises chert, argillite, limestone, mafic volcanic rocks, diorite-gabbro, and ultramafic rocks of early Mississippian age representing a former oceanic environment (Gabrielse, 1990). The overlying Kutcho Formation is composed of calc-alkaline, volcanoclastic basalt and basaltic andesite representing part of a volcanic arc (Gabrielse, 1990). The youngest assemblage of the Cache Creek terrane is the Sinwa Formation, consisting of upper Triassic limestone which is overlain by units of greywacke, shale, and minor conglomerate. The Sinwa Formation represents deposition in an intra-arc or fore-arc environment (Gabrielse, 1990).

Geological Description of Stikinia

Plutonic Rocks

The Canadian Cordillera is predominately composed of geochemically and isotopically juvenile intrusions derived from mantle-derived magmas that have been emplaced through the continental crust of the North American craton. Inboard of the Stikine terrane, the source of the plutonic rocks is harder to determine. Rocks of island-arc affinity have isotopic signatures that indicate the mixing of continental and oceanic isotopic reservoirs: rocks of oceanic island arc terranes are juxtaposed against, and contaminated by rocks of the North American craton (Patchett and Gehrels, 1998; Currie and Parrish, 1997).

There are three broad ages of intrusive activity represented in Quesnellia and Stikinia: late Triassic, early Jurassic, and late Jurassic to early Cretaceous. The late Triassic plutons are essentially restricted to those of small Alaskan-type ultramafic bodies in Quesnellia and Stikinia, with a belt of tholeiitic to calc-alkaline granitoid rocks that intrude Stikinia along the Stikine Arch. Early Jurassic plutons in Quesnellia, Stikinia and Wrangellia have close temporal and spatial affinity with upper Triassic to lower Jurassic extrusive volcanic rocks. Cretaceous intrusions, in the Intermontane belt, are confined to the Stikine and the Cache Creek terranes along the Skeena Arch (Woodsworth *et al.*, 1992). Ultramafic rocks of the Polaris Ultramafic Suite are limited to Stikinia and Quesnellia. In Stikinia, the Polaris suite intrudes the Stuhini volcanic rocks near Menard Creek and is coeval with most of the augite-porphyry basalts of the Stuhini Group. The similarities in lithology and

age (215 - 232 Ma) of the ultramafic bodies in both the Quesnel and Stikine terranes indicate that both terranes were amalgamated by the late Triassic. The linear nature of the ultramafic suite suggests there was very little faulting after intrusion of these bodies. However, if the assignment of the Polaris Ultramafic Suite as a connection between Quesnellia and Stikinia is in error then both terranes may have developed in separate arc systems until the early Jurassic (Woodsworth *et al.*, 1992).

Jurassic plutons in Stikinia are restricted in their distribution and typically comprise calc-alkaline intrusive rocks of two dominant plutonic suites. The Topley Lake Suite makes up the largest concentration of intrusions and occurs along the Skeena Arch. The Topley Lake intrusions range in age from 178 to 210 Ma and may be roots and feeders to the overlying Hazleton Group volcanic rocks of the early and middle Jurassic (Woodsworth *et al.*, 1992). The second group of intrusions, the Black Lake Suite, outcrops along the east and north margin on the Bowser basin and Slide Mountain terrane. The Black Lake Suite averages 190 Ma in age and intrudes many parts of the Hazleton Group volcanic rocks. The correlation in age, together with the similarity in mineralogical composition, of the Topley Lake and Black Lake Suite intrusions indicates a close spatial and temporal relationship for the plutons, which may represent a sub-volcanic equivalent of the Hazleton Group volcanic rocks (Woodsworth *et al.*, 1992).

Neodymium and strontium isotopic ratios suggest that the undersaturated and saturated alkalic igneous rocks, in Quesnellia and Stikinia were derived from similar source rocks. These intrusions postdate most of the upper Triassic

sequences and overlap in age with the oldest phases of the lower to middle Jurassic sequences (Lang *et al.*, 1998); therein indicating that both terranes were amalgamated before 210 to 200 Ma when these plutons were emplaced (Lang *et al.*, 1998). It has also been postulated that the magmatism in the Jurassic may be related to inter-arc collision events and the cessation of subduction. Although a Triassic-Jurassic arc system in Stikinia and Quesnellia has not been identified, the magmatism may be the result of a temporary hiatus in subduction and could represent a magmatic arc or separate arc-continent collisional event (Lang *et al.*, 1998).

Volcanic Rocks

The Permian Stikine and Stuhini assemblages are in conformable contact with Takla Group shale and are overlain by augite-porphyry flows. The augite-porphyry flows consist of light green to maroon lava flows, erupted in the late Triassic, that are rich in augite and plagioclase. Rocks of Stikinia have been compared to similar units in Quesnellia, and several authors (Moritmer, 1986; Monger, 1985, and references therein) consider Quesnellia and Stikinia to be two sections of the same magmatic belt separated by the Cache Creek terrane. The main evidence for such a relationship comes from the Sinemurian lavas of the Rossland Group in Quesnellia. The Rossland Group lavas have been correlated to Hazleton Group lavas of Stikinia, implying an overlap relationship in the Jurassic.

Mortimer (1986) suggests that some of the terranes may be genetically linked and should be grouped together. Mortimer (op.cit.) also suggests that there were

three separate arcs in the late Triassic. The eastern arc would have been made up of Quesnellia, and the Olds Ferry and Jackson terranes, all of which are considered intra-oceanic in character; the western belt would have been composed of the Stikinia and Wallowa terranes; and the third arc would have been composed of the Rattlesnake Creek and Foothills terranes.

The Hazleton group represents a Jurassic pre-accretionary volcanic and sedimentary assemblage in Stikinia (Marsden, 1990). The Hazleton volcanic rocks are transitional from marine to non-marine in character and may be related to volcanic buildups of tephra and lava. Following cessation of volcanism and magmatism, subsidence initiated extension through short-lived tectonic and graben structures (Marsden and Thorkelson, 1991). No evidence of sheeted dyke complexes, massive marine basalts, or other rifting indicators have been reported for the early to middle Jurassic. In addition, neither the Stikine nor the Skeena arches have been subsequently rifted (Marsden and Thorkelson, 1991).

Bounding faults make the determination of the original tectonic setting of the Hazleton Group unclear. The volcanic rocks of the Hazleton Group are composed of two subaerial volcanic chains that in combination are a minimum of 350 km wide (Marsden, 1990). Comparing such a width to today's island arc systems, there are none of the current arcs that are more than 150 km wide and most are less than 50 km apart (Marsden, 1990). Continental arcs can reach up to 250 km in width, with most of the magmatism concentrated in the first 50 km (Marsden, 1990). Therefore, the two most plausible explanations for the extreme width of the Jurassic arc

(Hazelton Group) system are:

1. The existence of two parallel subduction zones;
2. The occurrence of an island arc and continental back arc (Marsden, 1990).

If two parallel subduction zones existed it would indicate that there were two facing continental slabs, wherein one subduction zone is dipping east and the second subduction zone faces west (Figure 2.1; Marsden, 1990). This model is unlikely as there is no known accretionary prism west of the eastern volcanic chain. Also neither the original distance between the east and west facing arcs is known, nor the exact plate configuration in the Jurassic. Therefore, an island arc/continental back arc would seem to be a more plausible setting. A modern day example would be the Cocos plate, which is subducting beneath the Central American plate in the Caribbean; or the Atlantic plate, which is subducting beneath the Antilles chain (Marsden, 1990).

The southern and central portion of Stikinia in British Columbia is poorly defined on the west (Marsden, 1990). Rocks along the west side of Stikinia were involved in east-verging thrusting during the late Triassic and were later modified by Tertiary extension (Marsden, 1990; Van der Hayden, 1992). Stikinia in northern British Columbia and the Yukon was juxtaposed against the Nisling terrane, which is composed of continental Paleozoic and possibly older rocks, in the Triassic. Alternatively, the Nisling terrane could be the deeper part of the Stikine terrane that has been juxtaposed against higher structural levels (Marsden, 1990).

Figure 2.1 Schematic of Marsden and Thorkelson's model of the doubled volcanic arc that existed in the Late Triassic and Early Jurassic, on the Intermontane Belt (modified from Marsden and Thorkelson, 1992).

Bowser Basin

The Bowser basin is located in north-central British Columbia. The Bowser basin is composed almost entirely of late Bathonian to early Oxfordian marine sediments, with the exception of its lowermost units which comprise terrestrial sediments. The basin has many characteristics of a foredeep (Gabrielse, 1992; Yorath, 1992). The total areal extent of the Bowser basin (4900 km²) stretches from Quesnellia on the east to the Coast belt on the west, and is contained mainly within the Stikine terrane. The Bowser basin developed as a confined basin between the Stikine and Skeena arches from the Jurassic to middle Cretaceous, having been formed by the closure of the Cache Creek Ocean (Bassett and Kleinspehn, 1997; Woodsworth *et al.*, 1992; Evenchick, 1991). The Bowser basin is interpreted as a classic sedimentary wedge that formed in response to terrane uplift and deformation during contraction is interpreted to have experienced approximately 44% shortening in the late Cretaceous (Evenchick, 1990; Gabrielse, 1991).

Paleomagnetic interpretation of Stikinia

Paleomagnetic indicators are useful in determining the relative motion that has occurred between terranes and the North American craton during their evolution (Irving and Wynne, 1992). A large difference in paleopoles from the outboard terrane and the craton indicates that they have moved relative to each other. Most paleomagnetic work has focussed on the Intermontane and Insular belts of the Cordillera, with only a minor amount of research in the Foreland belt (Irving and Wynne, 1992). Current paleomagnetic results indicate that there has been no

rotation of the Cordilleran terranes since mid-Tertiary time, and no paleomagnetic tilting, rotation or horizontal motion. The only exceptions are the Paleogene rocks, which often show tilting, but no latitudinal motion relative to the North American craton (Irving and Wynne, 1992).

Paleomagnetic data from the Canadian Cordillera can be categorized into three distinct time periods, to determine the approximate location of terranes as they were forming (Irving and Wynne, 1992). In Stikinia, paleomagnetic poles of the Permian Asitka Group show large and variable rotations, with a paleolatitude of approximately 22°N (Irving and Wynne, 1992). Asitka Group rocks show scattered paleopoles with predominantly negative inclinations, a common feature for the Permian indicating a northern paleolatitude (Irving and Wynne, 1992). Early Jurassic and late Triassic paleolatitude data show scattered paleopoles and large, variable rotations (Irving and Wynne, 1992). Although a reference field has not been calculated for late Triassic and early Jurassic, terrane displacements for Stikinia of approximately 1000 km are implied. Displacements of $9^{\circ} \pm 7^{\circ}$ from the south give the Bonanza volcanic rocks of the Wrangellia terrane a paleolatitude similar to present day Baja California. This indicates that parts of Wrangellia had moved south by the early Jurassic, (Irving and Wynne, 1992).

The third grouping of paleopoles is from the Cretaceous rocks of the western Cordillera. These paleopoles show a clustering in the North Atlantic, whereas the paleopoles from the North American craton cluster northwest of Alaska. Such trends indicate that the Intermontane and Insular belts were joined by mid-Cretaceous time and were moving as one coherent mass, where initially Stikine of the Intermontane

belt and Wrangellia of the Insular belt were separated by an unknown distance (Figure 2.2; Irving and Wynne, 1992). Extreme metamorphism and the emplacement of the granitic batholiths that formed the Coast Plutonic Complex welded Stikinia and Wrangellia together, thereby creating a quasi-coherent plate or mini-plate that had a similar relationship to North America that Baja California has today. The mini-continent, with included pieces of the Quesnel terranes was accreted to North America in the Paleocene to Eocene time (Irving and Wynne, 1992). This landmass has been named "Baja British Columbia" (Irving and Wynne, 1992). Dislocations of approximately 2000 km and a rotation of approximately 60° clockwise have been implied for total displacement of "Baja British Columbia" (Figure 2.2; Irving and Wynne, 1992). During the Cretaceous, the paleomagnetic field for Baja British Columbia had a normal polarity placing the origin of Baja British Columbia in the northern hemisphere (Irving and Wynne, 1992).

"Baja British Columbia" was located at the edge of the Kula Plate 2000 km south of its present position between 85 to 50 Ma (Irving and Wynne, 1992). Moving northward between mid-Cretaceous and Tertiary time with a clockwise rotation, it collided with ancestral North America on the eastern margin of the Kula plate (Irving and Wynne, 1992). "Baja British Columbia" possibly began its rotation and movement northward when the Kula plate broke from its parent plate, the Falleron plate, around 85 Ma, much as Baja California is attached to the Pacific plate today (Irving and Wynne, 1992). The motion northward continued until 50 Ma when the Kula Plate joined with the America plate. The Pacific-America plate boundary formed and has continued to move northward with the Pacific Plate since that time.

Figure 2.2. Speculative scheme showing four stages (A-D) based on paleomagnetic evidence for assembly of major elements of the Canadian Cordillera (modified from Irvine and Wynne, 1992).

All of the rocks in the Cretaceous that make up “Baja British Columbia” have similar paleomagnetic rotations indicating that “Baja British Columbia” moved as a single plate and not as a series of mini plates (Figure 2.3).

Within “Baja British Columbia” the lower Permian rocks of the Stikine terrane have undergone significant rotation, which indicates that the Intermontane and Insular belts originated more or less near their present position before moving southward between early Jurassic to mid-Cretaceous (Irving and Wynne, 1992). Lower Permian rocks of Stikinia have an anticlockwise rotation indicating a sinistral strike-slip motion with southerly movement (Figure 2.4). Vandall and Palmer (1990) suggested that Stikinia was at a similar latitude from the Permian to the early Jurassic relative to the North America craton from evidence from paleomagnetic measurements of the Permian Asitka Group. The same interpretation of the paleomagnetic data is applied to Wrangellia.

Paleomagnetic data from Stikinia indicates that it was located approximately 1300 km south of its present position, relative to the North America craton, sometime between the Triassic to lower Jurassic and possibly into the Cretaceous (Monger and Irving, 1980). According to Monger and Irving (1980), although the data for this study were collected from a geographically small area, they are nevertheless useful because Stikinia is such a coherent entity.

Figure 2.3. Possible trajectory of Baja British Columbia from latest Cretaceous to earliest Eocene (modified from Irvine and Wynne, 1992).

Figure 2.4. Possible trajectory of Baja British Columbia from latest Cretaceous to earliest Eocene relative to the North American craton (modified from Irvine and Wynne, 1992).

Paleobiogeography of Stikinia

Paleobiogeography has played a very important part in the reconstruction of paleolatitudes of Cordilleran terranes. Paleobiogeography can place constraints on when, where, and under what environmental conditions the terrane formed. Paleobiogeographical indicators (ammonites in particular) show well-defined differentiations between the palaeogeographical Tethyan regions (present day Mediterranean region) and the Boreal region (present day Northwest European Province; Figure 2.5) and their differing faunal assemblages (Smith and Tipper, 1986). Because of the pelagic lifestyle and post-mortem drift of ammonites it was originally assumed that their palaeobiogeographical distribution would not permit delineation of definite biogeographic regions and terrane reconstruction models (Smith and Tipper, 1986). Although there are rare occurrences of Boreal ammonites found in Tethyan provinces and *vice versa*, the palaeogeographical contacts of Boreal and Tethyan fauna are generally very sharp (Figure 2.5), indicating that preservation of specimens affected by post-mortem drift was insignificant (Smith and Tipper, 1986).

Smith and Tipper (1986) found that the contact between the northern and southern faunal abundances of ammonites was sharp and that there was virtually no faunal overlap within terranes. Northern region fossils tended to have Boreal affinity, while southern region fossils tended to have Tethyan affinity. A similar pattern was repeated on the North American craton, and also around the world where Boreal fauna were restricted to northern latitudes and Tethyan fauna were restricted to southern latitudes with very minor latitudinal overlap between the two

▲▲H▲▲ Northern limit of abundant
Hildoceratidae

▼▼A▼▼ Southern limit of abundant
Amaltheidae

Figure 2.5. Schematic showing the distribution of two genera of fossils from the Boreal Region and the Tethyan region of the Permian (modified from Smith and Tipper, 1986).

faunal assemblages (Smith and Tipper, 1986).

Tethyan fossils in the Pliensbachian have a circum-global distribution, except for the genus *Fanninoceras* (Smith and Tipper, 1986). *Fanninoceras* has been found from Chile to southern Alaska in craton-bound faunas of Tethyan terranes and never has been found in Boreal craton regions. This suggests that the terranes of the Canadian Cordillera were palaeogeographically closer to the eastern side of the paleo-pacific ocean rather than to the western side (Smith and Tipper, 1986).

The north-south palaeobiogeographical division between the terranes, indicates that the allochthonous terranes were at low latitudes in the Jurassic and overlap in Boreal and Tethyan faunal assemblages indicated a common line parallel to the paleolatitude (Smith and Tipper, 1986). Ignoring other geological constraints, faunal evidence alone indicates terrane displacements (relative to the North American craton) of 500, 1800, and 2400 km for Quesnellia, Stikinia, and Wrangellia respectively, relative to the North America craton (Figure 2.6).

Using somewhat controversial longitudinal biodiversity studies from the Indo-Pacific region Belasky and Runnegar (1994) concluded that because of similar faunal assemblages found in Stikinia and Wrangellia, the terranes were situated near each other in the Permian. They also stated that faunal assemblages of the Klamath terrane were very much unlike the faunal assemblages of the Wrangellia terrane but moderately similar to those of the Stikine terrane; thus, indicating that Stikinia held an intermediate position between Wrangellia and Klamath. In terms of the North America craton, Belasky and Runnegar (op.cit.) concluded that: (a) the Klamath and Stikine terranes were in proximity to one another and up to 6700 km

Figure 2.6. (a) North-south biogeographic zonation within the Pliesensbachian allochthonous terranes (b) Diagrammatic representation of the latitudinal displacements suggested by biogeographical constraints No longitudinal position is implied (modified from Smith and Tipper, 1986).

west of the North America craton; whilst (b) Wrangellia was southeast of the other two terranes and up to 5000 km from the North American craton.

Accretion Models of Stikinia

Most studies of the Canadian Cordillera have commented on the similarity of the Quesnel and Stikine terranes, which are separated from one another by the Cache Creek terrane. The three hypotheses for the formation of the Quesnel and Stikine terranes are:

1. "Escape Hypothesis" by Wernicke and Klepacki (1988);
2. "Enclosure Hypothesis" by Mihalynuk *et al.*(1994); and
3. "Dextral strike slip model" by Monger *et al.*(1993).

The "Escape Hypothesis" proposed by Wernicke and Klepacki (1988), suggests that Stikinia was essentially pushed northward along dextral strike-slip faults from the south, as Wrangellia accreted to North America . They base their model on the absence of melange belts and marginal volcanic rocks in Stikinia, from the Columbia Embayment, where Wrangellia is in contact with the North American craton. In addition, Wernicke and Klepacki (op. cit.) provide evidence that Stikinia had moved from 750 to 1000 km northward between the middle Jurassic and Eocene. If this is true, and most authors tend to agree that there was a large displacement of Stikinia in that time period, it would place Stikinia at or near the Columbia Embayment before travelling northward.

Remnants of the Kootenay terrane together with the Quesnel terrane, were tied to North America, while Stikinia was still outboard of North America's melange

belt with respect to terranes of the Paleozoic and early Mesozoic to early Jurassic reconstruction models indicate that the Stikine terrane was inboard of Tethyan Fauna from the melange belt of North America at approximately the latitude of the Columbia Embayment (Figure 2.7; Wernicke 1988). Wernicke (op. cit.) suggested an alternative model for the accretion of Stikinia onto North America, wherein Stikinia was nearly accreted to North America by 160 Ma. As Wrangellia approached the North America craton and Stikinia it pierced the melange belt and began impinging onto North America around 130 Ma. Between 160 and 130 Ma, Wrangellia was stitched to the melange belt and the marginal volcanic rocks of the Columbia Embayment. By 100 Ma, Wrangellia had started squeezing the Stikine terrane northward along the margin of North America, where Stikinia was trapped between Quesnellia on the east, and the southern portion of Wrangellia on the west by early Cretaceous time. The penetration of Wrangellia continued in the Columbia Embayment rotating the melange approximately 60° clockwise and completing the collision by earliest late Cretaceous (Cenomanian). This model does require the large-scale displacements, suggested by the paleomagnetic data, to accommodate the suggested 60° rotation, and is well accepted. The "Escape Hypothesis" also explains the doubled volcanic belt of Stikinia and Quesnellia.

The "Escape Hypothesis" also predicts that Wrangellia had impinged on the melange and volcanic belt of Stikinia by middle Jurassic time (160 Ma). As Wrangellia approached North America, it broke through the melange and volcanic belt to start forcing Stikinia to the north and into its own melange and volcanic belt around 100 Ma. This interpretation is supported by detritus shed from Stikinia onto

Figure 2.7. Kinematic model of escape hypothesis for Stikine block. Wrangellia impinges upon the melange and marginal volcanic belts in Middle Jurassic time. Stikine block is squeezed northward during Late Jurassic and Early Cretaceous time. Suturing of Wrangellia superterrane with all inboard terranes is achieved by mid-Cretaceous time, allowing for some subsequent transpression and northward translation along northern Rocky Mountain trench-Fraser River fault system in Late Cretaceous to Eocene time. Diagonal pattern = Wrangellia superterrane; black = early Mesozoic melange; coarse stipple = Stikine Block; fine stipple = craton. (modified from Wernicke and Klepacki, 1988).

the melange belt, which has been subsequently overthrust by the King Salmon and Nahlin faults. The third stage of this model is the translation of Stikinia northward along the Wrangellia-Stikinia suture. This was finished by approximately 100 Ma (Figure 2.7) (Wernicke & Klepacki, 1988).

The “Enclosure Hypothesis” by Mihalynuk and others (1994), suggests that the Stikine terrane was enveloped by other terranes as it was accreted to North America. The Cache Creek terrane is the dominant terrane involved in the “Enclosure” model. The Cache Creek terrane is a composite oceanic terrane, distinct from its neighbours, and is surrounded by terranes that are characterized by North American fossils (Mihalynuk *et al.*, 1994). The “Enclosure” model builds the Stikine terrane on four stages of evolution.

Stage 1: The outer limb, or Stikinia, undergoes similar tectonic history as the inner limb of the model, or Quesnellia. There is a cessation of Permian arc volcanism, minor deformation and uplift and reactivation of the subduction zones. The process of subduction between the inner limb and Cache Creek terrane is supported by the presence of a blueschist melange that has the correct age (Figure 2.8A).

Stage 2: The eruption of augite porphyries, in Quesnellia and Stikinia, commencing at approximately the same time in both terranes. Also, common to both terranes are alkalic and ultramafic intrusions, and copper-gold deposits associated with subvolcanic monzonite-porphyries. Stikinia and Quesnellia both share a similar progression of felsic volcanic units to augite porphyries units that are loosely associated with the margins of the Cache Creek, Stikine and Quesnel

A)

B)

Figure 2.8. (A) Latest Permian to Middle Triassic arrangement of tectonic elements predicted by the model, with a modern analog for this stage of development. (B) Latest Permian to Middle Triassic arrangement of tectonic elements predicted by the model, with a modern analog for this stage of development. (modified from Mihalynuk *et al.*, 1994).

C)

D)

Figure 2.8 (cont.). (C) Early Jurassic arrangement of tectonic elements predicted by the model, with a modern analog for this stage of development. (D) Middle Jurassic arrangement of tectonic elements predicted by the model, with a modern analog for this stage of development. (modified from Mihalynuk *et al.*, 1994).

terrane. This suggests a gross two-fold symmetry around the Cache Creek terrane (Figure 2.8B).

Stage 3: Lower Jurassic rocks in Stikinia and Quesnellia pass into thick clastic sediments which cover sections of the Cache Creek Ocean where subduction had become “plugged”. The continued thickening of Stikinia and rotation in the hinge zone causes the creation of two segments with complex deformation, plutonism, and local dacitic volcanism in the hinge of this model. Deformation and syn-kinematic plutons are evident in the Yukon-Tanana terrane. Voluminous intermediate arc volcanism indicates that subduction continued on the east and west sides of the Cache Creek terrane. Sedimentation in the Cache Creek Ocean changed to wackes, tuffs and tufaceous argillites from pelagic sediments and cherts (Figure 2.8C).

Stage 4: Consumption of the Cache Creek terrane is similar to an hypothesis by Thorkelson and Marsden (1992), with thrusting from both limbs collapsing the sharp bend in the hinge zone of the model or orocline and bringing crystalline rocks closer to the surface. Arc volcanism ceased on Quesnellia, then on Stikinia, resulting from cessation of subduction of both the east and west side of the Cache Creek terrane. Quesnellia is then transported toward the North American craton. Rapid accumulation of Cache Creek- derived strata within the Bowser basin marks over-thrusting and foredeep clastic deposition during the final closure of the orocline (Figure 2.8D).

The large-scale rotations needed in this model would also support the large counterclockwise rotations of Stikinia indicated by the paleomagnetic data. In

general, the pre-Cretaceous rocks east of the Cache Creek terrane have a clockwise rotation and rocks west of the Cache Creek terrane have a counterclockwise rotation (Mihalynuk *et al.*, 1994).

The third hypothesis by Monger *et al.* (1993), suggests that the dextral strike-slip displacements are more important in the tectonic history of Stikinia than originally thought. Monger suggests that there were both intra- and inter-arc basins that were active in the pre-Cretaceous. The Bowser basin is derived from eastern source rocks with thrusting from the east as well. The Gravina-Nutzotin-Kahiltna basin is derived from a western source with western thrusting, which is ascribed to initiation of trans-tensional faulting or rifting in an intra- or back-arc setting.

The Monger *et al.* (1993) model has Stikinia moving southward in the pre-Jurassic, before it moves northward again in the Cretaceous as indicated by paleomagnetic and palaeobiogeographical data. Evidence of sinistral motion from the Stikine terrane shows that Stikinia moved northward in the mid-Cretaceous. To accommodate the Mesozoic accretionary arc complex in the southern Coast belt they suggest that the North American plate margin was transected and acutely offset by an early Cretaceous sinistral fault system, which may have offset Cretaceous rocks by as much as 800 km. This would be the southern limit of the displaced arc complex of the Coast belt, and may have been subsequently removed by post 40 Ma dextral strike-slip faulting (Figure 2.9).

The latter model requires dextral strike-slip motion that can be detected on the early Cretaceous, Pasayten fault in the southern Coast belt-Northern Cascades. Other structures indicate sinistral shear, through south-east vergent structures.

Figure 2.9. Possible Coast Belt paleogeographies. A: Continuity of Jurassic and Cretaceous plate margin arcs and accretionary complexes; restored offset on possible sinistral fault about 800 km. B: Prior to Late Cretaceous contraction; evidence for sinistral movement in Figure 2 suggests distribution of shear across entire accretionary complex, not along single fault shown. C: Late Cretaceous and younger; displacements restored: 450 km contraction across North Cascades (McGroeder, 1991), 185 km across Bowser basin (B) (Evenchick, 1991), and 130 km on Fraser-Straight Creek fault (Monger and Journeay, 1993). Not restored are ~450 km (based on geologic evidence) of orogen-parallel dextral displacement in north-central British Columbia-Yukon, or 1500-3000km of dextral displacement across entire Canadian Cordillera (based on paleomagnetic evidence cited herein), and 100-300km of shortening (based on geologic evidence) in easternmost Cordillera. K is Kahutna, G is Gravina basin, N is Nuizotin (modified from Monger, 1994).

Dextral strike-slip motion would also accommodate paleomagnetic and paleontological data, which indicates that Stikinia formed near its present position and moved south before reversing its motion to arrive at its present location.

Summary

The paleotectonic setting of the Stikine terrane is not well understood. The genesis and formation of Stikinia has been accepted, but the theories of how it arrived in its present location are numerous and controversial. It is generally accepted that Stikinia is well travelled and originated more or less in its present location before moving more than 1000 km south. Paleomagnetic and palaeobiogeographical evidence support this movement. Stikinia then returned north to its present location, almost where it started.

Each of the paleotectonic models explain some of the geological problems concerning Stikinia's motion but no model can explain most, or all of them. Monger's (1993) strike-slip model may provide explanations for most of the problems associated with the movement of Stikinia. However, it may not be possible to categorize the movement/s of Stikinia into one simple model, and a combination of the models discussed above (or other models) may be required.

Chapter 3: Local Geology

Introduction

Despite the apparent similarity in lithology, stratigraphy, and age of late Triassic successions across major fault boundaries immediately south of the Toodoggone river map area, these successions have been distinguished as the Stuhini Group in Stikinia, and the Takla Group in Quesnellia. Although the study area lies in Stikinia the Triassic rocks described herein are termed the Takla Group to maintain a consistent nomenclature with that adopted by Diakow (1986).

Geology Between Kemess Creek and Bicknell Lake

Three distinct lithostratigraphic units are recognized in the Kemess map area, and these can be correlated with major rock units that have been mapped regionally by Diakow and Metcalfe (1997) and Diakow and Rogers (1998). These major lithostratigraphic units are: (1) The mid-Pennsylvanian to lower Permian Asitka Group; (2) The upper Triassic Takla Group; and (3) The lower Jurassic Hazelton Group, specifically the Toodoggone Formation (Map Pocket). In the study area, the oldest rocks, the Asitka Group, consist of a series of rhyolitic to basaltic volcanic rocks that are succeeded by a limestone-chert sequence. The Takla Group is dominated by augite-plagioclase-phyrlic basalts. Pyritic mudstone locally marks the bottom of the upper Triassic sequence, and volcanogenic 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 the development of the open-pit at the Kemess South deposit. 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 Cu-Au deposit; here, they are correlated with the Toodoggone Formation. The uppermost unit is a distinct pyroxene-basalt flow that directly overlies and interdigitates the tuff-epiclastic unit.

Asitka Group

Rocks assigned to the Asitka Group underlie much of the topographically low section of the study area, east of the Omineca road and west of the Duncan fault (Map Pocket). In the region of the Kemess South deposit, which is situated between two major faults (*i.e.* the Kemess fault and the Duncan fault), the strata of the Asitka Group although scarce, are sufficiently exposed to suggest they comprise basement of the study area. Good exposures of the Asitka Group (particularly, the upper sedimentary part) comprise the footwall of the North Block fault (Map Pocket, Cross-section Pocket), whose trace cuts across the highest benches of the Kemess South open pit. The lower contact of the Asitka Group is neither exposed in the study area, nor regionally. However, the upper contact of the Asitka Group, which is probably an unconformity, is overlain by rocks of the Takla Group. At the upper contact, augite-phyric lavas lie above either distinctive andesite or limestone known to be lower Permian in age and older (Diakow, pers. comm. 1998). This upper 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 the study area, are based on similarities to rocks mapped in the adjacent region (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 agglomerate-lapilli-ash tuffs, which are exposed only at a solitary site in the waste-rock area of the mine (Map Pocket: Unit Pt), are believed to represent some of the oldest rocks of the Asitka Group. They are light greenish grey and contain sub-rounded to sub-angular, flattened lithic fragments that range in size from ash to fine blocks (Plates 3.1A and B). These tuffs generally weather a lighter greenish grey with rhyolitic fragments weathering a whitish tan to buff colour. The lithic fragments are generally very crystal poor, more commonly aphanitic and rhyolitic, or rarely basaltic in composition. The medium size lithic fragments are rimmed by small (<2mm) alteration halos and tension gashes perpendicular to the length of the fragments. The tension fractures do not penetrate into the alteration halo or the matrix and only show minor rotation (Plate 3.1B). The matrix of the tuff is composed of approximately 5-15 vol.% chloritic, devitrified volcanic glass. Interstitial to the lithic blocks is brick-red ash matrix. 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, pers. comm., 1998).

Up section from these tuffs are thick and widespread light turquoise green andesitic-welded-lapilli-ash tuff and flows (Map Pocket: Unit Pa₁; Plates 3.1C and

Plate 3.1 A: plate of the weathered surface of the lowest unit, (Lower Permian Asitka Group block and ash tuff) within the Kemess study area. Scale bar is in cm intervals. B: plate of the fresh surface of the lowest unit, (Lower Permian Asitka Group block and ash tuff) within the Kemess study area. Note the tension fractures in the larger clasts and alteration halos around the medium to larger lapilli. Scale is same as 3.1A. C and D: plate of the Lower Permian Asitka Group crystal tuff. Scale bar is in 1 cm intervals. E: plate of the weathering surface of the Lower Permian Asitka Group lithic ash flow tuff. Sample shows sub-angular to sub-rounded rhyolitic fragments. Scale bar is in 1 cm intervals. F: plate of the Lower Permian Asitka Group lithic tuff with angular to sub-angular lithic fragments. Scale bar is in 1 cm intervals. G: plate of the Lower Permian Asitka Group crystal tuff. Sample shows the stretched devitrified chloritic glass fragments (fiamme). Scale bar is in 1 cm intervals. H: plate of the Lower Permian Asitka Group sand- siltstone. Sample shows penecontemporaneous deformation and graded bedding. Scale bar is in 1 cm intervals.

Plate 3.1

D) or within the same unit dark green porphyritic-andesite and andesitic flows (Map Pocket: Unit Pa₂; Plates 3.2A and B). The light green andesitic tuffs and flows underlie the entire region between the Omineca road and the Duncan fault. These andesites contain 10-20 vol.% plagioclase and 5-10 vol.% pyroxene phenocrysts in an aphanitic light-turquoise green ground mass. The andesite flows are generally light green and contain variable amounts of epidote. Thinly-bedded, welded and non-welded tuffs (Plates 3.1E, F and G) and fine-grained sandstone layers (Plate 3.1H) are locally interbedded with these andesites. At two localities the tuffs are a few metres thick and contain dark green, chloritic fiamme and glass shards that range in length from 5-50 mm in length and up to 5 mm thick. Also, these tuffs contain sub-angular to sub-rounded, blocky, rhyolitic fragments that are up to 10 mm in diameter and weather a chalky white. Non-welded tuffs contain more compositionally varied fragments that are angular to sub-angular and range in size from 2-10 mm (Plate 3.1E). Fragments make up approximately 50-60 vol.% of the rock and are generally andesitic or basaltic in composition with plagioclase or feldspar phenocrysts. Lighter coloured fragments are rhyolitic in composition and similar in appearance to the welded tuff. Sandstone beds, interlayered locally with andesitic flows, may be up to 2 m thick. Exposed in a single location along the Omineca Mining Access road (Map Pocket), they are fine-grained, light green, internally graded and thinly to thickly laminated. Grains are generally composed of quartz and feldspar.

The dark green, chloritic andesites (Plates 3.2A and B) contain 10-30 vol.% blocky plagioclase phenocrysts (1-3 mm in diameter), and trace amounts of quartz

Plate 3.2 A: plate of the Lower Permian Asitka Group crystal tuff-flow within the Kemess study area. Sample shows the abundance of feldspar and pyroxene crystals. Scale bar is in cm intervals. B: plate of the Lower Permian Asitka Group crystal flow-tuff within the Kemess study area. Sample shows flow banding and the feldspar crystals are aligned parallel to flow banding. Scale bar is in cm intervals. C: plate of the freshly cut Lower Permian Asitka Group massive rhyolite within the Kemess study area. Sample shows the net texture formed by the epidote veining. Scale bar is in cm intervals. D: plate of the Lower Permian Asitka Group massive rhyolite within the Kemess study area. Sample shows the net texture formed by the epidote veining. Scale bar is in cm intervals. E: plate of the fresh surface of the altered Lower Permian Asitka Group massive rhyolite within the Kemess study area. Sample shows a typical massive texture of this unit. Scale bar is in cm intervals. F: plate of the weathered surface of the altered Lower Permian Asitka Group massive rhyolite within the Kemess study area. Sample shows a typical massive texture of this unit. Scale bar is in cm intervals. G: plate of the freshly cut Lower Permian Asitka Group massive limestone within the Kemess study area. Sample shows a typical massive texture of this unit, with numerous stylolites. Scale bar is in cm intervals. H: plate of the weathered surface of the Lower Permian Asitka Group massive limestone within the Kemess study area. Scale bar is in cm intervals.

Plate 3.2

as sub-rounded phenocrysts (about 1 mm in diameter). These andesites are several metres thick, flow banded and outcrop in only 3 localities in the study area.

Geochemical data, obtained from two samples collected West of the Duncan fault (Figure 3.1), indicate that both the Permian andesites and Permian tuffs are very similar in composition. The geochemical data in Figure 3.1 also distinguish the Permian andesitic rocks from the overlying massive basalts in the area.

A 50 m thick, massive grey-green rhyolite (Plates 3.2C and D; Map Pocket: Unit Pr) is found at one locality in the map area immediately east of Bicknell Lake. The rhyolite weathers chalky white (Plate 3.2D) and lacks any obvious phenocrysts, and tends to be highly fractured with epidote filling the fractures (Plate 3.2E). The weathering surface of this unit resembles the weathering characteristics of the clasts in selected light green Permian Tuffs (Map Pocket: Unit Pa).

The massive basalts, found stratigraphically beneath the andesites in the regional mapping, have not been identified 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 massive basalts outcrop slightly up slope from a small isolated exposure of Asitka Group limestone. The intervening area between exposures is not exposed.

Upper Sedimentary Unit

Limestone (Map Pocket: Unit Pl) and chert (Map Pocket: Unit Pc), with or without black argillite interbeds, comprise the upper, sedimentary division of the Asitka Group in the study area (Diakow and Rogers, 1998). These rocks are easily

Figure 3.1 Geochemical diagrams of the Early Permian Asitka Group Andesites and Tuffs, compared to the Upper Triassic Savage Mountain Formation within the Kemess study area.

recognized, and are typical of the lithologies found regionally, comprising the top of the Asitka Group below an unconformable contact with the overlying Takla Group. West of the Duncan fault (Map Pocket), a discontinuous 50 m thick band of limestone that is intermittently exposed for about 4 km, 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 the northern part of this region. East of the Duncan fault (Map Pocket), exposures of limestone are rare, with one outcrop between the Kemess South open pit and waste-rock area, and another north of the open pit. Chert interlayered with black argillite is the dominant Asitka Group unit exposed around the open pit. Northeast of the open pit, between Kemess Lake and Kemess Creek, limestone is once again exposed, presumably brought up along a strand of the Kemess fault, which trends northwest through a major valley between Kemess Lake and Duncan Lake (Map Pocket).

Limestone of the Asitka Group is typically white, recrystallized and weathers light-grey (Plates 3.2F and H). More impure samples contain small lenses (5 by 30 mm) of a creamy coloured limestone with numerous generations of stylolites (Plate 3.1G). Limestone that is exposed between Kemess Lake and Kemess Creek has an uncharacteristic light green colour and contains fine-grained silty impurities (*i.e.* “dirty limestone”) (Plates 3.3A and B; Map Pocket: Unit PI₂). This limestone is adjacent to several mafic, hornblende-bearing dykes and carries some minor pyrite, chalcopyrite and sphalerite mineralization (Appendix B: Geochemical Data-ICP Samples ROX22053 and ROX22054). A single 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 South open pit, where it is light to dark grey and thinly bedded (Plates 3.3C and D). The chert typically has partings of black mudstone (Plate 3.3D) and local siliceous mudstone interbeds. In exposures of the chert in the open pit, mudstone interbeds are intensely folded adjacent to the “10-180 fault” (Map Pocket, Plate 3.3E), and also show similar warping elsewhere (Plate 3.3D). Graphitic argillite with polished slip surfaces marks the fault plane in places. Indeterminate bivalves (Plates 3.3F and G) have been found in strongly sheared, siliceous and graphitic mudstone adjacent to the “10-180 fault”.

Takla Group

Lower Sedimentary Unit

Pyritic mudstone (Map Pocket: Unit TRms), with or without volcanogenic sandstone (Map Pocket: Unit TRss; Plates 3.4A), comprises the base of the Takla Group. A single 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 interpreted to be the northern extension of the “10-180 fault” (Map Pocket), which cuts the Kemess orebody. The mudstone is overlain by first volcanogenic 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* (sp) and rare ammonite fragments

Plate 3.3 A: plate of the altered light green Lower Permian Asitka Group massive limestone located near the Kemess Arch. Outcrop shows a typical massive texture of this unit and several dykes that cut this outcrop. Also shown is the location for assay sites collected from this outcrop. Outcrop is approximately 2 m high. B: plate of the Lower Permian Asitka Group massive limestone within the Kemess study area. Sample shows more intense stylolitic compaction as well as a dolomitic inclusion within the limestone. Scale bar is in cm intervals. C: plate of the Lower Permian Asitka Group chert within the Kemess study area. Sample shows typical thickness of bedding and wavy laminations within bedded units. Scale bar is in cm intervals. D: plate of the Lower Permian Asitka Group chert within the upper benches of the Kemess open-pit. Outcrop shows slight warping of the beds and thickness of the unit. E: plate of the Lower Permian Asitka Group chert and argillite within the upper benches of the Kemess open-pit. Outcrop shows intense folding of the chert beds to the left of the 10-180 fault. F: plate of the Lower Permian Asitka Group fossils from chert and argillite units. Scale bar is in cm intervals. G: plate of the Lower Permian Asitka Group fossils casts from chert and argillite units. Scale bar is in cm intervals.

Plate 3.3

Plate 3.4 A: plate of the weathered surface of the Upper Triassic Takla Group, Dewar Formation silt-sandstone within the Kemess study area. Sample shows the high percentage of broken pyroxene crystals within this particular sample. Scale bar is in cm intervals. B: plate of the weathered surface of the Upper Triassic Takla Group, Dewar Formation pyritic mudstone within the Kemess study area. Sample shows the typical oxidation colour of this unit. Also this sample has a sample of the *Halobia* (sp) fossil typical of this unit. Scale bar is in cm intervals. C: plate of the weathered surface of the Upper Triassic Takla Group, Dewar Formation pyritic mudstone within the Kemess study area. Sample shows the typical oxidation colour of this unit. Also this sample has a sample of the *Halobia* (sp) fossil typical of this unit. Scale bar is in cm intervals. D: plate of the weathered surface of the Upper Triassic Takla Group, Savage Mountain Formation augite phyric basalt within the Kemess study area. Sample shows the typical oxidation colour and pyroxene size and content of this unit. Scale bar is in cm intervals. E: plate of the weathered surface of the Upper Triassic Takla Group, Savage Mountain Formation augite phyric basalt within the Kemess study area. Sample shows atypical weathering colour and pyroxene and feldspar size and content of this unit. White weathering colour is from sample collected from beneath alpine mosses and grasses. Scale bar is in cm intervals. F: plate of the weathered surface of the Upper Triassic Takla Group, Savage Mountain Formation augite phyric basalt within the Kemess study area. Sample shows flow brecciation found at one locality within the Kemess open-pit. Scale bar is in cm intervals. G: plate of the Upper Triassic Takla Group, Savage Mountain Formation between two augite phyric basalt flows, within the Kemess study area. Scale bar is in cm intervals. H: plate of drill core of the Upper Triassic Takla Group, Savage Mountain Formation augite phyric basalt within the Kemess study area. Sample shows the atypical massive texture and small pyroxene size and content of this unit. This unit is also slightly mineralized with disseminated pyrite. Scale bar is in cm intervals.

Plate 3.4

(Plates 3.4B and C; Diakow *et al.*, 2001, Diakow and Metcalfe, 1997).

Volcanogenic sandstone (Plate 3.4A) that overlies the Triassic mudstone 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 pyritic mudstone; the second is on the west side of the same ridge where the sandstone is surrounded by Takla basalt (Map Pocket). The volcanogenic sandstone at these localities averages 6 m in thickness. Sections are characteristically graded from light green, very coarse-grained sandstone beds at the base to darker green, medium-grained siltstone beds that exhibit fine cross-laminations near the top. Volcanogenic 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 (Map Pocket: Unit Trb) called the Savage Mountain Formation. 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 5-20 vol.% pyroxene and 15-35 vol.% plagioclase phenocrysts (Plates 3.4D and E). Confusion arises locally because some Savage Mountain Formation members may also be aphyric (Plate 3.4G and H) and some Asitka basalts are porphyritic, containing pyroxene phenocrysts. Takla basalts, which weather rusty brown cover the two

highest points of land within the study area: the ridge north of the Kemess South open pit, herein called Kemess Ridge, and the south end of Duncan Ridge (Map Pocket). Although exposure is sparse, enough evidence exists to indicate that the Savage Mountain Formation form dip slopes on those ridges. Because no features indicative of submarine deposition (e.g. pillows or lava tubes) have been recognized these basalts are interpreted to have been subaerially deposited. Additionally, one location that sits topographically beneath, but stratigraphically above, the Permian Asitka Group limestone (exposed between the open-pit and waste-rock dump) shows features of a flow breccia that has incorporated clasts of basalt from the underlying rocks into the flow (Plates 3.4F and G). If this particular flow was deposited in a sub-marine setting then there would be haloclastite and/or volcanic glass surrounding the basalt clasts that the flow incorporated into it as it flowed over the land.

Geochemically the Takla basalts in the study area have compositions comparable to basalts from Monger's (1974) Savage Mountain Formation (Figure 3.2).

Hazleton Group-Toodoggone Formation

Duncan Member

Volcanic rocks of the Toodoggone Formation (Map Pocket: Unit JRct; Plate 3.5A) underlie a small area east of the Duncan fault. They consist of a grey-green, dacitic, crystal-rich ash tuff. Bounded on the west by the Duncan fault, these tuffs unconformably overlie Takla basalts and are cut by unnamed, early Jurassic (?)

Figure 3.2 Geochemical diagrams of the Upper Triassic Savage Mountain Formation within the Kemess study area and data obtained from Monger(1974) of the Moosevale Formation and the Savage Mountain Formation.

intrusive rocks. The tuffs contain diagnostic quartz phenocrysts (ca. 25 vol.%; <2mm) and plagioclase phenocrysts (ca. 30 vol.%; 1-3mm). The quartz phenocrysts typically have spherical to ovoid shapes (locally referred to as “quartz eyes”). Additionally, these tuffs contain some pyroxene phenocrysts (2-3 vol.% ; <2mm). Hydrothermal alteration of the tuffs is weak, and is characterized locally by the presence of sericite, chlorite, and pyrite. The tuffs weather a rusty brown from oxidation of pyrite (Plates 3.5A and B).

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 six intrusions that are thought to be part of the Black Lake Suite. They include the Maple Leaf intrusion, which hosts the Kemess South gold-copper porphyry deposit, and five other unnamed poorly exposed intrusions. Of the other intrusions, one is located east of Bicknell Lake, two are south of the lake, and three are at the northern end of the Kemess Ridge immediately south of Duncan Lake (Map Pocket). The contacts of the intrusions have not been directly observed but some of the country rocks are recrystallized, into hornfels, indicating proximity to an intrusive contact. The contacts of the Maple Leaf pluton have not been exposed¹ except for the faulted contact along the North Block fault. The Maple Leaf pluton is discussed in a later section that discusses the Kemess South orebody.

¹As of October 1998

Plate 3.5 A: plate of freshly cut surface of the Jurassic, dacitic crystal ash tuff within the Kemess study area. Sample shows the typical colour and feldspar and quartz size and content of this unit. Scale bar is in cm intervals. B: plate of typical Jurassic, dacitic crystal ash tuff within the Kemess study area. Outcrop shows the typical intensity of oxidation of this unit. C: plate of freshly cut surface of the Early Jurassic, unnamed Black Lake Suite of intrusives within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. D: plate of freshly cut surface of the Early Jurassic, unnamed Black Lake Suite of intrusives within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. E: plate of freshly cut surface of the Early Jurassic, unnamed Black Lake Suite of intrusives within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. F: plate of freshly cut surface of the Mega-Quartz-Feldspar-Porphyry within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Also this unit shows the porcelaneous alteration texture. Scale bar is in cm intervals. G: plate of freshly cut surface of a slightly mineralized sample of the Early Jurassic, unnamed Black Lake Suite of intrusives within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. H: plate of freshly cut surface of the Early Jurassic, unnamed Black Lake Suite of intrusives within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals.

Plate 3.5

Intrusions near Bicknell Lake

The largest of the intrusions (Plate 3.5C; Map Pocket: Unit Int-1), which is identified in small outcrops, covers less than 1 km² on a knoll south of Bicknell Lake and east of the Omineca road; it is located near the south end of the map area west of the Duncan fault. Although no contact has been observed, andesite of the Asitka Group crops out north, east and west of this intrusion. The intrusion has a medium-grained (2-4mm) equigranular texture of interlocking crystals. It weathers light tan to buff and is pinkish white on a fresh surface (Plate 3.3C). The intrusion has the following mode: 15 vol.% quartz, 40 vol.% plagioclase, 15 vol.% potassium feldspar, 15 vol.% hornblende, 10 vol.% biotite, and trace amounts of magnetite/ilmenite. Using the modal classification scheme for granitic rocks proposed by Streckeisen (1976) the intrusion has the composition of a quartz-monzodiorite or graniodiorite; a finding supported by the geochemical data (LeMaitre, 1982; Figure 3.3).

A second intrusion (Plate 3.5D; Map Pocket: Unit Int-2), located approximately 1.5 km further south, is exposed in a series of outcrops over a distance of 500 m. This intrusion has similar characteristics to the larger intrusion to the north, although it contains more mafic minerals. The approximate mode is: 30 vol.% hornblende and 20 vol.% biotite with 10 vol.% quartz, 30 vol.% plagioclase and 10 vol.% K-feldspar (Plate 3.5D), which supports its classification as a quartz-monzonite or graniodiorite (Figure 3.3). Both intrusions (*i.e.* Int-1 and Int-2) contain numerous (2-5 vol.%) mafic xenoliths that range in size from 1-20cm and are suggestive of I-type character (Chappell and White, 1982).

Figure 3.3 Geochemistry of the unnamed Black Lake Suite intrusions within the Kemess study area. All station numbers have the prefix 98-CRo-.

SiO₂ (Wt %) content:

6-2	66.95	7-1	68.87
8-4	64.55	18-4	68.38
26-6	48.32		

Thick overburden and glacial till in the area between the two intrusions hampered mapping, and it is unclear whether the intermittent series of granitic outcrops south of Bicknell Lake are part of the same intrusion or represent distinct intrusive bodies. Regardless, they are both considered to belong to the Black Lake Suite.

A third intrusion, east of Bicknell Lake (Map Pocket: Unit Int-3; Plate 3.5E), is exposed over a distance of about 200 m. It is interpreted to intrude porphyritic andesite of the Asitka Group. The intrusion is reddish brown and weathers tan to buff. It has an inequigranular texture (1-10 mm; average grain size around 2 mm) and comprises 15-20 vol.% quartz, 15-20 vol.% plagioclase, 40-50 vol.% potassium feldspar, and 5-10 vol.% biotite, placing it in the syeno- to monzo-granite field of Streckeisen (1976). The field and textural characteristics of this intrusion (Int-3) do not resemble those of the other intrusions (Int-1 and Int-2), and it may not be related to the Black Lake Suite, but rather to a distinct intrusive event.

Intrusions south of Duncan Lake

Approximately 1 km south of Duncan Lake, on the northwest end of Kemess Ridge, two granitic intrusions (Plates 3.5G and H; Map Pocket: Unit Int-4 & Int-5) and a quartz-feldspar porphyry crop out (Map Pocket: Unit Mqfp; Plate 3.4F). Outcrops of the larger of the two granitic intrusions (Plates 3.5G and H) occur over an area of approximately 1 km², whilst those of the smaller granitic intrusion (Plate 3.6B) and the quartz-feldspar porphyry are found over smaller areas (circa 500 m²). Disseminated pyrite is widespread in both granitic intrusions and also throughout

the adjacent country rocks of the Toodoggone Formation and Takla Group. Both the smaller intrusion and the quartz-feldspar porphyry intrude distinctive quartz-phyric dacitic rocks of the Toodoggone Formation; and Cu and Au-bearing, magnetite veins associated with the intrusions cut dacitic tuffs near the igneous contact (Plate 3.6A).

The granitic rocks of Units Int-4 and Int-5 are typically medium-grained, equigranular and consists of 5-10 vol.% quartz, 50-60 vol.% plagioclase, 10-15 vol.% potassium feldspar, 10 vol.% hornblende and 5 vol.% biotite (representing to the monzodiorite field of Streckeisen, 1976). Approximately 5 vol.% pyrite and 1-2 vol.% magnetite occur as disseminations in the outcrops of the granitic intrusions.

The quartz-feldspar-porphyry contains 15-25 vol.% euhedral quartz phenocrysts (up to 15 mm) and 5-10 vol.% plagioclase phenocrysts (up to 10 mm). The rock is highly altered and the original groundmass has been converted to a light greenish beige mixture of clay minerals and silica that gives it a porcelaineous appearance (Plate 3.6G).

The smaller intrusion (Plate 3.6B; Map Pocket: Unit Int-e), is located on the east side of the Duncan fault and south of Duncan Lake on Kemess Ridge. This intrusion is very similar to the larger intrusion on the east side of Kemess Ridge. This medium-grained equigranular granitic rock consists of 5-10 vol.% quartz, 50-60 vol.% plagioclase, 10-15 vol.% potassium feldspar, 10 vol.% hornblende and 5 vol.% biotite. Approximately 5 vol.% pyrite and 1-2 vol.% magnetite are disseminated through the intrusion. The mineral assemblage plots in the quartz-

Plate 3.6 A: plate of freshly cut surface of the mineralization of the Jurassic, dacitic crystal tuff within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. It also shows the size of magnetite veining prevalent to this local of intrusives. Scale bar is in cm intervals. B: plate of freshly cut surface of the Early Jurassic, unnamed Black Lake Suite of intrusives within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. C: plate of freshly cut surface of an unknown age felsic aplite dyke within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. D: plate of the East Dyke that cuts the Kemess orebody. Sample shows the typical colour and character of this unit. Person standing near the bottom of the dyke is approximately 6' tall. E: plate of freshly cut surface of the mafic dykes that intrudes within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. F: plate of weathered surface of the mafic dykes that intrudes within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. G: plate of freshly cut surface of the quartz-feldspar porphyry dykes that are found within the Kemess open-pit. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals. H: plate of hornblende mafic dyke that intrudes Asitka Group limestone near Kemess Creek. Sample shows the typical colour and grain size and content of this unit. Scale bar is in cm intervals

Plate 3.6

monzodiorite field of the Streckeisen ternary diagram (Figure 3.3).

Felsic Dykes

Felsic dykes (Map Pocket: Unit F-dykes; Plate 3.6C), which intrude Permian chert, are exposed only at three locations; along the uppermost bench in the open pit. The dykes are generally vertical in orientation and trend roughly north-south. These aphanitic dykes, which are brick red in colour, may be related to the small granitic intrusion (Int-3) east of Bicknell Lake.

Mafic Dykes

Mafic dykes (Map Pocket: Unit M-dykes; Plate 3.6 D, E, and F) are very similar in texture to the Savage Mountain basalts. The dark green mafic dykes are typically porphyritic in character with 5-15 vol.% pyroxene phenocrysts (1-5 mm) set in an aphanitic groundmass. Mafic dykes are most commonly exposed in the open pit, where they tend to be less than 1 m thickness and only exposed for a few metres along strike. The exception is the "East dyke", (approximately 20 x 20 m²), which is the only significant mafic dyke known to cut the Kemess deposit (Plate 3.6D) and therefore post dates the formation of the Cu-Ag mineralization. Geochemically the mafic dykes have compositions similar to the Takla basalts (Figure 3.4), and may represent feeder dykes to the overlying basalts.

Figure 3.4 Chemistry of the unknown pyroxene basalt, Upper Triassic Savage Mountain Formation and mafic dykes found within the Kemess study area.

Feldspar-Quartz-Porphyry Dykes

The feldspar-quartz-porphyry dykes (Map Pocket: Map Unit qfp Plate 3.6G) are found at three localities within 1.5 km north of the open pit. These dykes generally contain 15-20 vol.% plagioclase phenocrysts (up to 10 mm) and 5-20 vol.% quartz phenocrysts (up to 5 mm), together with discrete grains of pyrite (up to 2 mm), set in a fine-grained groundmass. The feldspar-quartz porphyry dykes intrude rocks of the Takla Group Savage Mountain Formation.

Structure

Two major, high-angle, brittle faults have been mapped within the study area: the Duncan and Kemess faults (Map Insert). The inferred traces of these structures correspond with major valleys, and have also 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 (Plate 3.7A and B).

The trace of the most significant fault in the study area, the Duncan fault, is projected along the axis of Duncan Lake to the north. To the south, the Duncan fault is covered by overburden for the most part, but its trend 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 in this area. West of the Duncan fault there is a broad region underlain by andesitic rocks, whereas east of the structure limestone and chert from the upper sedimentary division of the Asitka Group predominate. Farther north, the Duncan fault forms a prominent linear cleft in the slope and

Plate 3.7 A: plate of the North Block Fault in relation to the Permian Chert Upper Supergene zone (USG), Middle Supergene zone (MSG), Lower Supergene zone (LSG), and Hypogene zone (HG). The tire on the truck is approximately 11' high. B: plate of milled fault gauge from the Kemess South open-pit. This minor fault and others like it was originally reported as coarse basalt sand stone with calcite cement from drill core. Scale bar is in 1 cm intervals.

Plate 3.7

places basalt of late Triassic age (west of the fault), against dacitic tuff early Jurassic age (east of the fault). Juxtaposition of different rock units along the Duncan fault is consistent with a normal fault having east-side down displacement, although the actual amount of displacement is not known.

The Kemess fault (Map Insert), 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, rare argillite, and some chert comprising part of the Asitka Group is exposed (Diakow and Rogers, 1998). A series of en echelon, valley-parallel, normal faults with south side-down motion have been documented as cutting these rocks (Diakow, pers. comm., 1998). To the southwest, across the Kemess fault, pyroxene basalt and rare *Halobia*-bearing mudstones that form part of the lowermost sedimentary division of the Takla Group are exposed along the crest of the Kemess Ridge north of the Kemess South open 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: a feature that could explain the distribution of the stratigraphically underlying chert and argillite of the Asitka Group, which crop 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, subvolcanic, calc-alkaline porphyritic quartz-monzonite intrusion called the Maple Leaf pluton. Diamond drill-hole information indicates that the intrusion is a gently inclined sheet (Rebagliati *et al.* , 1995), which 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 primary (hypogene) copper-gold mineralization is contained within the upper part of the Maple Leaf pluton. After emplacement and exhumation, exposure and oxidation of the hypogene mineralization created the secondary, supergene zone of mineralization. The supergene event took place before deposition of a tuff-epiclastic sequence which now rests directly on the supergene zone in the open pit.

Maple Leaf Pluton

The Maple Leaf quartz monzonite intrusion is a tabular body that dips to the southwest at approximately 30° and is up to 250 m thick near the North Block fault. Samples of the Maple Leaf pluton, in surface exposures and in drill core are strongly altered (Plate 3.8A). The least altered part (Plate 3.8C) of the Maple Leaf pluton occurs near the east side of the open pit, where the intrusion consists of approximately 10-15 vol.% quartz, 45 vol.% plagioclase, 10-15 vol.% potassium feldspar, and 20-25 vol.% mafic minerals (largely replaced by hydrothermal chlorite

Plate 3.8. A: plate of the most altered hypogene zone at the Kemess South copper-gold porphyry deposit. Scale is in 1 cm intervals B: plate of upper supergene sub-zone at the Kemess South copper-gold porphyry deposit. The highly altered rock contains no primary igneous textures or any visible native copper but does contain high gold. Scale is in 1 cm intervals C: plate of the least altered hypogene zone at the Kemess South copper-gold porphyry deposit. Scale is in 1 cm intervals. D: Hand Specimen of upper-middle supergene sub-zone at the Kemess South copper-gold porphyry deposit. The highly altered rock contains only remnant primary igneous textures but does contain large amounts of native copper. Scale is in 1 cm intervals. E: plate of high gold sample within the supergene zone. The square close-up shows examples of “pin prick” copper. Scale is in 1 cm intervals. F: plate of upper-middle supergene sub-zone at the Kemess South copper-gold porphyry deposit. The highly to moderately altered rock contains only remnant primary igneous textures but does contain elevated amounts of native copper. Scale is in 1 cm intervals. F: close up of a sample of native vein copper. Scale is in 1 cm intervals G: plate of lowest supergene sub-zone at the Kemess South copper-gold porphyry deposit. The slightly altered rock contains only minor oxidation primary igneous textures but does contain large amounts of “pin prick” native copper (not shown). Scale is in 1 cm intervals.

Plate 3.8

and biotite). At this locality quartz veins (in the form of stockwork) make up approximately 5 vol.% of the rock.

Hypogene Zone

The hypogene zone comprises approximately 75% of the Kemess South deposit, is mineralized with gold and copper, and is confined to the upper part of the Maple Leaf pluton. Typically it contains 1-5 vol.% pyrite, chalcopyrite, magnetite-hematite and bornite as disseminations, with minor amounts of molybdenite, and traces of gold and other minerals (here collectively termed “hypogene ore minerals”). The hypogene ore minerals occur on fractures, in veins, in interstices, and along grain boundaries.

Sericite is the dominant hydrothermal alteration mineral associated with the hypogene ore in the Kemess South deposit, giving rise to widespread areas of “sericitic alteration” (see Meyer and Hemley, 1967, for an explanation of alteration terminology). Locally, sericite comprises up to 25 vol.% of the rock, and as its content increases, there also tends to be an increase in silica content and greater destruction of the primary minerals and original igneous textures.

The second most abundant hydrothermal alteration type is that of “potassic alteration”, characterized by the presence of pink potassium feldspar. Potassic alteration forms selvages on the quartz veins that range up to 3 cm 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 (Plate 3.7A).

According to Rebagliati *et al.* (1995) drilling has shown the presence of hydrothermal alteration patterns that are sub-parallel to the contact of the Maple Leaf intrusion, which hosts the hypogene mineralization. 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.

A representative sample of hypogene ore from the Maple Leaf pluton was collected for U-Pb zircon geochronology (Diakow and Rogers, 1996). The sample was light pink and collected without any quartz or other veining, and yielded an age for emplacement of 199 ± 0.6 Ma (Diakow and Rogers, 1998).

Supergene Zone

The supergene zone is a red, oxidized zone. It contains chalcocite and two forms of native copper: as large sheets (up to several metres in length), and as tiny (<2mm) disseminated flecks of native copper termed “pin-prick copper”. The supergene zone has been subdivided into three sub-zones (Plate 3.8B, D, F, and H), following the terminology used by the Kemess mine staff. Directly overlying the hypogene ore is the lowest sub-zone in which flecks of pin-prick copper (Plate 3.8E), are disseminated throughout the oxidized, and intensely clay- and hematite-altered intrusive rock. This lowest sub-zone also contains secondary sulphides, consisting mainly of chalcocite, and minor hypogene sulphides (chalcopyrite and

bornite). The middle sub-zone contains slightly larger leaves of native copper (typically up to 10 cm in diameter and 3 mm in thickness), which near its top can reach lengths of more than 3 m and thicknesses of greater than 3 mm (Plate 3.8G). This middle sub-zone is more intensely altered than the lower sub-zone and contains up to 30 vol.% hematite-stained clay. The upper sub-zone contains elevated levels of gold but very little copper, and is characterized by abundant hematite alteration.

Hazleton Group-Toodoggone Formation

Saunders Member

The supergene zone of the Maple Leaf pluton is overlain by poorly indurated lithic tuffs and interbedded epiclastic rocks (Map Unit JRt; Plates 3.9A thru H). This unit does not crop out at surface near the orebody; however, diamond-drill core sections show that it is widespread in the subsurface, thickening towards the southwest to more than 200 m. Similar rocks also crop out along Kemess Creek, south of the mine site, where cut banks up to 10 m high are dominated by reddish-brown to maroon epiclastic rocks (Plates 3.10 A and B). Farther downstream these rocks are covered by glacial till. West of the Duncan fault, bedded epiclastic rocks with similar lithological characteristics crop out sporadically in a small area, approximately 100 by 200 m. They consist of a relatively flat-lying bedded sequence more than 25 m 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.

Plate 3.9 A: plate of freshly cut surface of the Jurassic, Saunders Member within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. View is perpendicular to layering. Scale bar is in 1 cm intervals. B: plate of fresh surface of the Jurassic, Saunders Member within the Kemess study area. Sample shows the typical colour and grain size and content of this unit. View is parallel to layering (bedding surface). Scale bar is in 1 cm intervals. C: plate of freshly cut surface of the Jurassic, Saunders Member (epiclastic unit, wet, moderately well sorted), within the Kemess study area. Sample shows the typical colour and colour size and content of this unit. View is perpendicular to layering (bedding surface). Scale bar is in 1 cm intervals. D: plate of freshly cut surface of the Jurassic, Saunders Member (epiclastic unit, dry, moderately well sorted), within the Kemess study area. Sample shows the typical colour and colour size and content of this unit. View is perpendicular to layering (bedding surface). Scale bar is in 1 cm intervals. E: plate of freshly exposed face of the Jurassic, Saunders Member (tuff unit, well bedded), within the Kemess study area. Sample shows the typical colour and colour, and typical character of this unit. View is perpendicular to layering (bedding surface). F: plate of freshly exposed outcrop of the Jurassic, Saunders Member (tuff unit), within the Kemess study area. Sample shows the typical colour, character and clast distribution of this unit. Scale bar is in 1 cm intervals. G: plate of freshly exposed outcrop of the Jurassic, Saunders Member (epiclastic unit), within the Kemess study area. Sample shows the typical colour and thickly bedded sections of this unit. H: plate of basaltic clasts within the epiclastic unit. Sample is from diamond-drill core and is approximately 4 cm wide.

Plate 3.9

Plate 3.10 A: plate of freshly cut surface of the Jurassic, Saunders Member (tuff unit), near Kemess creek. Sample shows the typical colour and mineralogy of this unit. Scale is in 1 cm intervals. B: plate of freshly cut surface of the Jurassic, Saunders Member (epiclastic unit), near Kemess creek. Sample shows the typical colour of this unit. Scale is in 1 cm intervals. C: plate of freshly cut surface of the Jurassic, Saunders Member (epiclastic unit), within the Kemess study area, near an unnamed creek. Sample shows the typical colour of this unit. Scale is in 1 cm intervals. D: plate of freshly cut surface of the Jurassic, Saunders Member (epiclastic unit), within the Kemess study area, near an unnamed creek. Sample shows the typical colour of this unit. Scale is in 1 cm intervals. E: plate of freshly cut surface of the Jurassic, Saunders Member (tuff unit), within the Kemess study area, near an unnamed creek. Sample shows the typical colour of this unit. Scale is in 1 cm intervals. F: plate of typical Sustut sediments within the vicinity of Kemess South open pit. Outcrop is approximately 10 m high. G: plate of weathered surface of the Pyroxene basalt within the Kemess study area. Sample shows the typical weathering colour and mineralogy of this unit. Scale is in 1 cm intervals. H: plate of the contact of the pyroxene basalt with the Saunders Member along the 10-180 fault, within the Kemess open-pit.

Plate 3.10

At the Kemess South deposit, copper and gold assays from drill core collected across the contact of the tuff-epiclastic unit and the supergene zone indicate that the lower contact of the tuff-epiclastic unit is sharply defined against the supergene zone: gold and copper assays average 1 ppb and 0.015 wt.% respectively in the tuff-epiclastic unit, but raise to 45 ppb and 0.3 wt.% in the underlying supergene zone. Also, native copper is notably absent in the tuff-epiclastic unit. In the field, however, the contact looks more gradational; with plagioclase in the overlying tuff-epiclastic unit and quartz in the underlying supergene zone showing an antipathetic spatial relationship. The tuffs in the overlying tuff-epiclastic unit form very thick, crudely-layered, maroon to brick red beds (Plates 3.9C and G). The content of lithic fragments in the tuffs varies markedly, from 5-50 vol.%. The dominant lithic fragments are aphanitic (5-20 mm), light green in colour, and are greasy to the touch, and are composed of 15Å montmorillonite, with minor amounts of albite and quartz (Figure 3.5). Locally, the tuffs also contain rare quartz and altered biotite phenocrysts; and occasional sub-angular to sub-rounded clasts of basalt

Grey-green and maroon epiclastic rocks (Plates 3.9C, D, and H) comprise distinctive bedded intervals within the comparatively more massively bedded maroon tuffs. The epiclastic rocks are typically medium- to thickly-bedded in nature with thinner, parallel-laminated and graded sections. The epiclastic layers are composed mainly of volcanogenic 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

Figure 3.5 X-Ray Diffractogram of a sample of the light green scale like fragments in the tuffs from the Jurassic South Kemess Member (13-02). The pattern is dominated with 15Å Montmorillonite (Mont-15Å) and to a minor extent, the plagioclase Albite. There is also minor amounts of quartz in the sample.

occurs as discrete grains in some of the basaltic clasts, and the source of this detritus is thought to be that of nearby basaltic rocks of the Takla Group, Savage Mountain Formation.

A single, anomalous devitrified ash bed (~10 cm in thickness) was found within the maroon epiclastic rocks. Extremely friable in character, the light grey ash bed contained no primary textures and is composed of approximately 90 vol.% clay material with a subordinate amount of small (1-3 mm) rounded to sub-rounded basaltic clasts (Plate 3.9F). The tuff-epiclastic unit is also exposed in an unnamed creek west of the Duncan fault (Plates 3.10C, D, and E).

Rebagliati *et al.* (1995) correlated the tuff-epiclastic unit at the Kemess South deposit with the Tango Creek Formation (?) of the Sustut Group. However, there are significant lithological differences between typical rocks of the Sustut Group and those overlying the Kemess South deposit that make this correlation improbable. The nearby rocks of the Sustut Group are characterized by the presence of well-rounded chert, vein quartz, and granitic clasts in thick, parallel-bedded conglomerate and sandstone beds (Plate 3.10F). In contrast, the maroon-coloured rocks found directly above the Kemess South deposit are mainly sub-aerial tuffs with subordinate immature epiclastic rocks, more similar to the 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 dated by U-Pb zircon geochronology 196 ± 0.5 Ma (Diakow *et al.*, 2001). The unit is therefore correlated with the Saunders Member, which has an Ar-Ar age of 194 Ma, and is an andesite that is composed of tuffs with upper

sandstone units (Diakow *et al.*, 1986)

Post-Ore Intrusives: Pyroxene Basalt

A fresh, pyroxene-bearing basalt (Map Pocket Pxb; Plate 3.10G), in a flow more than 30m thick, sharply overlies and interdigitates the tuff-epiclastic unit, and represents the youngest rock unit in the study area. Electron micro probe analysis has proven that small granular crystals that were originally thought to be olivine are actually augite (Rogers and Houle, 1999). The basalt contains 30-35 vol.% plagioclase, up to 10 vol.% pyroxene phenocrysts, and is unlike any basalt mapped regionally. A sample was collected for Ar-Ar geochronology but did not return a reliable age. Geochemically these basalts are similar to the tuffs from the Toodoggone Formation, Saunders Member (Figure 3.6).

Local Structure in the Kemess South Open Pit

The North Block fault (Map Pocket; Cross-section Pocket) is the most prominent fault exposed in the open pit. The fault strikes roughly east and dips at about 70° 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 copper and gold grades reported in the hypogene zone are found adjacent to the North Block fault. The fault also truncates the supergene zone and the overlying tuff-epiclastic unit. Fault gouge zones, 5-10 m wide, are developed along the North Block fault. Other than the occurrence of "milled" pyrite, the fault zone is unmineralized; a finding that is consistent with data from the exploration drill-core

● Jurassic Tuffs

▼ Olivine Basalts

Figure 3.6 Geochemical diagrams of the unknown pyroxene basalt and the Jurassic Kemess South Member within the Kemess study area.

logs, which show that both hypogene and supergene mineralization are truncated by the fault. The sense of displacement 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 an unnamed fault that apparently uplifted and folded upper Triassic sedimentary rocks on the crest of Kemess Ridge, north of the open pit. This structure strikes due north and dips east at 80°. Like the North Block fault, the "10-180 fault" postdates the formation of the supergene zone of mineralization. The "10-180 fault" truncates both the tuff-epiclastic unit that directly overlies the supergene zone and the pyroxene 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 (with a dextral offset) the trace of the North Block fault by approximately 250 m. Approximately 150m north of the North Block fault, near the ring road around the open pit, the "10-180 fault" cuts deformed chert layers that contain native copper mineralization; mineralization that may have been deposited from groundwater that moved along the fault from where it cuts the supergene zone. The "10-180 fault" also has a rotational component; with the east block having rotated clockwise relative to the counterclockwise movement of the west block. Adjacent to the "10-180 fault", the tuff-epiclastic unit changes inclination: to the west of the fault 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 footwall section of the North Block fault. Folded Permian chert in the footwall of the deposit is cut by the North Block fault. The folds are asymmetric and verge in an east-northeast direction. The axial planes strike on average 132° and dip approximately 70° southwest, oriented roughly 30 to 60° relative to the strike off the North Block fault. Fold axes trend 145° and plunge 16° . 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 crest of Kemess Ridge. Here the mudstone unit is less than 5 m 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° . The orientation of these folds is almost parallel to the projection of the "10-180 fault" and the folds are interpreted as drag structures related to faulting.

Chapter 4: Supergene Zone

Introduction

Supergene enrichment is a secondary mineralization process of alteration and mineralization that involves oxidation of primary hypogene ore or “protore” in a specific host rock environment (Evans, 1997; Titley and Marozas, 1995; Ney *et al.*, 1974). Oxidation of sulphide minerals (notably pyrite) from the hypogene protore produces acidic solutions in an oxidizing environment above the water table that dissolve Cu and other metals and redeposit them in the more reducing environment below the water table (Figure 4.1).

The most soluble metals (*e.g.* copper) are generally oxidized and leached down to the water table, where they are precipitated when conditions become unfavourable for the ions to remain in solution (Evans, 1997). The insoluble iron oxides are usually left behind in the near surface environment where they form a “gossan”. The more stages of exhumation, weathering, leaching and re-deposition a porphyry deposit undergoes, the higher the final grade of mineralization is likely to be in the supergene zone. Therefore, weathering of the supergene zone is an indication of the maturity of the weathering profile of the deposit (Titley and Marozas, 1995).

The oxidation of sulphide minerals at the Earth’s surface is largely dependent on Eh and pH of the environment, and pH is largely dependent on the presence of iron bearing minerals, mainly pyrite (Faure, 1997). It has been demonstrated by Titley (1995) that 8 moles of pyrite are needed to dissolve 2 moles of chalcopyrite,

Figure 4.1 Idealized cross-section of a near-surface sulphide ore body, showing the zonation of oxidation due to oxygen bearing solutions. The mineral assemblages produced are illustrated by typical copper minerals (modified from Faure, 1991 and Gill, 1996).

to produce 2 moles of CuSO_4 , to finally produce 1 mole of chalcocite. Copper mobilized during oxidation of pyrite and chalcopyrite moves across the zone of oxidation to a level of reducing conditions (*i.e.* the water table), and where precipitation of copper oxide minerals occurs. The ore minerals that are precipitated below the water table, most commonly chalcocite, are usually spread laterally over considerable distances (<1000 m), but are restricted in thickness (<100 m). This supergene “blanket” is usually stable unless the base level is moved by a change in height of the water table (tectonic or otherwise). Weathering can then resume and re-enrichment of a section of the supergene blanket can occur.

The “ideal” weathering environment, for supergene zone development, has three main geochemical domains characterized by oxidation state and pH. The three domains are: (1) a source region that is composed of the rocks undergoing oxidation; (2) a sink region where mass from the source collects; (3) the protolith or unreacted material that is sometimes called “protore” (Figure 4.1) (Chaveux, 2001).

Development of a supergene zone in a porphyry copper deposit, and the related oxide copper minerals, is a function of: (1) source- and host-rock mineralogy; (2) the amount and availability of pyrite and other copper sulphide minerals in the hypogene ore/protore; (3) the abundance and intensity of the fracture network; (4) the phreatic and or vadose zone location and stability. Pyrite is the most omnipresent mineral and breaks down to produce insoluble iron hydroxides and sulphuric acid (Evans, 1997).

South Kemess Supergene Zone

Present exposure of the supergene zone at Kemess South likely represents a truncated version of what was once a more extensive supergene profile (Figure 4.1). This supergene profile (zone) of the Kemess South deposit had not been extensively studied prior to this project. The supergene zone has native copper, chalcocite, and bornite as its predominant ore minerals. Hematite and clay minerals derived from the weathering of earlier igneous and hydrothermal silicates and sulphides, are the gangue minerals that make up the rest of the supergene zone. A study of the supergene zone was undertaken in order to determine the nature and inter-relationships of the ore, gangue, and silicate alteration minerals in this zone of secondary copper enrichment. One objective of the present study was to determine the nature and distribution of gold: routine geochemical assaying has shown the supergene zone to be enriched in gold, in addition to copper (Appendix B:Geochemical Data-ICP); however, only one grain of visible gold (*i.e.* petrographic identification) had been identified petrographically during the feasibility study undertaken by El Condor Resources (*cf.*, Harris, 1991a).

Sample Collection

A suite of supergene samples, from the supergene ore zone in the Kemess South open pit, was collected under the guidance of the chief geologist from the then Royal Oak Mines (Plates 3.8 B, D, F, and H). Twelve representative samples were collected for a series of analyses that included: powder x-ray diffraction (XRD), transmitted and reflected polarizing microscopy, scanning electron microscopy

(SEM) and electron micro probe (EMP) analysis, whole rock geochemistry, ICP and fire assay analysis (see Figure 4.2). Exposure of the supergene zone in the newly-developed open pit, was limited to its eastern side, where a reasonably complete vertical section of the supergene zone was exposed and a suite of samples were collected. In addition to the representative whole-rock samples, several large sheets (>30 cm) of native copper were also collected from the supergene zone.

It was originally intended that diamond drill-core from the exploration and feasibility phases of the mining project was to be the source for the samples in this study. The drill-core would have provided the best possible sample coverage for a systematic study of the supergene zone. However, because the diamond drill-core was stored outdoors, it was heavily decomposed, and most samples were so poorly consolidated that they could not withstand sample preparation.

Sample Preparation

Hand Specimens

From each of the hand specimens, which varied in weight from 1-5 kg, a random sub-sample was processed for the following (Figure 4.2):

1. The extraction of <2 μm clay material (Table 4.1);
 - a. The clay material was further subdivided into several aliquots for:
 - i. X-Ray Diffraction (XRD),
 - ii. Identification using a scanning electron microscope (SEM).

Table 4.1 Results for the recovery of clay and heavy mineral separates from samples of the supergene zone (all weights are in grams).

Sample No.	Sub-Zone	Sub-Sample	>2 mm Fraction	<2.0 mm Sand Fraction		Silt Fraction	<2 μ m Clay Fraction
				M.I Lights	HMC		
98-CRO-49-1	Lower	250	34.8	181.4	7.6	24.9	1.3
98-CRO-49-2	Lower	250	111	110.7	2.3	24.4	1.6
98-CRO-49-3	Lower	250	124.2	100.2	1.7	22.3	1.6
98-CRO-49-4	Middle	250	124	92.2	9.6	23.2	1
98-CRO-49-5	Middle	250	38	178.3	8.2	23.1	2.4
98-CRO-49-6	Middle	250	59.5	161.7	5.1	21.7	2
98-CRO-49-7	Upper	250	86.3	102.8	33	25.1	2.8
98-CRO-49-8	Upper	250	57.2	86.5	73.3	28.5	4.5
98-CRO-49-9	Upper	250	87.9	137.6	3.2	18.2	3.1
98-CRO-49-10	Middle	250	38.6	181	3.5	24.7	2.2
98-CRO-49-11	Middle	250	44.4	175.8	4.8	22.3	2.7
98-CRO-49-12	Middle	250	79.9	142.7	3.6	22.5	1.3
98-CRO-13-2a	JRt	250	143.7	No MI Sep	85.9	18.9	1.5

Figure 4.2. Rock and mill concentrate analysis of samples collected from the Kemess South open pit during field mapping in 1998. The same procedure was used for preparing the 12 hand specimens for analysis, and a different set of procedures were needed to prepare the mill concentrate for analysis. Each of the hand specimens had the same analysis run. Each of the different analysis was to address a specific problem associated with the whole rock or mill concentrate samples. XRD was to determine the bulk mineralogy of the supergene clay and ore mineralogy. Polished grain mounts and thin sections were made to determine ore mineralogy and gangue mineral characteristics of the supergene zone. Clay separates were made to characterize the clay mineralogy of the supergene zone. Fire assay was to determine bulk elemental composition of the whole rock and ore concentrate. SEM analysis was to determine specific mineral composition. Chemical treatment of the clays was to remove a "coating" of hematite from the clay material. Heavy liquid separation was to split the samples into "heavy" (>3.66 SG) and "light" (<3.66 SG) mineral fractions to facilitate accurate mineral identification.

Kemess South Deposit: Supergene Study

2. The preparation of heavy mineral concentrates (HMC) (Table 4.1);
 - a. The HMC material was further subdivided into several aliquots for:
 - i. X-Ray Diffraction (XRD),
 - ii. Identification using a scanning electron microscope (SEM).
 - iii. Identification using a reflected light microscopy.
3. Inductively Coupled Plasma (ICP) analysis, for whole-rock geochemistry.
4. Fire assay for the determination of gold, copper, and silver concentrations.
5. The preparation of a polished slab of each of the hand specimens.

Clay Material

A sub-sample of approximately 250 g of original rock material was crushed to less than 2mm. The sub-sample was soaked in water for approximately 7 hours. The larger fragments were then removed through a series of filters. The <2 μm fraction was then separated by centrifugal methods. This <2 μm clay material was then placed in a drying pan and air dried. All of the remaining material (>2 μm , <2 mm) was processed on a Rodgers table to separate the heavy minerals from the lighter silicate materials (Table 4.1).

XRD Analytical Procedure

The less than 2 μm clay fraction was analysed at the University of Ottawa, with a Philips PW3710 X-ray diffractometer, using the following procedures:

1. Pressed powder slides, mounted in a non-reflective aluminium well sample holder;

2. Orientated samples, mounted on a non-reflecting glass slide, by pipetting a suspension of $<2\ \mu\text{m}$ clay fraction with either distilled water or ethanol;
3. Smear slides, where a paste was made from the $<2\ \mu\text{m}$ clay fraction using distilled water, and then spread onto a non-reflective glass sample holder;
4. Randomly orientated powder slides, where the non-reflective glass sample holder was coated in a thin film of petroleum jelly, and the $<2\ \mu\text{m}$ clay material was sieved over the slide to produce an even distribution of sample.

The samples were scanned from $2.990^\circ 2\theta$ to $80.00^\circ 2\theta$, using a number of test samples, and a variety of step sizes (0.020 to 0.040), and times (1 to 2 seconds) per step. Hematite dominated all of the diffractograms produced from the above sample types; therefore, an analytical procedure for the chemical treatment of clays to remove excess iron oxide (hematite) was introduced, which involved the following steps:

1. Weigh 0.200 g of dry clay that was collected from suspension in a 20 mL screw cap vial (see Appendix A: Analytical Procedure for exact weights).
2. Using a pipet add 20 mL of sodium citrate ($\text{Na}_3\text{C}_6\text{H}_5\text{O}_7 \cdot 2\text{H}_2\text{O}$) solution to the vial (Appendix A for specific chemical information).
3. Add approximately 0.3000 g of sodium dithionite ($\text{Na}_2\text{S}_2\text{O}_4$).
4. Cap vial and shake overnight in an end to end shaker.
5. Remove cap and centrifuge for 15 min at approximately 500G.
6. Decant remaining liquid and discard.
7. Wash with distilled water, shake vigorously to break up the clay and centrifuge for another 5 minutes.

8. Decant remaining liquid and discard.
9. Repeat process until clay material has lost its pinkish red colour.
10. For the final washing the clay suspension was poured into a petri dish, covered with a cloth and air dried.
11. Final analysis of the treated clay was then completed using a normal petrographic glass slide mount on a Philips PW 1710 X-Ray Diffractometer, using a 0.03 step scan, 1 second per step, from $3^{\circ} 2\theta$ to $41^{\circ} 2\theta$.

Native Copper Samples

The four samples of native copper collected from the Kemess South open pit were washed in an ultrasonic bath for one hour to remove any adhering gangue or silicate minerals. Two of the washed samples were then bathed in dilute hydrochloric acid (~5%) for 10 minutes to remove any oxidized coating on the native copper (with two remaining untreated with HCl). All four samples were washed in distilled/deionized water and air dried. Samples were submitted to MinEn Laboratories (Vancouver, British Columbia) for the commercial, geochemical analysis by ICP and fire assay analysis.

Whole-Rock Samples

Sub-samples of the whole rocks for geochemical analysis were produced in the laboratory, from hand specimens collected in the field, by cutting a random slice using a diamond-impregnated carbide steel rock saw. All samples were then crushed in a jaw crusher, and the supergene zone samples were pulverized (<150

mesh) using an Cr-Steel ring and puck mill, and all other whole rock samples were pulverized (<150 mesh) in an agate ring and puck mill. Contamination may include: Cr, Fe, and Ni for the Cr-Steel ring and puck mill and Si for the agate ring and puck mill.

1. Multi-Element ICP (Aqua Regia Leach Package) - Analyses involved partial digestion of a sample using two acids, HCl and HNO₃, heated in a bath to 95°C and then processed in an inductively coupled plasma (ICP) spectrometer. Elements analysed include: Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Sc, Sn, Sr, Ti, V, W, Y, Zn, and Zr.
2. Fire Assay - Analyses involved the total melting of a split in a furnace at 800°C, with a Pb-oxide fire assay block and niter. The liquid was then poured in a conical mould where the liquid separated into Pb metal and slag glass. The glass was removed and remaining Pb was pounded to remove any remaining glass. In a bone dish the Pb puck was oxidized in a O₂ rich atmosphere where the Pb was absorbed by the bone dish. Assay includes: Au, Ag, Cu, Cd, Zn, Mo, S-Total, SiO₂%, Total Cu%, Oxide Cu%, Native Cu% (where applicable).

Geology of the Supergene Zone

Field Relationships

The supergene zone of alteration and mineralization of the Kemess South copper-gold deposit has been divided into three sub-zones by the mine geological

staff (Royal Oak Mines, pers. comm. 1998). The discrimination of these sub-zones is based entirely on visual observations of ore characteristics in the open pit, supplemented by geochemical data gathered from subsequent copper and gold assays.

The lowest sub-zone (Plate 3.8H; Table 4.2), which has a planar character, and horizontal distribution, is approximately 10 m thick. It is in gradational contact (over 2-3 m) with the underlying hypogene zone of mineralization. This lowest sub-zone of the supergene zone is composed of slightly oxidized and hematite-enriched rocks. In the lowest sub-zone, primary igneous textures and hydrothermal quartz stockwork related to hypogene mineralization have not been completely obliterated by the later supergene enrichment process. Copper ore in this lowest sub-zone is composed of small nuggets (<1 mm) of native copper termed "pin prick copper" (Plate 3.8E) together with rare sulphides (*i.e.* pyrite or chalcopyrite).

The middle sub-zone (Plate 3.8D and F; Table 4.2) is also horizontal and planar in character. It has gradational contacts with both the lower and upper sub-zones of the supergene mineralization. This middle sub-zone contains only rare examples of primary igneous textures, together with larger nuggets of native copper (up to 5 mm). Hematite dominates the rock of the middle supergene sub-zone with Fe-oxide minerals having completely replaced the sulphide ore. The primary igneous and hydrothermal silicate minerals of the host rock have been almost completely replaced by clay minerals.

The upper sub-zone (Plate 3.8B; Table 4.2) is discontinuous in character with a thickness that varies from 2-10 metres. It is overlain by volcanic tuffs and

Table 4.2 Summary of supergene hand specimen descriptions.

Sample Number	Sub-Zone	Colour	Density*Porosity	Physical Condition*	Primary Igneous Texture	Bt. /Ser.	Clay Qtz. Nat. Cu	Xt. Hem.	Och. Hem.	Mag. Veins
98-Cro-49-1	Lower	Pinkish-Red to Reddish-Pink	Normal Weak	Firm, slightly Friable	Preserved, but feldspars coated with hematite and clay replaces most.	15- 20%	40- 50% 10%	5- 10%	1-2% 1-2%	1-2% 10%
98-Cro-49-2	Lower	Pinkish-Red to Reddish-Pink	Normal Weak	Firm, slightly Friable	Preserved, but feldspars coated with hematite and clay replaces most.	15- 20%	40- 50% 10%	5- 10%	1-2% 2-3%	10% 10%
98-Cro-49-3	Lower	Pinkish-Red to Reddish-Pink	Normal Weak	Firm, slightly Friable	Preserved, but feldspars coated with hematite and clay replaces most.	15- 20%	40- 50% 10%	5- 10%	1-2% 1-2%	10% 10%
98-Cro-49-4	Lower-Middle	Reddish-Pink	Normal Weak	Firm, slightly Friable	Slightly preserved, hematite dominates matrix and clay replaces feldspars	10- 15%	30- 40% 10%	5- 10%	1-2% 1-2%	15% 15%
98-Cro-49-5	Lower-Middle	Reddish-Pink to Blood-Red	Normal Moderate	Somewhat Friable	Almost obliterated, hematite dominates rock (red ocre)	10- 15%	30- 40% 10%	5- 10%	1-2% 1-2%	10% 10%
98-Cro-49-6	Lower-Middle	Reddish-Pink	Normal Weak	Firm, slightly Friable	Slightly preserved, hematite dominates matrix and clay replaces feldspars	10- 15%	30- 40% 15%	<1% 15%	1-2% 1-2%	10% 10%
98-Cro-49-7	Upper	Blood-Red	Slightly Heavy	Somewhat Friable	Completely obliterated, rock looks like consolidated red mud	0%	5% 2- 5%	- -	60- 70%	- -
98-Cro-49-8	Upper	Blood-Red	Slightly Heavy	Somewhat Friable	Completely obliterated, rock looks like consolidated red mud	0%	5% 2- 5%	- -	60- 70%	- -

Sample Number	Sub-Zone	Colour	Density	Porosity	Physical Condition*	Primary Igneous Texture	Bt. /Ser.	Clay Qtz. Nat. Cu	Xt. Hem.	Och. Hem.	Mag.	Ox. Veins
98-Cro-49-9	Upper	Blood-Red	Slightly Heavy	Moderate	Somewhat Friable	Completely obliterated, rock looks like consolidated red mud	0% 5% 2- 5%	-	5%	60- 70%	-	-
98-Cro-49-10	Upper-Middle	Reddish-Pink	Slightly Heavy	Weak-Moderate	Firm, slightly Friable	Slightly preserved, hematite dominates matrix and clay replaces feldspars	10- 30- 15% 40% 5- 10%	1%	5%	5%	1-2%	10%
98-Cro-49-11	Upper-Middle	Reddish-Pink	Slightly Heavy	Weak-Moderate	Firm, slightly Friable	Slightly preserved, hematite dominates matrix and clay replaces feldspars	10- 30- 15% 40% 5- 10%	1%	5%	5%	1-2%	10%
98-Cro-49-12	Upper-Middle	Reddish-Pink	Slightly Heavy	Weak-Moderate	Firm, slightly Friable	Slightly preserved, hematite dominates matrix and clay replaces feldspars	10- 30- 15% 40% 5- 10%	1%	5%	5%	1-2%	10%

* Term is defined in the glossary; Abbreviations are: Bt.=Biotite; Ser.=Sericite; Qtz.=Quartz; Nat. Cu=Native Copper; Xt Hem.=Crystalline Hematite; Och. Hem.=Red Ochre Hematite; Mag.=Magnetite; Ox. Veins=Oxide Veins

epiclastic rocks of a previously unnamed formation that is now termed the Saunders Member of the early Jurassic Hazleton Group, Toodoggone Formation. Primary igneous textures are very rarely preserved in the upper sub-zone, which is again dominated by hematite and clay minerals. The ore in the upper sub-zone comprises sheet-like masses of native copper that were deposited along fractures and/or faults. These sheets of native copper can attain lengths of several metres, and be up to 1 cm thick (see Plate 3.8G).

Nature and Distribution of Native Copper

Hand specimens from the supergene zone contain moderate amounts of native copper: generally around 5 vol.%, but locally up to 15 vol.%. The three most common morphologies of native copper are: (1) as small, irregular, disseminated grains (<1 mm in size) termed “pin prick” copper (Plate 3.8E); (2) as thin “wires” of copper up to 20 mm in length, which are concentrated along minor fractures and quartz veins (Plate 3.8G); and (3) as “sheets” that are up to several metres in length, almost a metre in width, and a few millimetres thick. The latter are concentrated along large fractures and minor fault zones.

Nature and Distribution of Hematite

Hematite is the most wide spread and variable mineral found in the supergene zone. It ranges in its occurrence from minor coatings on silicate minerals, giving the rock a pinkish-red colour; to major concentrations that give the rock a deep red colour and earthy texture. Disseminated hematite is the most

common form of hematite crystals in the lower sub-zone, where crystals are generally small (<1 mm). In the middle sub-zone, crystalline hematite forms small veins (~ 1 -2 mm in width), in addition to the disseminated crystals that are somewhat coarser. The upper sub-zone is dominated by “red ochre” hematite, which has the characteristics of neither vein or crystalline hematite; but rather a distinctive red, earthy texture (*i.e.* “red ochre”),. In thin section hematite, is found to pseudomorph and replace cubic minerals such as pyrite or magnetite (Plate 4.1A). Also, it is seen to form net textures (Plate 4.1B) around Fe-rich gangue minerals (*i.e.* biotite), where the hematite has replaced the edges of the original grain (Plate 4.1C).

Clay Minerals

A clay fraction (<2 μm) was collected from the hand specimens to help elucidate the composition and distribution of various clay minerals within the samples of the supergene zone. Commonly, clay mineral fractions were contaminated by the presence of a very fine-grained hematite dust that resulted in the clay fractions having a deep pink to blood red colour. Such ubiquitous contamination of the clay fractions with very fine-grained hematite resulted in the production of XRD diffractograms dominated by hematite patterns, which served to overprint and disguise the peaks associated with the clay minerals themselves. However, clay minerals that were consistently present in the XRD diffractograms and whose presence could be verified, regardless of hematite overprint, are muscovite, kaolinite, and illite.

Although the possibility of the chemical removal of hematite from the clay

fractions was considered, it was initially rejected because of potentially posing a problem by changing the mineralogical nature of the clay. Grain mounts of the clay material were also analyzed using the SEM in an attempt to determine relative abundances of each mineral. The results of the SEM analysis indicated that all of the clay grains are coated in hematite.

An analytical procedure was devised to remove excess hematite because of the ubiquitous presence of hematite coatings on all mineral phases in the <2 μm clay fraction. A process of chemical treatment using sodium dithionite and sodium citrate was devised to remove hematite that remained in the <2 μm clay samples (see Appendix A: Analytical Procedures). After use of this chemical treatment, hematite was not identified in any of the XRD diffractograms and the chemical procedure deemed effective. Amongst the minerals that were commonly identified in the “treated” samples of <2 μm clay fractions are (Figure 4.3):

1. montmorillonite-14Å $(\text{Na,Ca})_{0.3}(\text{Al,Mg})_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$;
2. illite $\text{K}_{0.65}\text{Al}_2[\text{Al}_{0.65}\text{Si}_{3.35}\text{O}_{10}(\text{OH})_2]$;
3. muscovite $\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$;
4. quartz SiO_2 ;
5. and kaolinite $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$;

In addition to the above minerals, halloysite was also present in a limited number of samples (Table 4.3). Overall, there appears to be no obvious zonal pattern of distribution of the minerals that are commonly present in the <2 μm clay fractions derived from each of the 3 main sub-units of the supergene zone.

Figure 4.3 X-Ray Diffractograms of samples 49-1 thru 49-12. Only the major peaks of each mineral are shown. Abbreviations are as follows: Musc=Muscovite, Mont14Å=Montmorillonite-14Å, Kao=Kaolinite. (A) 49-1 contains: Mont-14Å>>Musc>Kao>Qtz, (B) 49-2 contains: Mont-14Å>>Qtz>Musc>Kao, (C) 49-3 contains: Mont-14Å>>Musc>Qtz>Kao, (D) 49-4 contains: Mont-14Å>>Musc>Kao>Qtz, (E) 49-5 contains: Kao>>Mont-14Å>Musc>Qtz, (F) 49-6 contains: Kao>>Mont-14Å>Musc>Qtz.

Figure 4.3 (cont.) X-Ray Diffractograms of samples 49-8 thru 49-12. Only the major peaks of each mineral are shown. Abbreviations are as follows: Musc=Muscovite, Mont14Å=Montmorillonite-14Å, Kao=Kaolinite. (G) 49-8 contains: Mont-14Å>Musc>Qtz, (H) 49-9 contains: Mont-14Å>>Kao>Musc>>Qtz, (I) 49-10 contains: Mont-14Å>>Kao>Musc>>Qtz, (J) 49-11 contains: Mont-14Å>>Musc>Kao>>Qtz, (K) 49-12 contains: Mont-14Å>Musc>Kao>Qtz.

Table 4.3 Summary of the minerals identified in the Supergene Zone and overlying Toodoggone Formation, Saunders Member.

Sample Number	Ab	Hal-10Å	Ill	Kao	Mon-14Å	Mon-15Å	Mus	Qtz
98-Cro-49-1	Not ID	Present	Present	Present	Present	Not ID	Present	Present
98-Cro-49-2	Not ID	Not ID	Not ID	Not ID	Present	Not ID	Present	Present
98-Cro-49-3	Not ID	Not ID	Not ID	Not ID	Not ID	Not ID	Not ID	Not ID
98-Cro-49-4	Not ID	Present	Present	Present	Present	Not ID	Present	Present
98-Cro-49-5	Not ID	Present	Present	Not ID	Present	Not ID	Present	Present
98-Cro-49-6	Not ID	Not ID	Present	Present	Present	Not ID	Present	Present
98-Cro-49-8	Not ID	Not ID	Present	Present	Present	Not ID	Present	Present
98-Cro-49-9	Not ID	Not ID	Present	Present	Present	Not ID	Present	Present
98-Cro-49-10	Not ID	Not ID	Present	Present	Present	Not ID	Present	Present
98-Cro-49-11	Not ID	Not ID	Present	Not ID	Present	Not ID	Present	Not ID
98-Cro-49-12	Not ID	Not ID	Present	Not ID	Present	Not ID	Present	Present
98-Cro-13-02	Present	Present	Present	Present	Not ID	Present	Present	Present

Mineral Name	Abbreviation	Chemical Formula
Albite	Ab	$\text{NaAlSi}_3\text{O}_8$
Halloysite-10Å	Hal-10Å	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot 2\text{H}_2\text{O}$
Illite-2M1	Ill	$\text{K}_{0.65}\text{Al}_2[\text{Al}_{0.65}\text{Si}_{3.35}\text{O}_{10}(\text{OH})_2]$
Kaolinite-1Md	Kao	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$
Montmorillonite-14Å	Mon-14Å	$(\text{Na},\text{Ca})_{0.3}(\text{Al},\text{Mg})_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$
Montmorillonite-15Å	Mon-15Å	$(\text{Na},\text{Ca})_{0.3}(\text{Al},\text{Mg})_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$
Muscovite-3T	Mus	$\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$
Quartz	Qtz	SiO_2

Plate 4.1 A: Hematite pseudomorphing either pyrite or magnetite crystals. (Field of View=0.5mm). B: Box work texture of hematite replacing the gangue minerals. (Field of View=1mm). C: Box work texture of hematite (Hem) replacing gangue minerals and In one locality replacing Biotite (Bt).

Plate 4.1

Native Copper Samples

Four samples of native copper, in the form of large sheets, were collected for geochemical analysis (in particular to ascertain if gold or any other metal was alloyed with the native copper). Of the 4 native copper samples, all of which were partially covered in an oxidized coating, two were de-oxidized with HCl and two were left untreated. The “HCl leach” was applied in an attempt to determine whether gold (or other metals) were actually alloyed with the copper or otherwise present as a constituent of the oxidized coating. In addition to the geochemical assaying of gold and copper, 30 other elements were determined in both the treated and untreated native copper samples using ICP analysis (Appendix B:Geochemical Data-ICP). Geochemical analysis of native copper, however, did not indicate the presence of gold in either the oxidized coating or the native copper itself. In contrast elemental silver appears to be alloyed (dissolved in) with the native copper. Concentrations of silver range from 43 to 48 ppm were determined in all four of the native copper samples.

In addition to the geochemical analysis of the samples of native copper described above, polished sections of the copper “sheets” were also analyzed for the presence of gold, using the electron micro probe. In each of the polished sections, several analytical traverses were made to provide spot analyses of all parts of the “copper sheets”. None of the quantitative electron micro probe analyses indicated the presence of gold in concentrations above the minimum detection limit of the instrument (*i.e.* approximately 50-100 ppm Au; Appendix B:Geochemical Data-Probe Copper).

Heavy Mineral Concentrate

A heavy mineral concentrate (HMC) was made from a portion of the hand specimens collected from the supergene zone. Micro-panning of the HMC did not reveal any gold but did identify the predominance of hematite (up to 90 modal percent in some samples). Accessory minerals (<1 to 5 modal percent) in the HMC include: native copper, azurite, malachite, limonite-goethite, cuprite, arsenopyrite, and pyrite (Table 4.4).

The mineralogy of the supergene zone at Kemess South is consistent with that found in other deposits around the world (Plate 3.7A; Faure, 1991; Gill, 1996; Guilbert, 1986; Chaveux, 2001): (1) the characteristic ore minerals comprise native copper, chalcocite, covellite, and bornite; and (2) the gangue minerals include hematite, limonite, and goethite; (3) the silicate minerals from both the original igneous assemblage of the Maple Leaf pluton, and the hypogene alteration (*i.e.* sericitic and potassium silicate types), have been converted to kaolinite and other clay minerals (Table 4.4) with the almost total destruction of all prevailing igneous and hypogene textures. Ferrous minerals (*i.e.* pyrite and biotite) have been extensively oxidized, and the iron typically redeposited as crystalline hematite, which is the predominant Fe-oxide in the supergene zone.

Table 4.4: Results from shaking table and panning experiments.

Sample #	Panned (Y/N)	Diameter Measurement (μm)	Remarks
98-CRO-49-01	Y	No Visible Gold	No sulphides. ~500 grains of native copper. HMC dominated by hematite.
98-CRO-49-02	Y	No Visible Gold	No sulphides. 15 grains of native copper. HMC dominated by magnetite and hematite.
98-CRO-49-03	Y	No Visible Gold	No sulphides. HMC dominated by magnetite and hematite.
98-CRO-49-04	Y	No Visible Gold	No sulphides. Sample contains ~100 lithic fragments hosting native copper-cuprite-malachite mineralization. HMC dominated by hematite.
98-CRO-49-05	Y	No Visible Gold	No sulphides. ~5% native copper. HMC dominated by hematite.
98-CRO-49-06	Y	No Visible Gold	No sulphides. ~100 grains of native copper. ~10 malachite-bearing lithic rock fragments. HMC dominated by hematite.
98-CRO-49-07	Y	No Visible Gold	1 grain of pyrite. 99% limonite/goethite. ~50 grains of native copper.
98-CRO-49-08	Y	No Visible Gold	2 grains of pyrite. 99% limonite/goethite. ~200 grains of native copper.
98-CRO-49-09	Y	No Visible Gold	1 grain of pyrite. 99% limonite/goethite.
98-CRO-49-10	Y	No Visible Gold	No sulphides. 15% native copper. HMC dominated by magnetite and hematite.
98-CRO-49-11	Y	No Visible Gold	~100 grains of pyrite. 5 grains of arsenopyrite. 20% limonite/goethite. 5% native copper. +10 mesh fraction contains copper nuggets (<3 mm). HMC dominated by hematite.
98-CRO-49-12	Y	No Visible Gold	No sulphides. 20% native copper. HMC dominated by magnetite and hematite.

Chapter 5: Conclusions

Summary and Conclusions

The four main lithological units mapped in the environs of the Kemess South open pit can be correlated with lithological units found regionally. A fifth basaltic unit cuts the uppermost lithological unit and is not seen outside of the area of the open pit, either locally or regionally. The lithological units are:

1. The early Permian Asitka Group lower volcanic unit (*i.e.* rhyolite, andesites, and tuffs) and upper sedimentary unit (*i.e.* chert and limestone) are widespread regionally, and show similar features to those mapped within the study area (Diakow and Rogers, 1998; this study, Map Pocket).
2. The late Triassic Takla Group lower sedimentary unit (*i.e.* mudstone and siltstone) and upper volcanic unit (*i.e.* Savage Mountain Formation basalts) within the study area exhibit similar features (such as the occurrence of *Halobia* fossils in the pyritic mudstone; and the presence of cross-bedding and broken pyroxene fragments in the sandstone) to those found regionally. The Savage Mountain Formation basalt shows similar textures, and is geochemically similar, to those mapped by Diakow and others (1997, 1998, 2001) and Monger (1974). These basalts cap the Kemess ridge and form a dip slope towards the Kemess South deposit.
3. The Maple Leaf pluton, which hosts the Kemess South copper-gold deposit, and a series of related unnamed intrusions, which together comprise the Black Lake Suite.

4. The early Jurassic Hazleton Group, Toadoggon Formation tuffs and epiclastic rocks. This unit lies directly on the supergene zone.
5. Pyroxene-basalt that cuts and interdigitates the early Jurassic Saunders Member.

The Maple Leaf pluton was intruded obliquely into Savage Mountain Formation basalt (of the Takla Group), and is in fault contact with Asitka Group chert. Its age of emplacement, based on a U-Pb zircon analysis, is 199 ± 0.6 Ma (Diakow and Rogers, 1998). The majority of the hypogene copper-gold mineralization is contained within the Maple Leaf pluton. After emplacement and exhumation, weathering and oxidation of the upper portion of the mineralized intrusion caused the supergene zone to form. This took place before deposition of a tuff-epiclastic sequence, which rests directly upon the upper surface of the supergene zone.

The hypogene ore zone (50-250 m thick) consists predominantly of pyrite, and chalcopyrite, with local molybdenite, and minor but economically important amounts of native gold. The majority of the hypogene mineralization is disseminated throughout the host quartz-monzodiorite body, and is composed of pyrite (5-10 vol.%) and chalcopyrite (0.5 vol.%). The quartz-K-feldspar stockwork (*i.e.* complex of intersecting veinlets) present within the hypogene zone of the Maple Leaf pluton is not well developed; in most drill-core samples, the stockwork makes up less than 10 vol% of the rock, although it can represent up to 40 vol.% in thin localized sections. Gold is apparently associated with the chalcopyrite in the hypogene zone (Rebagliati *et al.*, 1995), although this study was unable to establish such a

relationship. Weathering of the hypogene ore produced the zone of supergene alteration and mineralization.

The supergene zone is typically present as a 10-70 m thick blanket, resting directly upon the hypogene ore zone. The major copper minerals present are chalcocite, bornite, and most importantly native copper. The latter occurs in several different forms, the most distinguishable of which are: as large "sheets" (up to 3 m long); and as fine (<1 mm) disseminated grains of "pin prick" copper. In the Kemess South open pit, three sub-zones have been distinguished within the supergene zone. The lowest, located directly above the hypogene ore zone, typically contains "pin prick" native copper (locally up to 5 vol.%). Rare hypogene sulphides can also occur in this sub-zone. Hematite is locally present in its crystalline form. The middle sub-zone is a redder colour than the lower sub-zone and contains approximately 50 vol.% hematite-stained, clay-altered material. This sub-zone is characterized by small "leaves" of native copper at the base that become larger and more sheet-like upward. The upper sub-zone can be distinguished by its deep-red earthy texture caused by the predominance of "red ochre" hematite, in contrast to the crystalline hematite of the lower sub-zone. Large "sheets" of native copper, several metres in length, have been found in fractures and minor fault zones present in the upper sub-zone.

The Kemess South deposit is truncated to the north by the east-west striking, south-dipping "North Block fault", which displays evidence for both 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 fault". The "10-180 fault" cuts, and

therefore post dates, the “North Block fault”. There is evidence for approximately 250 m of dextral offset and approximately 30° of rotation on the “10-180 fault”.

Known to be part of the oldest unit found within the Kemess South study area, chert and black argillite was originally correlated with the Takla Group (Dewar Formation) by Rebagliati and others (1995). However, sediments of the Dewar Formation are described as: (1) dark grey to black pyritic siltstones to mudstones that contain *Halobia* (sp) fossils and ammonite fragments; (2) light turquoise green sandstone to siltstone with internal grading and laminations (Monger, 1974, Diakow, 1986, Diakow and Metcalfe, 1997, or Diakow and Rogers 1998). Conversely, the sediments Rebagliati and others correlated with the Takla Group are light grey chert with interbeds of graphitic argillite. Although fossils are found in the graphitic argillite, they do not resemble *Halobia* (sp) or ammonite fragments common to the Dewar Formation. Instead the fossils are intact, unidentifiable brachiopods without any ornamentation (Schröder-Adams, pers. comm., 2002). Thus, a more accurate lithostratigraphic classification for the chert and argillite is early Permian Asitka Group (Figure 5.1).

The uppermost and youngest (tuff and epiclastic) unit in the study area was originally thought to be part of the upper Cretaceous Sustut Group sediments (Rebagliati et. al., 1995). This study has shown that these tuffs and epiclastic rocks show none of the characteristics of the Sustut Group sediments. Deposits of the Sustut Group in the region are predominantly made up of pebble and cobble conglomerates composed of well-rounded chert, vein quartz and granitic clasts; features that are in marked contrast to the lithological characteristics of the tuff-

■ Takla Gp. Limestone (Old)/
Permian Gp. Limestone (New)

epiclastic unit in the mine area (Yorath, 1992; Diakow and Metcalfe, 1997 and Diakow and Rogers, 1998), in which conglomerates are relatively scarce and where present are composed of volcanic clasts. This distinction, based upon field observations, is also supported by a U-Pb age date of 196 ± 0.6 Ma. (Diakow *et al.*, 2001), which places the deposition of the tuff-epiclastic unit in the early Jurassic, coeval with the deposition of the Toodoggone Formation (Figure 5.1).

Together, the U-Pb zircon ages of 196 ± 0.6 Ma for the Saunders Member, and 199 ± 0.6 Ma for the Maple Leaf pluton, indicate that the formation of the supergene zone occurred soon after the emplacement of the mineralized intrusion (*i.e.* within a period of 5 million years). In addition, the ages suggest that the deposition of the Saunders Member, soon after the pluton's emplacement, may have protected the newly developed supergene zone from subsequent removal by erosion.

References

- Allegre, C. J., and Ben Othman, D., 1980. Nd-Sr isotopic relationship in granitoid rocks and continental crust development; a chemical approach to orogenesis. *Nature*, v. 286, p.335-342
- Barnes, H. L., 1979. *Geochemistry of Hydrothermal Ore Deposits*. John Wiley & Sons, New York, United States.
- Barrie, C.T., 1993. Petrochemistry of shoshonitic rocks associated with porphyry copper-gold deposits of central Quesnellia, British Columbia, Canada. *Journal of Geochemical Exploration*, v. 48, p. 225-258.
- Bassett, K.N., and Kleinspehn, K.L., 1997. Early to Middle Cretaceous Paleogeography of north-central British Columbia: Stratigraphy and Basin Analysis of the Skeena Group. *Canadian Journal of Earth Sciences*, v. 34, p. 1644-1669.
- Belasky, P., and Runnegar, B., 1994. Permian longitudes of Wrangellia, Stikinia, and Eastern Klamath terranes based on coral biogeography. *Geology*, v. 22, p. 1095-1098.
- Boettcher, A., 1966. Vermiculite, hydrobiotite and biotite in the Rainy Creek Igneous Complex near Libby, Montana. *Clay Mineralogy*, v. 6, p. 283-295.
- Boyle, R.W., 1979. *The Geochemistry of Gold and its Deposits*. Geological Survey of Canada Bulletin 280, 584 p.
- Brown, D.A., Logan, J.M., Gunning, M.H., Orchard, M.J., and Bamber, W.E., 1991. Stratigraphic evolution of the Paleozoic assemblage in the Stikine and Iskut rivers area, northwestern British Columbia. *Canadian Journal of Earth Sciences*, v. 28, p. 958-972.
- Brown, G C., and Hennessy, J., 1978. The initiation and thermal diversity of granite magmatism. *Philosophical Transactions of the Royal Society of London, Series A: Mathematical and Physical Sciences*, v. 288, p. 631-643.
- Brown, R.L., Carr, S.D., Johnson, B.J., Coleman, V.J., Cook, F.A., and Varsek, J.L., 1992. The Monashee decollement of the southern Canadian Cordillera: a crustal-scale zone linking the Rocky Mountain Foreland belt to lower crust beneath accreted terranes. *Thrust Tectonics* (ed., K.R.McClay), Chapman & Hall, London, p. 357-364.
- Burns, P.J., 1973. Stratigraphy and Low Grade Metamorphism of the 'Takla-Hazleton' Group, McConnell Creek Map-Area, North-Central British Columbia. B.Sc. Honours Thesis, unpublished, The University of British Columbia.

Carr, J.M., and Reed, A.J., 1976. Afton: A Supergene Copper Deposit. *In* Porphyry Deposits of the Northwestern Cordillera of North America (Ney, C., ed.), Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 15, p. 376-387.

Carter, M.R., 1993. *Soil Sampling and Methods of Analysis*. Canadian Society of Soil Science. Lewis Publishers.

Chappell, B.W., and White, A.J. R., 1982. I- and S- type granitoids in the Lachlan fold belt, southeastern Australia. Symposium on Geology of Granites and their Metallogenic Relations, Nanjing, China, Oct. 26-Nov. 29, p. 8-9.

Chavez, W., Jr., 2000. Supergene oxidation of copper deposits: zoning and distribution of copper oxide minerals. Society of Economic Geologists Newsletter No. 41.

Childe, F.C., and Thompson, F.H., 1997. Geological setting, U-Pb geochronology, and radiogenic isotopic characteristics of the Permo-Triassic Kutcho Assemblage, north-central British Columbia. Canadian Journal of Earth Sciences, v. 34, p. 1310-1324.

Coleman, N., LeRoux, F., and Cacy, J. 1963. Biotite-hydrobiotite-vermiculite in soils. *Nature*, v. 198, p. 409-410.

Compton, R.R., 1985. *Geology in the Field*. Wiley Interscience, New York, USA.

Coney, P.J., 1972. Cordilleran tectonics and North America plate motion. *American Journal of Science*, v. 272, p. 603-628.

Coney, P.J., Jones, D.L., and Monger, J.W.H., 1980. Cordilleran suspect terranes. *Nature*, v. 288, p. 329-333.

Cook, F.A., 1995. Lithospheric processes and products in the southern Canadian Cordillera Lithoprobe perspective. Canadian Journal of Earth Sciences, v. 32, p. 1803-1824.

Currie, L., and Parrish, R.R., 1997. Paleozoic and Mesozoic rocks of Stikinia exposed in northwestern British Columbia: Implications for correlation in the northern Cordillera. *Geological Society of America Bulletin*, v. 109, p. 1402-1420.

Davis, E.E., and Lewis, T.J., 1984. Heat flow in a back-arc environment: Intermontane and Omineca Crystalline belts, southern Canadian Cordillera. Canadian Journal of Earth Sciences, v. 21, p. 715-726.

Diakow, L., Metcalfe, P., Rogers, C., and Whittles, J., 2001. Geology of the Southern Toodoggone River and Northern McConnell Creek Map Areas, North-

Central British Columbia Parts of NTS 94E/2, 94D/15 and 94D/16. British Columbia Geological Survey Branch Geoscience Map 2001-1.

Diakow, L., and Rogers, C., 1998. Toodoggone-McConnell Project: Geology of the McConnell range - Serrated Peak to Jensen Creek, parts of NTS 92E/2 and 94D/15. *In Geological Fieldwork for 1996*, B.C. Ministry of Employment and Investment, Paper 1998-1, p. 8a-1 to 8a-14.

Diakow, L. J. and Metcalfe, P., 1997. Geology of the Swannell Ranges in the vicinity of the Kemesscopper-gold porphyry deposit, Attycelley Creek (NTS 94E/2), Toodoggone River map area. *In Geological Fieldwork 1996*, B. C. Ministry of Employment and Investment, Paper 1997-1, p. 101-116.

Diakow, L. J. , Panteleyev, A., and Schroeter, T. G., 1993. Geology of the Early Jurassic Toodoggone Formation and gold-silver deposits in the Toodoggone River map area, northern British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Bulletin 86, 72 p.

Diakow, L. J., and Rogers, C., 1998. Toodoggone McConnell Project: Geology of the McConnell Range Serrated Peak to Jensen Creek, parts of NTS 92E/2 and 94D/15. *In Geological fieldwork 1997*, B. C. Ministry of Employment and Investment, Paper 1998-1, p. 8a1 to 8a14.

Dutrizac, J., and Jambor, J. 2000. Jarosites and their application in hydrometallurgy. *In Sulfate Minerals Crystallography, Geochemistry, and Environmental Significance* (Alpers, C., and Jambor, J., eds.), Reviews in Mineralogy and Geochemistry, Mineralogical Society of America, v. 40, p. 405-417.

Evans, A.M., 1997. *Ore Geology and Industrial Minerals: An Introduction*. Third edition, Blackwell Science, Toronto, Ontario.

Evenchick, C.A., 1991. The Skeena fold belt: a link between the Coast Plutonic Complex, the Omineca Belt and the Rocky Mountain Fold and Thrust Belt. *In Thrust tectonics*.

Faure, G., 1991. *Principles of Inorganic Geochemistry*. MacMillan Publishing Company, New York. 626 p.

Faure, G., 1998, *Principles and Applications of Geochemistry*, Second Edition. Prentice-Hall Inc, New Jersey, USA

Ferri, F., 1997. Nina Creek Group and Lay Range Assemblage, north-central British Columbia: remnants of late Paleozoic oceanic and arc terranes. *Canadian Journal of Earth Sciences*, v. 34, p. 854-874.

Gabrielse H., and Yorath C.J., 1992. Introduction. *In* Geology of the Cordilleran Orogen in Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada, no. 4. p. 5-10.

Gabrielse H., and Yorath C.J., 1992. Tectonic Framework. *In* Geology of the Cordilleran Orogen in Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada no. 4, p. 13-58.

Gabrielse H. 1991. Structural Styles. *In* Geology of the Cordilleran Orogen in Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada no. 4. p. 573-603.

Gabrielse, H., 1991. Late Paleozoic and Mesozoic terrane interactions in North-Central British Columbia. *Canadian Journal of Earth Sciences*, v. 28, p. 947-957.

Gabrielse H., Monger, J.W.H., Wheeler, J.O., and C.J. Yorath, 1992. Volcanic Regimes. *In* Geology of the Cordilleran Orogen in Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada no. 4, p. 15-59.

Gabrielse H., Monger, J.W.H., Templeman-Kluit, D.J., and Woodsworth, G.J., 1992. Structural Styles. *In* Geology of the Cordilleran Orogen in Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada no. 4, p. 571-675.

Gabrielse, H., Souther, J., Woodsworth., Tipper, H., and Monger, J. 1992. Upper Jurassic to Paleogene Assemblages: The Intermontane Belt. *In* Geology of the Cordilleran Orogen in Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada no. 4, p. 331-372.

Gale, Vanessa, 1996. Paleotectonic Setting of the Takla Group Volcanic Sedimentary Assemblage, Stikine Terrane, McConnell Creek Map area, North Central British Columbia. B.Sc. Honours Thesis, unpublished, Dalhousie University, Halifax, Nova Scotia.

Gill, R., 1996. *Chemical Fundamentals of Geology*. Chapman Hall, New York, USA, 290 p.

Gustafson, L.B, and Hunt, J.P., 1975. Evolution of mineralization at El Salvador, Chile. *Economic Geology*, v. 66, p.1266-1267.

Harris, J. 1991a. Ore mineralogy and textures at the Kemess South property. Internal report for El Condor Resources Ltd.

Harris, J. 1991b. A petrographic study of drill core samples from the South Kemess Property. Internal report for C.E.C. Engineering Ltd.

Irvine, T. N., and Baragar, W. R. A., 1971. A guide to the chemical classification of the common volcanic rocks. *Canadian Journal of Earth Sciences*, v. 8, p.523-548.

Irving, E., and Wynne, P.J., 1992. Paleomagnetism: review and tectonic implications. *In* *Geology of the Cordilleran Orogen in Canada* (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, *Geology of Canada* no. 4, p. 63-86.

Irving, E., and Wynne, P.J., 1991. Paleomagnetic evidence for motions of parts of the Canadian Cordillera. *Tectonophysics*, v.187, p. 259-275.

Johannson, G.G., Smith, P.L., and Steven, P.G. 1997. Early Jurassic evolution of the northern Stikinian arc: evidence from the Laberge Group, northwestern British Columbia. *Canadian Journal of Earth Sciences*, v. 34, p. 1030-1057.

Johnson, B.J., and Brown, R.L., 1996. Crustal structure and early Tertiary extensional tectonics of the Omineca belt at 51°N latitude, southern Canadian Cordillera. *Canadian Journal Earth Sciencess*, v.33, p. 1596-1611.

Klein, C., and Hurlbut, C. Jr., 1993. *Manual of Mineralogy*. John Wiley and Sons Inc. New York, 681 p.

Krauskopf, K., 1979. *Introduction to Geochemistry*. 2nd Edition, McGraw-Hill Book Company, New York, USA.

Lang, J.R., Lueck, B., Mortensen, J.K., Russell, J.K., Stanley, C.R., and Thompson, J.F.H., 1995. Triassic-Jurassic silica-undersaturated and silica-saturated alkalic intrusions in the Cordillera of British Columbia: Implications for arc magmatism. *Geology*, v. 23, p. 451-454.

Lang, J.R., Stanley, C.R., and Thompson, J.F.H., 1995. Porphyry copper-gold deposits related to alkalic igneous rocks in the Triassic-Jurassic arc terranes of British Columbia. *Arizona Geological Society Digest*, v. 20, p. 219-236.

Le Maitre, R.W., 1982. *Numerical Petrology; Statistical Interpretation of Geochemical Data*. Elsevier, Amsterdam.

Lord, C.S., 1948. McConnell Creek Map-Area Cassiar District, British Columbia. *Geological Survey of Canada*, v. 248, p. 1-72.

Lowell, J.D., and Guilbert, J.M., 1970. Lateral and vertical alteration-mineralization zoning in porphyry ore deposits. *Economic Geology*, v. 65, p. 373-408.

McCulloch, M.T., and Chappell, B.W., 1982. Nd isotopic characteristics of S- and I-type granites. *Earth and Planetary Science Letters*, v. 58, p. 51-64.

McGroder, M.F., and Umhoefer, P.J., 1989. Comment and Reply on "Escape hypothesis for the Stikine block". *Geology*, p. 1161-1193.

McPhie, J., Doyle, M., and Allen, R., 1993. *Volcanic Textures; A Guide to the Interpretation of Textures in Volcanic Rocks*. University of Tasmania, 196 p.

Meade, H.D., 1977. Petrology and Metal Occurrences of the Takla Group and Hagem and Germansen Batholiths, North Central British Columbia. Unpublished Ph.D. thesis, The University of British Columbia.

Meyer, C., and Hemley, J.J., 1967. Wall Rock Alteration. *In* *Geochemistry of Hydrothermal Ore Deposits* (Barnes, H. L., ed.), Holt, Rinehart and Winston, New York, p.166-235.

Mihalynuk, M.G., Nelson, J., and Diakow, L.J., 1994. Cache Creek terrane entrapment: Oroclinal paradox within the Canadian Cordillera. *Tectonics*, v. 13, p. 575-595.

Monger, J.W.H., 1977a. The Triassic Takla Group in McConnell Creek Map-Area, North-Central British Columbia. *Geological Survey of Canada, Paper 76-29*, p. 1-37.

Monger, J.W.H., 1977b. Upper Paleozoic rocks of the western Canadian Cordillera and their bearing on Cordilleran evolution. *Canadian Journal of Earth Sciences*, v. 14, p. 1832-1859.

Monger, J.W.H., 1985. Structural evolution of the southwestern intermontane belt, Ashcroft and Hope map areas, British Columbia. *Geological Survey of Canada, Paper 85-1A*, p. 349-358.

Monger, J.W.H., 1993. Canadian Cordilleran tectonics: from geosynclines to crustal collage. *Geological Survey of Canada Contribution 51991*. *Canadian Journal of Earth Sciences*, v. 30, p. 209-231.

Monger, J.W.H., and Irving, E., 1980. Northward displacement of north-central British Columbia. *Nature*, v. 285, p. 289-293.

Monger, J.W.H., Price, R.A., and Tempelman-Kluit, D.J., 1982. Tectonic accretion and the origin of the two major metamorphic and plutonic welts in the Canadian Cordillera. *Geology*, v.10, p. 70-75.

Monger, J.W.H., Souther, J.G., and Gabrielse, H., 1972. Evolution of the Canadian Cordillera: A Plate Tectonic Model. *American Journal of Science*, v. 272, p. 577-602.

Mortimer, N., 1986. Late Triassic, arc-related, potassic igneous rocks in the North American Cordillera. *Geology*, v.14, p. 1035-1038.

Newton, C.R., 1988. Significance of "Tethyan" Fossils in the American Cordillera. *Science*, v. 242, p. 385-391.

Ney, C.S., Cathro, R.J., Panteleyev, A., and Rotherham, D.C., 1974. Supergene Copper Mineralization Porphyry Deposits of the Canadian Cordillera. *Canadian Institute of Mining and Metallurgy*, v.15, p. 72-78.

Parrish, R.R., 1995. Thermal evolution of the southeastern Canadian Cordillera. *Canadian Journal of Earth Sciences*, v.32, p. 1618-1642.

Patchett, P.J., and Gehrels, G.E., 1998. Continental influence on Canadian Cordilleran terranes from Nd isotopic study, and significance for crustal growth processes. *Journal of Geology*, v.106, p. 269-280.

Rebagliati, C. M. , Bowen, B. K. , Copeland D. J. , and Niosi, D. W. A., 1995. Kemess South and Kemess North porphyry gold-copper deposits, northern British Columbia. *In* *Porphyry Deposits of the Northwestern Cordillera of North America* (T. G. Schroeter, ed.), Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46, p. 377-396.

Roberts, W., Campbell, T., and Rapp, G., Jr., 1987. *Encyclopedia of Minerals*. 2nd Edition. Van Nostrand Reinhold Company New York.

Rogers, C.R., and Houle, J., 1999. Geological Setting of the Kemess South Au-Cu Porphyry Deposit and Local Geology between Kemess Creek and Bicknell Lake (NTS 94E/2). *British Columbia Geological Survey Branch Geological Fieldwork 1998, Paper 1999-1*, p. 103-114.

Royal Oak Mines Inc., 1998. Kemess South Cu-Au mine

Royal Oak Mines Inc. 1996. Annual Report; Kirkland, Washington, USA.

Royal Oak Mines Inc. 1995. Annual Report; Kirkland, Washington, USA.

Sheldrick, B.H., 1984. *Analytical Methods Manual*. Land Resource Research Institute, Agriculture Canada.

Marsden H., and Thorkelson, D.J., 1992. Geology of the Hazelton volcanic belt in British Columbia; implications for the early to middle Jurassic evolution of Stikinia. *Tectonics*, v. 11, p. 1266-1287.

Smith, P.L., and Tipper, H.W., 1986. Plate Tectonics and Paleobiogeography: Early Juassic (Pliensbachian) Endemism and Diversity. *Palaeos*, v. 1, p. 399-412.

Souther, J.G., 1992. Volcanic Regimes. *In* *Geology of the Cordilleran Orogen in*

Canada (Gabrielse H., and C.J. Yorath, eds.), GSC Volume, Geology of Canada no. 4, p. 571-675.

Sroffregen, R., Alpers, C., and Jambor, J., 2000. Alunite-Jarosite Crystallography, Thermodynamics and Geochemistry. *In*: Sulfate Minerals Crystallography, Geochemistry, and Environmental Significance. Alpers, C, and Jambor, J Editors. Reviews in Mineralogy and Geochemistry Mineralogical Society of America V40 pp 453-473

Thorkelson, D.J., and Taylor, R.P., 1989. Cordilleran slab windows. *Geology*, v. 17, p. 833-836.

Tipper, H.W., 1958. Revision of the Hazelton and Talka Groups of Central British Columbia. Geological Survey of Canada, Bulletin 47, p. 1-51.

Titley, S. R., 1983. Geologic Setting of Porphyry Copper Deposits. *In* Advances in Geology of the Porphyry Copper Deposits: Southwestern North America (Titley, S.R., ed.), American Journal of Science, v. 283, p. 37-58.

Titley, S. R., 1995. Geological summary and perspective of porphyry copper deposits in southwestern North America Arizona Geological Society Digest, v. 20, p. 6-20.

Titley, S.R., 1993. Characteristics of Porphyry Copper Occurance in the American Southwest. Geological Association of Canada Special Paper, v. 40, p.433-464.

Titley, S.R., and Marozas, D. C., 1995. Processes and Products of Supergene Copper Enrichment. *In* Porphyry Copper Deposits of the American Cordillera. Arizona Geological Society Digest Volume 20.

Titley, S.R., 1989. Contrasting Characteristics of Precious-Metal-Bearing Porphyry Systems. Northwest Mining Association, 95th Annual Convention and Trade Show Spokane Washington.

van der Heyden, P., 1990. Eastern Margin of the Cast Belt in west-central British Columbia. *In* Current Research, Part E, Geological Survey of Canada, Paper 90-1E, p. 171-182.

van der Heyden, P. 1992. A Middle Jurassic to Early Tertiary Andean-Sierran arc model for the coast belt of British Columbia. *Tectonics*, v. 11, p. 82-97.

Vandall, T.A. and Palmer, H.C., 1990. Canadian Cordilleran displacement: palaeomagnetic results from the Early Jurassic Hazelton Group, Terrane I, British Columbia, Canada. *Geophysics Journal International*, v. 103, p. 609-619.

Wernicke, B., and Klepacki, D.W., 1988. Escape hypothesis for the Stikine block. *Geology*, v. 16, p. 461-464.

Wilson, M., 1970. A Study of Weathering in a Soil Derived from a Biotite-Hornblende Rock: I Weathering of Biotite Clay Minerals, v.8, p. 291-303.

Wilson, M., 1989. *Igneous Petrogenesis*. Chapman and Hall., London, 466 p.

Woodsworth, G.J., Anderson, R.G., Armstrong, R.L., with contributions by Struik, L.C., & van der Heyden, P. , 1992. Plutonic Regimes. *In* *Geology of the Cordilleran Orogen in Canada* (Gabrielse H., and C.J. Yorath, eds.) GSC Volume, *Geology of Canada* no. 4. p. 491-531.

Yorath, C.J., 1992. Upper Jurassic to Paleogene Assemblages. *In* *Geology of the Cordilleran Orogen in Canada* (Gabrielse H., and Yorath C.J., eds.) GSC Volume, *Geology of Canada* no. 4. p. 329-371.

Glossary of Terms

Terminology and Techniques

1. Tholeiitic, calc-alkaline, and alkaline rock suites

Scrutiny of chemical variation diagrams for igneous rocks provides convincing evidence for the existence of many different chemical trends, some of which can be grouped (Wilson, 1989). For example, the silica (SiO_2)-alkalies ($\text{Na}_2\text{O} + \text{K}_2\text{O}$) variation diagram can be used to subdivide all igneous rocks into two categories - alkaline and sub-alkaline (Best, 1982). Alkaline rocks have relatively high concentrations of alkalies (Na, K) relative to silica, so that they are usually under-saturated and have normative nepheline. These chemical properties are manifest in the presence of actual minerals such as alkali feldspar, feldspathoids, alkali-rich pyroxenes, and alkali-rich amphiboles. The most common alkaline rocks belong to the alkali basalt suite, comprising basalts as well as more felsic types.

Sub-alkaline rocks have higher silica relative to alkalies and consequently generally have orthopyroxene or quartz in the norm and never feldspathoids. Sub-alkaline rocks may be further subdivided into the tholeiitic suite and the calc-alkaline suite. The tholeiitic suite, comprised primarily of basalts but including more felsic rocks as well, shows a higher degree of iron enrichment on an AFM variation diagram (e.g., see Irvine and Baragar, 1971) and lower concentrations of aluminum. The calc-alkaline suite comprises the common volcanic (basalt-andesite-dacite-rhyolite) and plutonic (gabbro-diorite-granodiorite-granite) associations, which contain combinations of olivine, Ca-rich clinopyroxene, Ca-poor

orthopyroxene, hornblende, biotite, feldspars, and quartz.

2. I-type *versus* S-type magmas/granites

Phanerozoic granites - The major sites of granitic batholiths during the Phanerozoic are in linear belts where the crust is thick and where geothermal gradients are high. The greatest volumes of modern granitic rocks are found at Cordilleran tectonic settings (Brown and Hennessey, 1978). Typical lithological proportions in Cordillera-type batholiths are as follows: gabbro-diorite, 7-16%; tonalite, 50-58%; granodiorite-adamellite, 25-35%; granite, <1-4% (Cobbing and Pitcher, 1972). In most other orogenic belts, granodiorites and granites are dominant.

The Paleozoic granitic batholiths of southeastern Australia have been divided into two major types on the basis of chemistry, mineralogy, and field relations (Chappell and White, 1983). I-type granitic rocks are thought to have been derived from lower crustal material of igneous origin whereas S-type granitic rocks are derived from a source which has been through at least one cycle of weathering (and thus bear a sedimentary signature). The applicability of the I-S classification, outside of southeastern Australia, remains to be fully documented. However, where used in this thesis, the terms "I-type" and "S-type" granite are based upon the criteria for such a classification developed by Chappell and White (1974, 1983).

Some isotopic studies of Phanerozoic granitic rocks, however, indicate a wide (and continuous) range in both Sr and Nd isotopic characteristics (Allegre and Ben Othman, 1980; McCulloch and Chappell, 1982) - with the range of values consistent with mixing of old continental crust (i.e., craton) and a depleted and/or undepleted

mantle component); a situation which obviously makes the categorization of granites as either I- or S-type more difficult. The amounts of each component (continental crust; mantle) are highly variable both among batholiths (Hamilton et al., 1980), and within many batholiths (McCulloch and Chappell, 1982). Also, it should be noted that the presence of a component with mantle-like isotopic ratios does not imply a direct mantle origin for the granite, but rather indicates a short crustal residence time for the mantle-derived igneous material. S-type granitic rocks are thus characterized by low $^{143}\text{Nd}/^{144}\text{Nd}$, and high and variable $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (McCulloch and Chappell, 1982); whereas I-types show the reverse (high $^{143}\text{Nd}/^{144}\text{Nd}$, and low and more constant $^{87}\text{Sr}/^{86}\text{Sr}$ ratios). These isotopic data are consistent with S-types being derived predominantly (70-100%) from an older (*circa* 1.0 Ga) crustal sources with an important sedimentary component; with I-types also having a significant crustal component (25-80%), but with the I-types being derived from igneous sources of various ages.

3. Hydrothermal alteration assemblages

A number of approaches have been taken to the classification of hydrothermal alteration. Historically, the terminology has been strongly influenced by the environment of formation, and hence, classifications tend to reflect detailed work on individual types of deposit; for example, porphyry deposits (Meyer and Hemley, 1967; Lowell and Guilbert, 1970; Gustafson and Hunt, 1975; Bean and Titley, 1981).

Alternative approaches to classification, which are summarized by Rose and Burt (1979), are based on the identification of the most important alteration mineral,

the mineral assemblage, or the chemical changes that have occurred during alteration. Classification by alteration minerals or mineral assemblages involves field and petrographic observations, supported in some cases by other techniques (e.g., XRD, SEM), and provides the simplest non-genetic approach to alteration. This is the approach adopted in this study. However, when using alteration mineralogy in this manner, care must be taken to determine the paragenetic (or timing) relationship among minerals prior to assigning them to a single assemblage or interpreting their relationship to other types of alteration.

Classifying alteration by chemical changes requires some knowledge of the parent rock and an understanding of the processes and reactions involved in alteration. This approach is particularly useful where progressive changes in mineralogy are observed in a single wallrock unit around a vein, structure, or mineralized zone. Under these circumstances, the mineralogy may be used to document graphically the changing conditions in terms of the chemical components or the activity ratios of these components (e.g., Rose and Burt, 1979).

4. Volcanic textures

The terms used to describe volcanic rocks and their textures are those recommended by McPhie et al. (1993), in their guide to the interpretation of textures in volcanic rocks. The terms utilized by McPhie et al. (1993) incorporate many of those that have gained widespread acceptance in the geological literature: for example, (1) the grain size terms (*i.e.* ash, lapilli, blocks and bombs) developed by Fisher (1966) for primary pyroclastic rocks; and (2) the grain-sized based genetic nomenclature for common types of volcanoclastic deposits (modified from Fisher,

1961, and Schmidt, 1981).

Terms

Anhedral - a crystal that lack any of its characteristic faces.

Aplite Dykes - small voluminous intrusive bodies that are composed entirely fine-grained crystals.

Coarse-grained - crystals with diameters greater than 5 mm.

Crystalline - crystals can be identified with the unaided eye or a hand lens.

Equigranular - crystals that are all approximately the same size.

Euhedral - a crystal that is completely bounded by its characteristic faces.

Fine-grained - crystals with diameters less than 1 mm.

Medium-grained - crystals with diameters of 1-5 mm.

Microcrystalline - crystals that can be identified with a petrographic microscope in thin section, but that are not distinguishable with the naked eye.

Nugget effect - in a large sample of rock all the gold is concentrated within one or two large nuggets.

Porphyritic - crystals that differ in size.

Subhedral - a crystal that is almost completely bounded by its characteristic faces.

Table G.1. Grain-Size Classification

Grain-size		
Size in millimetres	Pyroclastic Name	Sediment Name
256	Coarse Blocks and Bombs	Boulder
128	Fine Blocks and Bombs	coarse Cobble
64		Fine Cobble
32	Lapilli	Very Coarse Pebble
16		Coarse Pebble
8		Medium Pebble
4		Fine Pebble
2		Very Fine Pebble
1	Coarse Ash	Very Coarse Sand
0.5		Coarse Sand
0.25		Medium Sand
0.125		Fine Sand
0.06	Fine Ash	Very Fine Sand
0.03		Coarse Silt
0.015		Medium Silt
0.008		Fine Silt
0.004		Very Fine Silt
<0.004		Clay

Table G.2 Bed Form Classification

Bed Forms	
Bedform Thickness in Millimetres	Bedform Name
>100	Thickly Bedded
10-100	Bedding
2-10	Thinly Bedded
1-2	Very Thinly Bedded
0.5-1	Lamination
<0.5	Fine Lamination

Table G.3 Pyroclastic Rock Classification

Pyroclastic Rocks				
	Blocks and Bombs (%)	Lapilli (%)	Ash (%)	
Pyroclastic Breccia	100-75	0-25	0-25	
Tuff-breccia	25-75	0-75	0-75	
Lapilli-stone	0-25	75-100	0-25	
Lapilli-Tuff	0-25	0-75	0-75	
Tuff	0-25	0-25	75-100	

Table G.4 Consolidation and Lithification Classification

Consolidation	
Loose	Unconsolidated Sediment
Very Friable	Slightly consolidated sediment that breaks under slight hand pressure
Friable	Slightly consolidated sediment that breaks under light hand pressure
Somewhat Friable	Slightly consolidated sediment that breaks under moderate hand pressure
Firm, Slightly Friable	Consolidated sediment that breaks under strong hand pressure
Weak, Non-Friable	Consolidated sediment that does not break under hand pressure, but has a dull "whop" or "thud" sound when hit with a hammer
Moderately Strong	Material that has a dull "whop" with a slight ringing sound when hit with a hammer
Strong	Material that has a definite "whack" with a slight ringing sound when hit with a hammer
Very Strong	Material that has a "boink" with a ringing sound when hit with a hammer

Table G.5 Density Classification

Density	
Light	Lower than SG for Granite
Normal	Standard SG for Granite (~3.00)
Heavy	Higher than SG for Granite

Table G.6 Porosity Classification

Porosity	
Poor	Sample resists water when
Weak	Sample absorbs a little bit of water
Moderate	Sample absorbs approximately 0.5 of water
High	Sample absorbs nearly all the water

Appendix A: Analytical Procedures

- a. Sodium Citrate- BDH Inc. Lot# 128097/M199072
 - i. Min Assay 99.0%
 - ii. PH (5% solution) 7.5-9
 - iii. Max limit of impurities in Water Solution
 - (1) Cl - 0.001%
 - (2) N - 0.001%
 - (3) PO₄ - 0.002%
 - (4) SO₄ - 0.004%
 - (5) Ca - 0.005%
 - (6) Cu - 0.0002%
 - (7) Heavy Metals - 0.0005%
 - (8) Fe - 0.0005%
 - (9) Pb - 0.0005%

- b. Sodium Dithionite - JT Baker Chemical Co. Lot# 234374

Table A.1 Exact weights and measures for the chemical treatment of clays to remove excess iron oxide (hematite)

Date	Sample Number	Hematite Removal					
		Mass of Dry Clay (g)	Mass of Na Dithionite (g)	Na Citrate (mL)	Na Citrate Molarity	Shaker (hours)	Centrifuge (minutes)
		(g)					
22-Mar-0098-CRo-49-1		0.2115	0.3453	20	0.7007	12	15
22-Mar-0098-CRo-49-2		0.2197	0.3121	20	0.7007	12	15
22-Mar-0098-CRo-49-3		0.2045	0.3315	20	0.7007	12	15
22-Mar-0098-CRo-49-4		0.2121	0.3226	20	0.7007	12	15
22-Mar-0098-CRo-49-5		0.2037	0.3239	20	0.7007	12	15
22-Mar-0098-CRo-49-6		0.2180	0.3336	20	0.7007	12	15
22-Mar-0098-CRo-49-7		0.2151	0.3281	20	0.7007	12	15
22-Mar-0098-CRo-49-8		0.2130	0.3286	20	0.7007	12	15
22-Mar-0098-CRo-49-9		0.2135	0.3272	20	0.7007	12	15
22-Mar-0098-CRo-49-10		0.2133	0.3248	20	0.7007	12	15
22-Mar-0098-CRo-49-11		0.2332	0.3314	20	0.7007	12	15
22-Mar-0098-CRo-49-12		0.2173	0.3266	20	0.7007	12	15
23-Mar-0098-CRo-49-8		0.2621	0.0977	10	0.7007	72	15
23-Mar-0098-CRo-49-8		0.2621	0.1366	10	0.7007	72	15
23-Mar-0098-CRo-49-8		0.2621	0.1123	10	0.7007	72	15
30-Mar-0098-CRo-49-1		0.2115	0.0860	10	0.7007	12	15
30-Mar-0098-CRo-49-2		0.2197	0.0948	10	0.7007	12	15
30-Mar-0098-CRo-49-3		0.2045	0.0916	10	0.7007	12	15
30-Mar-0098-CRo-49-4		0.2121	0.0948	10	0.7007	12	15
30-Mar-0098-CRo-49-5		0.2037	0.0949	10	0.7007	12	15
30-Mar-0098-CRo-49-6		0.2180	0.0993	10	0.7007	12	15
30-Mar-0098-CRo-49-7		0.2151	0.0971	10	0.7007	12	15
30-Mar-0098-CRo-49-8		0.2130	0.0919	10	0.7007	12	15
30-Mar-0098-CRo-49-9		0.2135	0.0877	10	0.7007	12	15
30-Mar-0098-CRo-49-10		0.2133	0.0897	10	0.7007	12	15
30-Mar-0098-CRo-49-11		0.2332	0.0905	10	0.7007	12	15
30-Mar-0098-CRo-49-12		0.2173	0.0876	10	0.7007	12	15
16-May-0098-CRo-49-1		0.2115	0.0929	10	0.7007	12	20
16-May-0098-CRo-49-2		0.2197	0.0896	10	0.7007	12	20
16-May-0098-CRo-49-3		0.2045	0.0832	10	0.7007	12	20
16-May-0098-CRo-49-4		0.2121	0.0802	10	0.7007	12	20
16-May-0098-CRo-49-5		0.2037	0.0782	10	0.7007	12	20
16-May-0098-CRo-49-6		0.2180	0.0963	10	0.7007	12	20
16-May-0098-CRo-49-7		0.2151	0.0892	10	0.7007	12	20
16-May-0098-CRo-49-8		0.2130	0.1082	10	0.7007	12	20
16-May-0098-CRo-49-9		0.2135	0.0809	10	0.7007	12	20
16-May-0098-CRo-49-10		0.2133	0.0956	10	0.7007	12	20
16-May-0098-CRo-49-11		0.2332	0.0816	10	0.7007	12	20
16-May-0098-CRo-49-12		0.2173	0.0855	10	0.7007	12	20
17-May-0098-CRo-49-1		0.2115	0.0908	10	0.7007	12	20
17-May-0098-CRo-49-2		0.2197	0.0813	10	0.7007	12	20

Hematite Removal

Date	Sample	Mass of	Mass of	Na Citrate	Na Citrate	Shaker	Centrifuge
	Number	Dry Clay (g)	Na Dithionite (mL)		Molarity	(hours)	(minutes)
		(g)					
17-May-0098-CRo-49-3		0.2045	0.0859	10	0.7007	12	20
17-May-0098-CRo-49-4		0.2121	0.0853	10	0.7007	12	20
17-May-0098-CRo-49-5		0.2037	0.0951	10	0.7007	12	20
17-May-0098-CRo-49-6		0.2180	0.0820	10	0.7007	12	20
17-May-0098-CRo-49-7		0.2151	0.0852	10	0.7007	12	20
17-May-0098-CRo-49-8		0.2130	0.0963	10	0.7007	12	20
17-May-0098-CRo-49-9		0.2135	0.0806	10	0.7007	12	20
17-May-0098-CRo-49-10		0.2133	0.0991	10	0.7007	12	20
17-May-0098-CRo-49-11		0.2332	0.0919	10	0.7007	12	20
17-May-0098-CRo-49-12		0.2173	0.0926	10	0.7007	12	20
23-May-0098-CRo-49-1		0.2115	0.1010	10	0.7501	12	20
23-May-0098-CRo-49-2		0.2197	0.0999	10	0.7501	12	20
23-May-0098-CRo-49-3		0.2045	0.1009	10	0.7501	12	20
23-May-0098-CRo-49-4		0.2121	0.0989	10	0.7501	12	20
23-May-0098-CRo-49-5		0.2037	0.1074	10	0.7501	12	20
23-May-0098-CRo-49-6		0.2180	0.1074	10	0.7501	12	20
23-May-0098-CRo-49-7		0.2151	0.0989	10	0.7501	12	20
23-May-0098-CRo-49-8		0.2130	0.0998	10	0.7501	12	20
23-May-0098-CRo-49-9		0.2135	0.1091	10	0.7501	12	20
23-May-0098-CRo-49-10		0.2133	0.1119	10	0.7501	12	20
23-May-0098-CRo-49-11		0.2332	0.0927	10	0.7501	12	20
23-May-0098-CRo-49-12		0.2173	0.1131	10	0.7501	12	20
28-May-0098-CRo-49-1		0.2115	0.1061	10	0.7501	12	20
28-May-0098-CRo-49-2		0.2197	0.0938	10	0.7501	12	20
28-May-0098-CRo-49-3		0.2045	0.0944	10	0.7501	12	20
28-May-0098-CRo-49-4		0.2121	0.0999	10	0.7501	12	20
28-May-0098-CRo-49-5		0.2037	0.0902	10	0.7501	12	20
28-May-0098-CRo-49-6		0.2180	0.0987	10	0.7501	12	20
28-May-0098-CRo-49-7		0.2151	0.0997	10	0.7501	12	20
28-May-0098-CRo-49-8		0.2130	0.0930	10	0.7501	12	20
28-May-0098-CRo-49-9		0.2135	0.0983	10	0.7501	12	20
28-May-0098-CRo-49-10		0.2133	0.0825	10	0.7501	12	20
28-May-0098-CRo-49-11		0.2332	0.0962	10	0.7501	12	20
28-May-0098-CRo-49-12		0.2173	0.0835	10	0.7501	12	20

Appendix B: Geochemical Data

Assay and ICP samples were crushed in a jaw crusher and pulverized using a Cr-Steel ring and puck mill

1. Multi-Element ICP (Aqua Regia Leach Package) - Analysis involves partial digestion of a sample using two acids, HCl and HNO₃, Heated in a bath to 95 degrees Celcius and then processed in an Induced Coupled Plasma (ICP) machine. Elements include: Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Sc, Sn, Sr, Ti, V, W, Y, Zn, Zr

2. Fire Assay - Analysis involved the total melting of a split in a furnace at 800degrees Celcius, with a Pb-oxide fire assay block and niter. The liquid was then poured in a conical mould where the liquid separated into Pb metal and slag glass. The glass was removed and remaining Pb was pounded to remove any remaining glass. In a bone dish the Pb puck was oxidized in a O₂ rich atmosphere where the Pb was absorbed by the bone dish. The remaining material was analysed by AAS. Assay includes: Au, Ag, Cu, Cd, Zn, Mo, S-Total, SiO₂%, Total Cu%, Oxide Cu%, Native Cu% (where applicable).

Geochemical samples were crushed in a jaw crusher and pulverized using an agate ring and puck mill.

Legend of Table Abbreviations.

X* indicates a calculated field

NA= Not Analysed

ADL= Above Detection Limits

BDL= Below Detection Limits

Table B.1 Unit Abbreviations

	Unit Abbreviations
Cu	Native Copper
HG	Maple Leaf Pluton Hypogene Ore
HiSG	Supergene enriched in Gold
Idyke	Felsic Dyke
Int	Black Lake Suite Intrusives
JRct	Jurassic Kemess Member Dacitic Crystal Tuff
JRt	Jurassic South Kemess Member Tuffs
MSG	Lower-Middle Supergene Zone
LSG	Lower Supergene Zone
Mdyke	Mafic Dykes
MQFP	Mega-Quartz-Feldspar-Porphyry
Pa	Permian Asitka Group Andesite
Pbx	Pyroxene Basalt
Pc	Permian Asitka Group Chert
Pl	Permian Asitka Group Limestone
Pr	Permian Asitka Group Rhyolite
QFPI	Quartz-Feldspar-Porphyry
SG	Maple Leaf Pluton Supergene Ore
TRb	Triassic Savage Mountain Formation Basalt
UMSG	Upper-Middle Supergene Zone
USG	Upper Supergene Zone

Table B.2 Mineral Abbreviations

Mineral Abbreviations	
Apa	Apatite
Bio	Biotite
Bor	Bornite
Cal	Calcite
Chl	Chlorite
Cla	Clay Mineral
Cov	Covellite
Cpy	Chalcopyrite
Cte	Chalcocite
Cu	Native Copper
Fel	Plagioclase Feldspar
Hem	Hematite
Ilm	Ilmenite
Kspar	Potassic Feldspar
Mag	Magnetite
Mus	Muscovite
Py	Pyrite
Pyr	Pyroxene
Rut	Rutile
Zeo	Zeolite

Appendix B: ICP Geochemical Data

Sample Number	Chemistry Lab	Analysis	Detection Limits	Ag	Al ⁺	Al	Al2O3 ⁺	As	Ba	Be	Bi	Ca ⁺	Ca	CaO ⁺	Cd	Co	Cr	Cu	Fe ⁺	Fe	FeO ⁺	Fe2O3 ⁺	K ⁺	K	K2O ⁺	Mg ⁺	Mg	
				ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	%	ppm	ppm
				MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn	MinEn
ICP	Calc	ICP	Calc	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP		
94-Cro-48-1	0.60	9400	0.01	0.94	178	BDL	5	50	BDL	BDL	BDL	23500	2.35	3.15	12	7	108	1947	64000	6.40	8.23	7.11	1800	0.18	0.22	5000	0.01	
94-Cro-48-2	0.20	10200	1.02	1.93	BDL	90	1	BDL	27800	2.78	3.72	5	6	367	44000	4.40	5.66	489	1700	1700	4.40	5.66	4.89	1700	0.17	0.20	4900	0.49
94-Cro-48-3	BDL	9900	0.99	1.87	15	150	1	BDL	22500	2.25	3.01	3	7	57	548	34400	3.44	4.42	382	2300	2300	4.42	3.82	2300	0.23	0.28	5100	0.51
94-Cro-48-4	0.80	4500	0.45	0.85	BDL	140	BDL	5	12300	1.23	1.65	2	10	74	3749	84800	8.48	10.91	9.42	1800	1800	10.91	9.42	1800	0.18	0.22	1500	0.15
94-Cro-48-5	1.00	9000	0.90	1.70	BDL	250	1	BDL	21000	2.10	2.81	2	19	74	8664	68700	6.87	8.83	7.63	3000	3000	8.83	7.63	3000	0.30	0.36	3700	0.37
94-Cro-48-6	0.60	7900	0.79	1.49	BDL	210	1	5	26900	2.69	3.60	2	14	48	845	64800	6.48	8.33	7.20	2800	2800	8.33	7.20	2800	0.28	0.34	3000	0.30
94-Cro-48-7	BDL	7200	0.72	1.36	BDL	200	1	10	5900	0.59	0.79	1	13	46	596	146700	14.67	18.87	16.30	2100	2100	18.87	16.30	2100	0.21	0.25	700	0.07
94-Cro-48-8	BDL	12300	1.23	2.32	BDL	270	1	10	9600	0.96	1.29	2	16	32	3692	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL
94-Cro-48-9	BDL	12600	1.26	2.38	5	230	1	10	6900	0.69	0.92	1	9	43	625	143800	14.38	18.49	15.98	1900	1900	18.49	15.98	1900	0.19	0.23	1300	0.13
94-Cro-48-10	0.20	16300	1.63	3.08	BDL	1090	1	BDL	6800	0.68	0.91	BDL	11	53	1087	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL	ADL
94-Cro-48-11	0.20	19800	1.98	3.74	10	140	1	BDL	6300	0.63	0.84	BDL	236	228	ADL	102	81	ADL	40900	4.08	5.25	4.53	2900	0.29	0.35	11400	1.14	
94-Cro-48-12	0.20	15800	1.58	2.98	BDL	260	1	BDL	6200	0.62	0.83	BDL	102	81	ADL	37600	3.76	4.84	4.18	2800	2800	4.84	4.18	2800	0.28	0.34	5600	0.56
94-Cro-48-13a	32.80	800	0.08	0.15	20	310	BDL	BDL	1500	0.15	0.20	BDL	BDL	BDL	BDL	BDL	BDL	ADL	300	0.03	0.04	0.03	200	0.02	0.02	100	0.01	
94-Cro-48-13b	37.60	900	0.09	0.17	15	440	BDL	BDL	1000	0.10	0.13	BDL	1	BDL	ADL	BDL	ADL	ADL	2800	0.28	0.36	0.31	300	0.03	0.04	400	0.04	
94-Cro-48-13c	35.40	3200	0.32	0.60	15	230	BDL	BDL	4400	0.44	0.59	BDL	7	BDL	ADL	BDL	ADL	ADL	2800	0.28	0.36	0.31	300	0.03	0.04	400	0.04	
94-Cro-48-13d	31.00	BDL	BDL	BDL	10	70	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ROX 22040	BDL	5900	0.59	1.11	BDL	BDL	BDL	BDL	BDL	BDL	BDL	500	0.05	0.07	BDL	1	87	80	17400	1.74	2.24	1.93	1700	0.17	0.20	2100	0.21	
ROX 22041	15.00	16900	1.69	3.19	BDL	35	1	35	300	0.03	0.04	4	40	4	691	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ROX 22042	BDL	13400	1.34	2.53	5	BDL	BDL	BDL	BDL	BDL	BDL	5000	0.50	0.67	BDL	5	92	51	33900	3.38	4.35	3.76	800	0.08	0.10	13500	1.35	
ROX 22043	BDL	4600	0.46	0.87	BDL	BDL	BDL	BDL	BDL	BDL	BDL	300	0.03	0.04	BDL	2	119	19	14600	1.46	1.88	1.62	1600	0.16	0.19	1700	0.17	
ROX 22044	BDL	17800	1.78	3.36	BDL	BDL	BDL	BDL	BDL	BDL	BDL	6000	0.60	0.80	BDL	7	152	76	33800	3.38	4.35	3.76	1800	0.18	0.22	9400	0.94	
ROX 22045	21.00	6100	0.61	1.15	25	5	1	5	107800	10.78	14.43	ADL	74	34	ADL	64600	6.46	8.31	7.18	100	0.01	0.01	100	0.01	0.01	4500	0.45	
ROX 22046	12.40	900	0.09	0.17	20	25	1	25	127600	12.76	17.09	ADL	78	39	ADL	25300	2.53	3.25	2.81	100	0.01	0.01	100	0.01	0.01	800	0.80	
ROX 22047	1.60	700	0.07	0.13	20	BDL	2	BDL	131600	13.16	17.62	ADL	21	47	ADL	16000	1.60	2.06	1.78	100	0.01	0.01	100	0.01	0.01	9200	0.92	
ROX 22048	0.60	200	0.02	0.04	15	BDL	BDL	BDL	ADL	ADL	ADL	12	2	4	392	2100	0.21	0.27	0.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ROX 22049	6.40	2500	0.25	0.47	15	15	1	15	145900	14.59	19.54	ADL	100	18	134	47300	4.73	6.08	5.26	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ROX 22050	0.20	8600	0.86	1.62	5	BDL	1	BDL	6600	0.66	0.88	16	3	99	271	11600	1.16	1.49	1.29	3700	3700	1.49	1.29	3700	0.37	0.45	3900	0.39
ROX 22051	ADL	25900	2.59	4.89	40	200	BDL	BDL	20500	2.05	2.74	16	12	57	ADL	142300	14.23	18.30	15.81	1500	1500	18.30	15.81	1500	0.15	0.18	12700	1.27
ROX 22052	45.00	3200	0.32	0.60	65	95	7	95	57100	5.71	7.65	ADL	22	64	1145	46100	4.61	5.93	5.12	200	200	5.93	5.12	200	0.02	0.02	8600	0.86
ROX 22053	0.60	300	0.03	0.06	35	120	BDL	BDL	ADL	ADL	ADL	BDL	4	6	4	16100	1.61	2.07	1.79	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ROX 22054	1.60	200	0.02	0.04	235	180	BDL	BDL	ADL	ADL	ADL	BDL	10	13	16	48600	4.86	6.25	5.40	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ROX 22055	0.20	10400	1.04	1.96	BDL	50	BDL	BDL	6300	0.63	0.84	BDL	25	155	53	70500	7.05	9.07	7.83	1600	1600	9.07	7.83	1600	0.16	0.19	5300	0.53
ROX 22108	BDL	14900	1.49	2.80	5	30	BDL	BDL	8800	0.88	1.18	BDL	14	39	116	39900	3.99	5.13	4.43	900	900	5.13	4.43	900	0.09	0.11	13900	1.39
ROX 22109	BDL	12700	1.27	2.40	BDL	50	BDL	BDL	4600	0.46	0.62	1	19	102	1867	94400	9.44	12.14	10.49	1500	1500	12.14	10.49	1500	0.15	0.18	12500	1.25
ROX 22206	BDL	4900	0.49	0.93	10	160	1	5	5600	0.56	0.75	1	7	192	491	89500	8.95	11.51	9.94	2700	2700	11.51	9.94	2700	0.27	0.33	900	0.09
ROX 22207	1.00	2200	0.22	0.42	BDL	220	BDL	5	1400	0.14	0.19	1	8	176	970	79200	7.92	10.19	8.80	1600	1600	10.19	8.80	1600	0.16	0.19	200	0.02
ROX 22208	0.60	2200	0.22	0.42	5	1800	BDL	BDL	2800	0.28	0.37	1	4	93	531	149600	14.96	19.24	16.62	1200	1200	19.24	16.62	1200	0.12	0.14	200	0.02
ROX 22209	0.40	8600	0.86	1.62	BDL	120	1	5	16500	1.65	2.21	2	17	101	1044	130500	13.05	16.78	14.50	2000	2000	16.78	14.50	2000	0.20	0.24	4400	0.44
ROX 22210	1.20	3100	0.31	0.59	BDL	70	1	5	8900	0.89	1.19	2	4	190	779	81800	8.18	10.52	9.09	1800	1800	10.52	9.09	1800	0.18	0.22	400	0.04
ROX 22213	57.40	3400	0.34	0.64	450	50	BDL	BDL	5800	0.58	0.78	ADL	40	115	ADL	102200	10.22	13.14	11.35	900	900	13.14	11.35	900	0.09	0.11	600	0.06
ROX 22214	76.40	1300	0.13	0.25	625	40	BDL	BDL	3500	0.35	0.47	ADL	54	125	ADL	109400	10.94	14.07	12.15	600	600	14.07	12.15	600	0.06	0.07	300	0.03
ROX 22215	73.80	1300	0.13	0.25	610	40	BDL	BDL	3600	0.36	0.48	ADL	47	136	ADL	102500	10.25	13.18	11.39	600	600	13.18	11.39	600	0.06	0.07	300	0.03

Appendix B: ICP Geochemical Data

Sample Number	Chemistry Lab	Analysis	Detection Limits	Cd %	Zn %	Mo %	S-Total %	SiO ₂ %	Total Cu %	Oside Cu %	Native Cu %	Eastng	Northng	Type of Sample	Collector of Sample
				MinEn	Fire Assay	MinEn	Fire Assay	MinEn	Fire Assay	MinEn	Fire Assay				
98-Cro-48-1				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-2				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-3				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-4				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-5				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-6				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-7				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-8				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-9				NA	NA	0.001	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-10				NA	NA	0.001	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-11				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-12				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-13a				NA	NA	NA	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-13b				NA	NA	NA	NA	NA	NA	NA	NA			Hand Specimen	Chris Rogers
98-Cro-48-13c				NA	NA	NA	NA	NA	NA	NA	NA			Native Copper (washed)	Chris Rogers
98-Cro-48-13d				NA	NA	NA	NA	NA	NA	NA	NA			Native Copper (washed)	Chris Rogers
ROX 22040				NA	NA	NA	NA	NA	NA	NA	NA			Native Copper (Bathed in HCl)	Chris Rogers
ROX 22041				NA	NA	NA	NA	NA	NA	NA	NA	634666	6323023	Grab	Chris Rogers
ROX 22042				NA	NA	NA	NA	NA	NA	NA	NA	634821	6322914	Chip	Chris Rogers
ROX 22043				NA	NA	NA	NA	NA	NA	NA	NA	634164	6322615	Grab	Chris Rogers
ROX 22044				NA	NA	NA	NA	NA	NA	NA	NA	634315	6322644	Float Grab	Chris Rogers
ROX 22045				0.08	10.60	NA	NA	NA	NA	NA	NA	634045	6322908	Grab	Chris Rogers
ROX 22046				0.08	10.10	NA	NA	NA	NA	NA	NA	631874	6326320	Grab	Chris Rogers
ROX 22047				0.02	2.46	NA	NA	NA	NA	NA	NA	631374	6326320	Grab	Chris Rogers
ROX 22048				NA	17.20	NA	NA	NA	NA	NA	NA	631374	6326320	Grab	Chris Rogers
ROX 22049				0.14	NA	NA	NA	NA	NA	NA	NA	631374	6326320	Grab	Chris Rogers
ROX 22050				NA	NA	NA	NA	NA	NA	NA	NA	631131	6326617	Grab	Chris Rogers
ROX 22051				0.04	6.65	NA	NA	NA	NA	NA	NA	631422	6327073	Float Grab	Chris Rogers
ROX 22052				NA	NA	NA	NA	NA	NA	NA	NA	631422	6327073	Grab	Chris Rogers
ROX 22053				NA	NA	NA	NA	NA	NA	NA	NA	631422	6327073	Grab	Chris Rogers
ROX 22054				NA	NA	NA	NA	NA	NA	NA	NA	631422	6327073	Grab	Chris Rogers
ROX 22055				NA	NA	NA	NA	NA	NA	NA	NA	632398	6323963	Grab	Chris Rogers
ROX 22108				NA	NA	NA	NA	NA	NA	NA	NA				Chris Rogers
ROX 22206				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Jacques Houle
ROX 22207				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Jacques Houle
ROX 22208				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Jacques Houle
ROX 22209				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Jacques Houle
ROX 22210				NA	NA	BDL	NA	NA	NA	NA	NA			Hand Specimen	Jacques Houle
ROX 22213				NA	NA	NA	7.28	38.10	37.56	0.04	4.63			Concentrate	Jacques Houle
ROX 22214				NA	NA	NA	9.23	30.60	42.32	0.07	4.52			Concentrate	Jacques Houle
ROX 22215				NA	NA	NA	8.11	29.70	43.37	0.09	5.15			Concentrate	Jacques Houle

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-72	12.19 Jrt		0.01	1.3	3.82	55	17	148	0.2	17	3.96	0.1	24	24	5.7	0.48	19	2.45	1490	1
91-72	14 Jrt		0.01	0.8	2.87	19	9	253	0.2	12	1.46	0.1	18	20	4.27	0.29	13	2.14	965	1
91-72	16 Jrt		0.01	0.9	2.76	11	7	148	0.1	12	2.74	0.1	18	81	4.6	0.31	11	1.82	1150	1
91-72	18 Jrt		0.01	0.8	3.12	20	6	153	0.1	11	3.96	0.1	20	24	4.79	0.42	10	1.65	1136	1
91-72	20 Jrt		0.01	0.9	3.45	37	7	172	0.3	8	4.91	0.1	18	26	4.21	0.81	16	1.82	1781	1
91-72	22 Jrt		0.01	0.7	3.33	15	4	149	0.1	10	2.32	0.1	20	20	4.88	0.33	12	1.82	917	1
91-72	24 Jrt		0.01	0.7	3.16	20	3	136	0.3	8	3.69	0.1	17	12	4.24	0.3	14	1.65	1177	1
91-72	26 Jrt		0.01	0.7	3.19	18	3	414	0.3	8	4.24	0.1	18	28	4.32	0.25	13	1.78	1244	1
91-72	28 Jrt		0.01	0.5	3.35	19	3	336	0.3	9	1.92	0.1	22	23	4.79	0.2	17	2.38	1062	1
91-72	30 Jrt		0.01	0.5	4.05	9	4	456	0.3	9	2.2	0.1	24	30	5.25	0.25	22	2.75	1175	1
91-72	32 Jrt		0.01	0.8	3.72	27	3	269	0.3	8	4.11	0.1	20	35	4.77	0.18	23	2.98	1270	1
91-72	34 Jrt		0.01	0.9	3.63	23	2	1586	0.6	7	4.66	0.1	16	12	3.75	0.25	18	2.73	1474	1
91-72	36 Jrt		0.01	1.1	3.6	24	2	1109	0.5	8	4.23	0.1	16	13	3.82	0.27	16	2.28	1395	1
91-72	38 Jrt		0.01	1.1	2.13	24	1	290	0.3	4	2.74	0.1	9	9	2.13	0.15	8	1.27	841	1
91-72	40 Jrt		0.01	0.9	3.71	29	1	573	0.7	5	3.43	0.1	10	13	2.53	0.17	10	1.72	806	1
91-72	42 Jrt		0.01	0.8	3.93	31	1	354	0.6	6	2.2	0.1	15	27	3.57	0.23	16	1.94	710	1
91-72	44 Jrt		0.01	0.6	3.99	23	1	210	0.4	6	2.25	0.1	17	18	4.02	0.21	18	2.03	935	1
91-72	46 Jrt		0.01	0.7	3.95	26	1	175	0.5	6	3.65	0.1	17	13	4.42	0.2	10	1.42	996	1
91-72	48 Jrt		0.01	0.5	3.97	21	1	164	0.5	6	4.12	0.1	18	15	4.45	0.21	12	1.18	811	1
91-72	50 Jrt		0.01	0.7	3.97	18	2	561	0.5	6	5.08	0.1	17	65	4.41	0.28	5	0.76	766	1
91-72	52 Jrt		0.01	0.8	1.62	90	12	141	0.3	5	5.62	0.1	14	55	3.55	0.12	4	0.28	1054	1
91-72	53.5 Jrt		0.08	1	1.61	8	7	783	0.3	4	6.02	0.1	9	87	3.38	0.16	2	0.18	995	1
91-72	55 SG		1.3	0.5	0.78	4	7	2533	0.1	2	1.79	0.1	5	154	3.75	0.21	2	0.09	144	4
91-72	57 SG		1.03	0.6	0.81	10	5	1957	0.1	3	0.6	0.1	4	463	3.06	0.24	2	0.07	23	8
91-72	59 SG		1.17	0.6	0.71	1	4	942	0.1	2	0.71	0.1	3	510	2.82	0.29	1	0.07	33	7
91-72	61 SG		0.84	0.3	0.78	3	5	1160	0.1	2	0.42	0.1	3	146	3.28	0.24	2	0.06	5	9
91-72	63 SG		1.12	0.1	0.78	4	5	1112	0.1	1	0.42	0.1	4	218	4.15	0.23	2	0.06	1	13
91-72	65 SG		0.95	0.1	0.75	2	5	914	0.1	2	0.43	0.1	4	299	4.44	0.25	1	0.07	1	11
91-72	67 SG		1.32	0.3	0.78	9	4	1070	0.1	1	0.35	0.1	3	249	3.3	0.33	1	0.07	7	11
91-72	69 SG		0.99	0.2	0.78	6	5	716	0.1	2	0.39	0.1	4	351	3.92	0.41	1	0.08	1	11
91-72	71 SG		0.72	0.4	0.93	10	4	632	0.1	1	0.33	0.1	4	328	3.88	0.44	1	0.1	4	14
91-72	73 SG		0.93	0.3	1.07	14	4	637	0.1	3	0.21	0.1	3	165	3.34	0.35	2	0.09	7	21
91-72	75 SG		0.98	2.5	0.99	37	11	721	0.1	3	0.22	0.1	4	313	3.15	0.44	54	0.09	11	22
91-72	77 SG		0.62	0.4	0.87	24	3	478	0.1	1	0.3	0.1	3	224	3.25	0.29	2	0.06	3	24
91-72	79 SG		1.26	0.6	0.87	4	3	839	0.2	2	0.56	0.1	4	177	3.17	0.22	2	0.12	32	19
91-72	81 SG		0.65	0.5	0.69	11	3	398	0.1	1	0.22	0.1	2	120	2.56	0.24	2	0.04	7	21
91-72	83 SG		0.81	0.4	0.71	12	3	551	0.2	2	0.18	0.1	3	135	2.97	0.27	1	0.05	10	29
91-72	85 SG		0.7	0.5	0.83	7	3	921	0.2	1	0.2	0.1	3	109	3.37	0.28	2	0.06	5	35

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm	
91-72	87	SG	0.94	0.4	1.08	11	5	1076	0.1	0.1	2	0.28	0.1	5	115	5.21	0.34	2	0.06	1	40
91-72	89	SG	0.6	3.1	1.39	10	4	572	0.3	0.3	16	0.28	0.1	10	10000	3.36	0.29	4	0.11	34	67
91-72	91	SG	0.23	1.7	1.15	11	3	273	0.3	0.3	13	0.47	0.1	12	10000	2.78	0.39	2	0.18	37	72
91-72	93	SG	0.48	1.7	1.88	15	5	484	0.6	0.6	9	1.45	17.8	17	6554	3.47	0.49	4	0.58	377	158
91-72	95	HG	0.41	1.1	1.99	10	4	384	0.5	0.5	4	1.73	26.4	18	2207	3.54	0.54	5	0.63	511	52
91-72	97	HG	0.33	1	2.02	15	4	397	0.7	0.7	3	1.11	3	18	1515	3.19	0.57	5	0.73	391	58
91-72	99	HG	0.4	0.8	1.51	59	18	389	0.3	0.3	3	1.12	0.1	19	1937	2.64	0.57	5	0.45	385	149
91-72	101	HG	0.38	0.7	2.01	18	11	399	0.5	0.5	3	0.95	0.1	20	1680	3.16	0.65	5	0.56	329	45
91-72	103	HG	0.61	1.5	2.09	12	11	436	0.4	0.4	5	0.88	0.1	18	3150	2.82	0.73	4	0.46	267	225
91-72	105	HG	0.37	0.9	2.3	27	8	608	0.6	0.6	4	0.89	0.1	22	1981	3.05	0.81	5	0.68	367	96
91-72	107	HG	0.51	1	1.73	19	7	403	0.3	0.3	4	1.25	0.1	21	2188	2.83	0.62	4	0.68	568	129
91-72	109	HG	0.36	0.7	1.97	10	6	406	0.3	0.3	5	1.38	0.1	20	1861	3.1	0.69	4	0.76	614	63
91-72	111	HG	0.22	0.8	1.81	8	4	359	0.5	0.5	5	1.41	0.1	14	1276	2.74	0.61	4	0.9	557	29
91-72	113	HG	0.28	0.9	1.72	10	4	343	0.3	0.3	5	1.24	0.1	11	1520	2.68	0.67	4	0.76	384	46
91-72	115	HG	0.3	1.2	1.38	9	4	298	0.4	0.4	4	1.63	0.1	13	1666	2.77	0.57	3	0.52	393	48
91-72	117	HG	0.27	1.4	1.81	13	4	280	0.5	0.5	6	1.38	0.1	11	1575	2.68	0.7	4	0.86	333	73
91-72	119	HG	0.71	1.5	1.51	9	6	317	0.3	0.3	6	1.24	0.1	13	2975	2.9	0.61	3	0.75	271	200
91-72	121	HG	0.31	1.1	2.03	13	4	517	0.4	0.4	4	1.57	0.1	12	1771	2.59	0.8	4	0.84	299	96
91-72	123	HG	0.25	1.2	2.08	17	4	286	0.4	0.4	6	1.52	0.1	13	1689	2.64	0.83	4	1.03	297	103
91-72	125	HG	0.3	1	2.3	16	4	423	0.5	0.5	5	0.98	0.1	15	1782	3.09	0.95	4	0.9	152	83
91-72	127	HG	0.39	1.1	2.24	12	5	575	0.4	0.4	6	1.23	0.1	12	2131	2.85	0.88	5	0.98	222	76
91-72	129	HG	0.28	1.1	1.93	14	3	383	0.4	0.4	5	1.11	0.1	13	1420	2.8	0.79	4	0.9	194	71
91-72	131	HG	0.41	0.9	1.94	23	4	363	0.3	0.3	4	0.96	0.1	12	1894	3	0.8	4	0.74	157	76
91-72	133	HG	0.31	1	2	15	3	313	0.4	0.4	4	1.24	0.1	11	1558	2.61	0.81	4	0.79	224	66
91-72	135	HG	0.3	1	1.93	13	3	392	0.3	0.3	5	1.43	0.1	11	1400	3.13	0.77	4	0.86	251	60
91-72	137	HG	0.31	1	1.99	10	3	222	0.5	0.5	4	1.61	0.1	12	1624	3.02	0.82	4	0.86	255	72
91-72	139	HG	0.18	0.5	1.6	8	2	98	0.1	0.1	2	1.78	0.1	12	813	4.17	0.68	3	0.76	222	39
91-72	141	HG	0.23	0.8	1.69	10	2	255	0.3	0.3	4	1.58	0.1	12	1367	2.8	0.64	4	0.83	240	74
91-72	143	HG	0.19	0.9	1.76	16	2	318	0.4	0.4	4	1.53	0.1	11	973	2.42	0.62	4	0.92	248	50
91-72	145	HG	0.18	0.7	1.81	8	2	247	0.5	0.5	3	1.49	0.1	11	1241	3.12	0.68	4	0.77	217	67
91-72	147	HG	0.22	0.8	2.91	26	15	290	0.6	0.6	5	1.51	0.1	11	1019	3.24	1.06	6	0.94	255	125
91-72	149	HG	0.28	0.9	2.84	23	11	524	0.5	0.5	5	1.26	0.1	11	1227	2.86	1.07	5	0.98	211	153
91-72	151	HG	0.14	0.5	2.22	19	7	266	0.4	0.4	4	1.67	0.1	11	765	3.46	0.81	5	0.92	291	54
91-72	153	HG	0.21	0.8	2.21	15	6	346	0.3	0.3	4	1.36	0.1	9	936	2.58	0.84	5	0.84	251	49
91-72	155	HG	0.38	0.7	1.07	19	6	170	0.4	0.4	4	1.06	0.1	12	1494	2.73	0.36	4	0.62	158	188
91-72	157	HG	0.28	0.4	2.1	17	8	282	0.1	0.1	4	0.77	0.1	16	1146	3.69	0.96	4	0.74	93	140
91-72	159	HG	0.28	0.6	1.92	16	6	272	0.3	0.3	4	0.84	0.1	14	918	2.57	0.84	4	0.72	134	128
91-72	161	HG	0.23	0.9	2.75	19	6	560	0.5	0.5	5	1.35	0.1	14	1124	2.88	1.02	7	1.05	351	64

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-72	163 HG		0.18	0.7	2.41	26	7	415	0.4	5	0.96	0.1	14	902	3.38	0.99	5	0.88	205	80
91-72	165 HG		0.29	2.1	2.4	25	5	435	0.5	5	1.22	0.1	11	1067	2.79	0.88	6	0.88	298	51
91-72	167 HG		0.2	0.9	2.34	21	5	404	0.4	4	1.1	0.1	15	984	3.15	0.86	5	0.86	230	69
91-72	169 HG		0.17	1	3.1	24	6	673	0.4	5	1.31	0.1	12	979	2.98	1.13	7	1.07	302	78
91-72	171 HG		0.23	1.1	2.46	23	6	510	0.5	5	1.2	0.1	11	1060	2.89	0.84	6	0.95	274	116
91-72	173 HG		0.1	0.7	2.38	20	4	412	0.4	4	1.2	0.1	12	672	2.93	0.82	6	0.97	267	44
91-72	175 HG		0.2	0.8	1.97	17	4	366	0.4	3	0.71	0.1	9	735	2.2	0.75	4	0.68	119	66
91-72	177 HG		0.12	1	2.27	35	61	182	2.6	10	0.78	11.6	18	962	4.44	0.88	24	0.7	136	84
91-72	179 HG		0.13	0.9	2.82	23	4	437	0.4	5	1.08	0.1	11	849	2.71	0.92	5	1.04	232	55
91-72	181 HG		0.18	1	2.85	25	5	446	0.3	6	1.27	0.1	12	917	3.39	0.98	6	1.15	276	69
91-72	183 HG		0.24	1.1	3.14	27	6	594	0.4	6	1.25	0.1	14	1217	3.38	1.09	8	1.36	226	113
91-72	185 HG		0.21	1.3	2.96	33	7	533	0.3	7	1.05	1	15	1553	3.48	1.07	7	1.13	204	153
91-72	187 HG		0.17	1.3	3.04	35	7	570	0.5	6	1.48	1.4	13	1136	3.19	1.07	6	1.01	245	88
91-72	189 HG		0.22	0.8	2.32	15	4	345	0.3	6	0.88	0.1	14	867	3.66	0.79	4	0.8	122	67
91-73	4.8 Jrt		0.01	0.9	4.3	44	15	207	0.8	10	2.32	0.1	18	16	4.32	0.3	23	3.27	1093	1
91-73	7 Jrt		0.01	0.6	4.23	20	10	272	1	8	1.57	0.1	15	8	3.99	0.32	19	2.73	703	1
91-73	9 Jrt		0.01	0.9	4.96	18	10	387	1	10	2.66	0.1	18	9	4.27	0.4	23	3.45	1155	1
91-73	11 Jrt		0.01	1.3	4.82	22	8	189	0.8	10	4.38	0.1	16	29	3.91	0.46	21	2.91	1474	1
91-73	13 Jrt		0.01	1.2	5.66	25	9	330	0.8	11	4.67	0.1	20	22	4.35	0.43	21	3.44	1355	1
91-73	15.9 Jrt		-2	1.1	6.6	22	9	142	0.7	14	4.83	0.1	23	27	5.35	0.67	25	3.11	1165	1
91-73	24 Jrt		0.01	1.4	5.7	31	8	140	0.7	10	4.84	0.1	14	17	3.81	0.58	18	2.53	1181	1
91-73	26 Jrt		0.01	1.1	5.4	26	7	6720	0.6	10	4.99	0.1	21	18	4.65	0.63	13	2.02	950	1
91-73	28 Jrt		0.01	0.6	4.8	26	5	243	0.9	7	2.13	0.1	20	18	4.3	0.29	14	1.83	462	1
91-73	30 Jrt		0.01	0.9	5.08	27	6	373	0.7	8	4.62	0.1	18	15	4.53	0.43	13	1.63	839	1
91-73	32 Jrt		0.01	0.8	3.23	19	4	426	0.8	7	4.99	0.1	16	15	4.28	0.22	11	1.08	964	1
91-73	34 Jrt		0.01	1.1	3.23	17	5	3017	0.6	9	6.41	0.1	20	28	4.45	0.28	8	0.84	1617	1
91-73	36 Jrt		0.01	1	1.99	44	11	449	0.1	7	6.03	0.1	17	75	4.4	0.21	4	0.28	1292	1
91-73	38 Jrt		0.01	0.8	1.94	7	8	783	0.2	6	5.34	0.1	13	52	4.08	0.31	2	0.2	805	1
91-73	40 Jrt		0.02	0.5	1.33	19	16	134	0.9	6	5.11	0.1	9	196	3.55	0.32	4	0.11	875	1
91-73	42 Jrt		0.11	1.5	1.74	6	6	149	0.3	5	5.25	0.1	9	357	3.86	0.4	2	0.15	930	1
91-73	44 SG		0.62	0.8	0.81	13	6	929	0.2	3	0.67	0.1	5	653	3.78	0.42	1	0.07	50	22
91-73	46 SG		0.53	0.3	0.72	1	8	1028	0.1	3	0.77	0.1	7	1157	6.37	0.38	1	0.07	75	48
91-73	48 SG		0.81	0.3	0.61	7	6	770	0.1	3	0.45	0.1	6	1189	6.05	0.27	1	0.05	26	42
91-73	50 SG		0.97	0.8	0.67	9	5	261	0.1	5	0.35	0.1	5	2011	5.21	0.24	2	0.05	22	42
91-73	52 SG		0.83	0.5	0.35	5	4	47	0.1	2	0.27	0.1	4	465	4.73	0.2	1	0.02	18	37
91-73	54 SG		0.61	0.4	0.48	1	5	39	0.1	3	0.2	0.1	5	458	6.01	0.22	1	0.03	15	36
91-73	56 SG		0.27	0.9	0.25	4	3	28	0.1	3	0.21	0.1	4	242	3.85	0.13	1	0.02	11	38
91-73	58 SG		0.45	0.9	0.43	6	4	43	0.1	3	0.32	0.1	5	364	5.03	0.23	1	0.03	34	49

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-73	60 SG		0.73	0.9	0.49	1	3	93	0.1	1	0.76	0.1	4	247	4.4	0.24	1	0.03	90	27
91-73	62 SG		0.91	0.9	0.57	11	4	38	0.1	3	0.81	0.1	5	295	5.31	0.28	1	0.04	126	44
91-73	64 SG		0.82	1.2	0.56	6	3	33	0.1	3	0.52	0.1	4	227	4.18	0.28	1	0.04	82	39
91-73	66 SG		0.65	1	0.58	7	4	77	0.1	3	0.51	0.1	5	287	4.9	0.31	2	0.05	75	32
91-73	68 SG		0.42	1.1	0.6	3	4	585	0.1	2	0.41	0.1	5	279	5.01	0.32	2	0.05	60	38
91-73	70 SG		0.97	3.4	0.57	1	4	682	0.1	4	0.2	0.1	6	803	5.87	0.29	2	0.05	14	35
91-73	72 SG		0.51	1.2	0.57	6	3	818	0.1	4	0.18	0.1	5	265	4.8	0.29	1	0.05	23	38
91-73	74 SG		1.1	2.7	0.6	3	4	426	0.1	17	0.21	0.1	8	7635	4.62	0.32	1	0.07	121	40
91-73	76 SG		0.8	1	1.39	19	5	109	0.1	10	0.27	9.3	23	4571	5.94	0.31	4	0.18	276	73
91-73	78 SG		1.1	1.2	1.03	9	4	648	0.1	6	0.34	0.1	22	3016	6.14	0.33	3	0.2	610	28
91-73	80 SG		0.97	1.4	0.78	72	4	516	0.1	6	0.8	0.1	26	3248	6.05	0.37	2	0.19	1051	35
91-73	82 SG		1.3	2.4	0.38	33	3	194	0.1	9	0.99	0.1	16	3744	3.93	0.21	1	0.1	668	75
91-73	84 SG		1.22	1.3	0.82	50	11	742	0.5	8	1.6	0.1	17	3121	4.8	0.37	4	0.19	1182	62
91-73	86 SG		0.9	0.3	1	24	7	495	0.3	9	1.59	0.1	19	3031	5.83	0.48	2	0.24	1861	61
91-73	88 SG		1	0.7	0.95	12	2	273	0.3	8	1.46	0.1	15	2821	4.47	0.44	2	0.21	1131	40
91-73	90 SG		0.58	0.4	1.44	22	1	539	0.2	8	1.45	0.1	19	2738	5.61	0.49	3	0.29	1731	25
91-73	92 SG		0.57	1.3	0.96	63	1	474	0.3	9	1.02	3.3	17	2991	3.4	0.4	2	0.15	736	32
91-73	94 SG		0.5	1.3	1.69	52	1	667	0.5	10	0.98	0.1	14	2815	2.82	0.53	6	0.34	696	48
91-73	96 SG		0.71	1.5	1.12	68	1	636	0.3	7	0.8	0.1	12	1981	1.73	0.38	2	0.1	199	72
91-73	98 SG		0.51	2	1.87	18	1	503	0.6	10	1.15	0.1	17	3299	3.05	0.58	4	0.36	397	58
91-73	100 SG		0.67	1.4	1.72	18	1	480	0.4	10	1.15	0.1	15	3418	2.68	0.46	4	0.26	378	80
91-73	102 SG		0.72	1.5	1.72	28	1	513	0.3	10	1.15	0.1	21	3810	2.53	0.5	4	0.23	362	94
91-73	104 SG		1.12	1.6	1.66	8	1	596	0.4	10	1.71	0.1	12	2733	2.9	0.57	4	0.45	552	41
91-73	106 SG		0.43	1.9	1.59	14	1	432	0.3	9	1.99	0.1	11	2792	2.75	0.63	3	0.44	648	68
91-73	108 HG		0.52	1.8	2	15	1	429	0.4	9	2.06	0.1	13	2909	2.89	0.78	4	0.56	593	239
91-73	110 HG		0.64	1.8	2.21	15	1	493	0.5	11	1.94	0.1	13	3646	2.84	0.95	4	0.77	452	123
91-73	112 HG		0.47	1.1	2.25	12	1	251	0.5	9	2.46	0.1	12	1592	3.55	1.08	5	1.1	505	47
91-73	114 HG		0.28	2.2	1.99	14	1	185	0.5	20	1.71	0.1	18	7349	3.39	0.93	4	0.94	325	118
91-73	116 HG		0.69	1.3	2.18	19	1	189	0.6	10	1.77	0.1	13	1969	3.28	0.97	5	1.1	360	150
91-73	118 HG		0.4	2	1.97	20	1	357	0.5	10	1.55	5.7	13	2873	2.84	0.78	3	0.71	301	261
91-73	120 HG		0.97	1.3	1.82	15	1	329	0.6	10	1.41	0.1	12	2485	3.16	0.72	4	0.87	281	66
91-73	122 HG		0.62	2.1	1.85	18	1	421	0.6	11	1.42	0.1	15	3416	3.47	0.64	5	0.84	311	98
91-73	124 HG		0.77	1.5	2.26	19	1	320	0.8	10	1.41	0.1	12	2310	3	0.79	6	1.1	324	65
91-73	126 HG		0.5	1.8	2.07	17	1	425	0.7	9	1.42	0.1	14	3083	2.5	0.78	5	0.83	276	165
91-74	202 HG		0.23	1	2.33	18	11	292	0.4	9	1.13	0.1	11	1302	2.83	0.71	9	1.01	237	54
91-74	204 HG		0.22	1	2.24	16	7	488	0.4	7	1.25	0.1	10	1291	2.91	0.71	7	0.88	248	54
91-74	206 HG		0.28	1	2.4	15	7	591	0.4	7	1.12	0.1	10	1706	2.64	0.77	6	0.79	190	77
91-74	208 HG		0.29	1.3	2.93	17	7	818	0.5	8	1.4	0.1	10	1538	2.78	1	5	0.88	216	64

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-74	210 HG		0.27	1.3	3.2	18	8	585	0.5	9	1.39	0.1	9	1413	2.35	1.07	5	0.93	194	136
91-74	212 HG		0.32	1.1	3.26	21	9	456	0.5	9	1.14	0.1	11	1504	2.13	1.12	4	0.83	145	159
91-74	214 HG		0.33	1.3	3.11	13	8	590	0.6	8	1.69	0.1	13	1837	2.6	1.11	4	0.83	194	138
91-74	216 HG		0.43	0.9	1.75	10	6	287	0.5	6	1.96	0.1	12	1151	2.75	0.56	5	0.75	236	85
91-74	218 HG		0.26	1.1	2.05	9	5	231	0.3	5	1.3	0.1	9	1275	2.68	0.58	5	0.82	259	62
91-74	220 HG		0.44	1.2	1.85	7	5	230	0.5	5	1.3	0.1	14	1707	2.72	0.62	4	0.79	239	65
91-74	222 HG		0.31	0.4	2.27	7	6	343	0.3	5	1.24	0.1	13	960	3.78	0.81	4	0.78	207	89
91-74	224 HG		0.38	1.2	1.74	6	5	343	0.2	5	1.37	0.1	12	1888	2.77	0.56	5	0.77	247	129
91-74	226 HG		0.21	0.8	1.84	11	5	160	0.3	6	1.12	0.1	20	1380	3.61	0.61	4	0.77	252	85
91-74	228 HG		0.2	0.8	1.85	20	4	321	0.4	5	1.25	0.1	12	1215	2.78	0.58	5	0.79	251	66
91-74	230 HG		0.24	1.2	2.12	7	6	315	0.5	5	1.31	0.1	13	1828	3.14	0.87	4	0.64	240	94
91-74	232 HG		0.21	1	1.9	9	5	261	0.4	5	1.79	0.1	13	1434	3.03	0.69	4	0.67	316	106
91-74	234 HG		0.27	1.2	1.27	7	4	143	0.3	5	1.37	0.1	12	1587	3.08	0.42	4	0.63	220	97
91-74	236 HG		0.23	1	1.77	8	5	218	0.3	5	1.53	0.1	14	1471	3.14	0.66	4	0.66	231	88
91-74	238 HG		0.2	0.9	2.16	6	5	218	0.3	5	1.52	0.1	15	1387	2.86	0.75	4	0.77	167	115
91-74	240 HG		0.23	1.2	1.94	12	4	134	0.3	4	2.06	0.1	12	1521	2.65	0.73	3	0.73	228	84
91-74	241.8 FRb		0.12	1.2	3.14	1	6	54	0.1	11	2.31	0.1	25	1291	5.49	0.69	14	2.53	589	54
91-78	3.59 JRI		0.01	0.5	3.33	44	19	261	0.7	11	2.03	0.1	22	34	5.19	0.24	17	2.35	1152	1
91-78	5 JRI		0.01	0.7	4.67	19	12	272	0.5	13	1.56	0.1	23	51	5.3	0.44	20	2.75	834	1
91-78	7 JRI		0.01	0.6	4.21	4	10	476	0.7	11	2.05	0.1	19	31	4.82	0.28	22	3.41	1082	1
91-78	9 JRI		0.01	0.4	5.22	17	10	359	1	14	1.56	0.1	20	21	5.18	0.46	25	3.55	844	1
91-78	11 JRI		0.01	0.5	5	20	9	553	0.9	12	1.72	0.1	17	22	4.58	0.46	20	2.83	662	1
91-78	13 JRI		0.01	0.4	4.71	17	8	442	1	11	1.41	0.1	17	28	4.41	0.29	22	3.35	695	1
91-78	15 JRI		0.01	0.6	6.08	33	7	327	1	10	2.03	0.1	12	19	3.46	0.49	16	2.92	541	1
91-78	17 JRI		0.01	0.8	5.94	28	8	261	1	12	4.64	0.1	14	32	3.69	0.46	15	2.66	1035	1
91-78	19 JRI		0.01	0.7	5.27	27	8	159	0.9	12	2.03	0.1	20	31	5.23	0.49	20	2.3	676	1
91-78	21 JRI		0.01	0.7	5.2	22	7	120	0.7	12	5.7	0.1	20	36	5.1	0.61	10	1.69	1025	1
91-78	23 JRI		0.02	0.6	4.65	21	6	124	0.9	9	5.35	0.1	18	35	4.92	0.28	10	1.56	980	1
91-78	25 JRI		0.01	0.4	5.07	17	5	108	0.9	6	4.98	0.1	18	25	4.47	0.29	13	1.47	905	1
91-78	27 JRI		0.01	0.4	4.12	11	4	79	0.8	7	4.98	0.1	18	20	4.78	0.21	11	1.13	877	1
91-78	29 JRI		0.02	0.4	3.89	21	15	137	0.5	11	6.28	0.1	16	122	4.44	0.34	5	0.57	1264	1
91-78	31 JRI		0.02	0.7	4.1	17	10	196	0.5	10	6.09	0.1	16	127	4.39	0.39	5	0.56	1168	1
91-78	33 JRI		0.33	0.7	1.24	5	6	5634	0.4	4	1.37	0.1	5	84	2.58	0.6	1	0.15	146	6
91-78	35 SG		0.54	0.6	1.7	16	5	1838	0.4	3	1.06	0.1	3	153	2.38	0.83	1	0.16	78	11
91-78	37 SG		0.9	0.7	1.25	15	4	1348	0.5	4	0.95	0.1	3	233	2.84	0.66	1	0.12	85	14
91-78	39 SG		0.78	0.5	1.73	15	3	1217	0.4	3	0.62	0.1	4	275	3.51	0.71	1	0.13	30	12
91-78	41 SG		1.01	0.2	1.43	8	3	874	0.4	3	0.42	0.1	3	184	3.35	0.55	1	0.11	11	12
91-78	43 SG		0.6	0.5	2.16	16	3	763	0.5	4	0.34	0.1	3	253	2.82	0.7	2	0.15	16	14

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-78	45 SG		0.96	0.4	1.71	8	2	713	0.4	3	0.29	0.1	3	169	2.77	0.47	2	0.1	18	29
91-78	47 SG		0.41	0.7	1.69	5	1	1156	0.4	2	0.33	0.1	3	196	2.26	0.46	2	0.12	21	18
91-78	49 SG		0.62	0.6	1.3	5	1	637	0.4	3	0.32	0.1	3	209	2.74	0.5	1	0.1	20	24
91-78	51 SG		0.77	1.1	1.13	17	11	489	0.3	4	0.47	0.1	3	446	2.24	0.53	1	0.1	32	16
91-78	53 SG		0.69	0.6	1.13	15	1	244	0.5	3	0.43	0.1	3	294	3.08	0.58	1	0.08	31	47
91-78	55 SG		0.3	0.5	1.21	9	1	256	0.4	4	0.34	0.1	3	201	2.57	0.62	1	0.09	23	22
91-78	57 SG		0.71	0.8	0.87	10	1	407	0.4	3	0.24	0.1	3	149	2.89	0.42	1	0.08	14	23
91-78	59 SG		1.42	0.9	0.97	6	1	558	0.3	3	0.3	0.1	4	268	4.49	0.53	1	0.13	23	46
91-78	61 SG		0.51	0.3	1.07	16	2	254	0.5	3	0.35	0.1	5	249	5.4	0.57	1	0.08	17	64
91-78	63 SG		1.36	0.4	1.07	16	2	192	0.5	4	0.31	0.1	5	393	4.6	0.59	1	0.09	17	48
91-78	65 SG		0.33	0.6	1.13	15	1	224	0.5	3	0.39	0.1	4	394	3.77	0.61	1	0.09	9	27
91-78	67 SG		0.72	0.2	0.95	21	1	528	0.5	4	0.23	0.1	6	604	5.46	0.46	1	0.09	14	42
91-78	69 SG		0.8	0.5	1.3	22	2	564	0.6	6	0.37	0.1	7	1162	5	0.56	1	0.11	34	42
91-78	71 SG		0.46	0.6	1.45	23	1	978	0.6	6	0.33	0.1	6	1796	4.24	0.63	1	0.1	12	26
91-78	73 SG		0.32	0.8	1.62	28	1	332	0.7	6	0.32	0.1	4	1470	3.32	0.73	1	0.11	14	23
91-78	75 SG		0.35	0.7	1.42	55	1	320	0.7	4	0.15	0.1	4	387	3.32	0.77	1	0.1	34	41
91-78	77 SG		0.4	2.4	0.71	46	18	383	0.4	16	0.31	0.1	5	3216	3.85	0.41	1	0.06	43	31
91-78	79 SG		0.34	0.9	0.84	22	13	569	0.3	7	0.33	0.1	5	1118	3.64	0.44	1	0.07	57	31
91-78	81 SG		0.48	0.7	0.59	11	10	435	0.1	6	0.23	0.1	4	825	4.41	0.39	1	0.04	24	54
91-78	83 SG		0.64	0.8	0.79	16	8	359	0.5	4	0.19	0.1	5	716	4.77	0.47	1	0.06	27	50
91-78	85 SG		0.81	3.4	0.76	43	10	678	0.5	13	0.3	0.1	7	761	7.03	0.47	1	0.05	19	65
91-78	87 SG		0.83	2.2	1.12	29	7	533	0.3	3	0.13	0.1	5	180	4.3	0.64	1	0.08	33	38
91-78	89 SG		1.04	0.9	0.88	19	5	582	0.4	3	0.13	0.1	4	273	4.17	0.5	1	0.07	20	35
91-78	91 SG		0.85	0.1	1.1	12	6	596	0.3	6	0.14	0.1	6	274	5.2	0.53	1	0.09	25	24
91-78	93 SG		0.52	0.1	1.22	17	6	547	0.5	22	0.18	0.1	8	7828	5.58	0.49	1	0.1	35	43
91-78	95 SG		0.65	1	1.46	74	6	966	0.3	24	0.24	0.1	29	8826	6.04	0.42	2	0.15	54	54
91-78	97 SG		0.97	1.3	0.8	37	4	317	0.3	9	0.21	0.1	20	3080	4.71	0.34	1	0.09	23	46
91-78	99 SG		0.99	2	0.97	51	3	285	0.4	11	0.11	0.1	17	3714	3.39	0.23	3	0.05	65	46
91-78	101 SG		0.72	0.9	1.99	24	4	1941	0.3	11	0.14	0.1	19	3213	4.22	0.29	7	0.12	264	22
91-78	103 SG		0.71	3	1.38	21	2	631	0.3	17	0.1	0.1	6	5496	1.9	0.26	4	0.03	19	28
91-78	105 SG		0.84	2	1.01	25	3	665	0.3	30	0.32	0.1	12	10000	3.05	0.26	5	0.11	760	60
91-78	107 SG		0.97	1.6	1.13	21	2	830	0.2	11	1.46	0.1	21	3239	4.09	0.29	3	0.2	1826	40
91-78	109 HG		0.87	1.2	2.23	6	4	369	0.5	11	1.96	0.1	18	2863	4.09	0.55	4	0.4	1212	61
91-78	111 HG		1	1.7	2.14	11	4	468	0.5	11	1.94	0.1	15	3156	3.43	0.57	3	0.35	902	79
91-78	113 HG		0.62	1.8	1.85	25	4	716	0.5	8	1.24	0.1	16	2300	2.82	0.49	4	0.28	464	148
91-78	115 HG		0.69	1.5	2.14	21	4	957	0.6	9	1.39	0.1	14	2592	2.3	0.59	4	0.39	515	58
91-78	117 HG		0.56	1.1	2.79	18	5	1167	0.8	7	1.27	0.1	19	2093	3.48	0.78	5	0.45	560	105
91-78	119 HG		0.96	2.1	2.34	29	4	626	0.7	11	1.44	0.1	17	3128	3.11	0.7	4	0.4	629	110

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-78	121 HG		0.61	1.8	2.5	15	3	137	0.7	8	2.23	0.1	19	1769	3.23	0.89	4	0.71	1084	48
91-78	123 HG		0.9	2.2	2.6	20	6	482	0.6	11	1.68	0.1	20	3192	3.45	0.96	5	0.81	700	154
91-78	125 HG		1.07	3.1	2.27	26	34	555	0.7	19	1.46	0.1	18	3137	3.55	0.88	4	0.98	574	64
91-78	127 HG		0.56	1	2.15	17	20	521	0.4	11	1.61	0.1	11	1805	3.02	0.83	3	0.99	629	37
91-78	129 HG		0.68	1.3	2.29	15	18	402	0.6	13	1.53	0.1	11	1978	3.03	0.97	4	1.06	560	69
91-78	131 HG		0.49	1.2	2.44	22	15	306	0.7	11	1.25	0.1	10	1798	2.59	1.03	3	0.98	400	50
91-78	133 HG		0.66	1.2	2.75	18	17	334	0.7	16	1.16	0.1	16	2495	3.66	1.15	4	1.08	319	37
91-78	135 HG		0.72	1.3	2.52	18	14	652	0.5	13	1.52	0.1	13	2524	2.87	1.05	3	1.02	449	76
91-78	137 HG		1.02	2.1	2.01	23	12	838	0.5	17	1.22	0.1	10	4214	2.11	0.88	1	0.56	233	131
91-78	139 HG		0.77	3.3	2.52	13	11	450	0.4	14	1.81	0.1	12	2772	2.91	1.08	3	0.98	436	84
91-78	141 HG		1.66	2.2	2.13	14	11	321	0.4	18	1.68	0.1	11	4400	3.01	0.88	3	1.01	368	121
91-78	143 HG		0.96	1.5	2.04	18	9	411	0.5	13	1.49	0.1	13	3009	3.05	0.81	3	0.98	318	59
91-78	145 HG		0.68	1.6	2.04	16	9	178	0.3	15	1.6	0.1	12	2747	2.8	0.91	3	1.06	322	51
91-78	147 HG		0.78	1.5	2	12	9	555	0.5	14	1.26	0.1	14	2753	2.65	0.79	3	0.9	259	60
91-78	149 HG		0.43	1.2	1.98	13	9	222	0.4	13	1.38	0.1	12	2938	2.78	0.75	3	0.96	267	62
91-78	151 HG		0.61	1	2.28	19	9	343	0.5	11	1.21	0.1	13	2052	2.85	0.9	3	0.95	229	106
91-78	153 HG		0.52	1.2	2.08	12	10	350	0.4	13	1.41	0.1	12	2935	3.54	0.78	3	0.97	280	96
91-78	155 HG		0.73	1.2	2.26	18	8	303	0.5	11	1.67	0.1	12	2259	3.02	0.91	3	0.99	295	58
91-78	157 HG		0.62	1.2	2.08	17	8	402	0.5	10	1.78	0.1	10	2023	2.65	0.77	3	0.83	268	68
91-78	159 HG		0.53	0.9	2	10	7	233	0.2	12	1.67	0.1	11	1698	3.36	0.89	3	1.22	278	56
91-78	161 HG		0.29	0.8	1.88	9	7	227	0.3	13	1.5	0.1	13	1543	3.51	0.88	3	1.25	261	43
91-78	163 HG		0.64	1.4	2.14	17	8	492	0.5	13	1.52	0.1	13	2305	3.13	0.8	4	1.04	283	67
91-78	165 HG		0.6	1.5	2.29	16	10	375	0.3	12	1.68	0.1	12	2319	3.28	0.81	4	1.04	309	189
91-78	167 HG		0.55	0.9	2.48	17	9	186	0.5	11	1.92	0.1	12	1806	3.48	0.9	5	1.14	351	126
91-78	169 HG		0.57	2.3	2.19	13	8	276	0.4	12	1.65	0.1	12	2127	3.03	0.78	5	1.13	335	128
91-78	171 HG		0.46	1.2	2.38	23	10	258	0.4	11	1.57	0.1	11	1900	3.25	0.88	5	1.1	289	149
91-78	173 HG		0.32	0.9	2.86	122	14	348	0.6	10	2.28	0.1	13	1096	2.83	0.48	7	1.34	573	37
91-78	175 HG		0.44	1.2	1.76	10	7	370	0.5	8	1.39	0.1	12	1468	2.79	0.55	6	0.95	264	52
91-78	177 HG		0.42	1.2	2.43	17	7	326	0.5	10	1.51	0.1	11	1679	3.19	0.87	7	1.16	279	88
91-78	179 HG		0.47	1	2.54	11	5	337	0.5	11	1.52	0.1	11	1375	3.44	0.94	7	1.35	291	43
91-78	181 HG		0.49	1.2	2.75	19	4	512	0.6	11	1.33	0.1	12	1511	3.02	1.01	7	1.16	285	76
91-78	183 HG		0.76	2.2	2.43	28	16	670	0.5	12	1.15	0.1	17	2812	3.02	0.84	6	1	261	774
91-78	185 HG		0.74	2.1	2.46	21	2	289	0.5	11	1.47	0.1	13	2541	3.05	0.84	7	1.2	318	116
91-78	187 HG		0.49	1.2	2.8	20	3	337	0.7	10	1.53	0.1	12	1908	3.13	0.98	7	1.18	320	95
91-78	189 HG		0.3	0.8	2.48	14	1	263	0.6	7	1.49	0.1	12	1190	3.27	0.81	7	1.12	319	41
91-78	191 HG		0.46	1.2	2.41	10	1	237	0.6	10	1.89	0.1	12	1456	3.57	0.82	8	1.25	395	97
91-78	193 HG		0.41	1.5	2.51	15	1	256	0.5	11	1.16	0.1	13	1669	3.35	0.87	7	1.26	288	123
91-78	195 HG		0.72	1.4	2.3	9	1	709	0.5	10	1.48	0.1	12	2037	3.59	0.79	6	1.12	343	93

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-78	197 HG		0.84	1.6	2.55	26	1	448	0.6	9	0.9	0.1	13	2448	2.48	1.07	4	0.8	174	113
91-78	199 HG		0.29	1.1	2.23	15	1	324	0.5	7	1.2	0.1	11	1116	2.71	0.78	5	0.96	248	59
91-78	201 HG		0.63	1.6	2.35	16	1	268	0.6	11	1.2	0.1	12	2241	3.09	0.8	6	1.08	290	86
91-78	203 HG		0.41	1.3	1.95	17	1	333	0.5	9	0.98	0.1	10	1619	2.47	0.65	5	0.84	236	74
91-78	205 HG		0.52	1.5	2.47	18	1	514	0.7	9	1.05	0.1	10	1926	2.73	0.89	5	0.92	252	87
91-78	207 HG		0.48	1.7	2.27	33	1	488	0.5	8	1.12	0.1	10	2072	2.2	0.91	3	0.66	205	77
91-78	209 HG		0.53	1.9	2.72	17	1	538	0.6	9	1.22	0.1	15	1966	2.92	1.07	4	0.88	252	62
91-78	211 HG		0.68	1.7	2.75	20	1	594	0.6	9	1.31	0.1	10	2325	2.2	1.15	3	0.79	255	108
91-78	213 HG		0.62	1.2	2.67	9	1	471	0.5	11	1.9	0.1	14	2522	3.44	0.95	5	1.15	344	61
91-78	215 HG		0.5	1.1	2.64	13	1	418	0.7	9	1.48	0.1	12	1930	2.5	1.02	5	1.04	280	73
91-78	217 HG		0.44	1.6	2.93	19	1	485	0.6	11	1.74	0.1	12	1936	3.17	1.08	6	1.11	382	76
91-78	219 HG		0.62	1.7	2.81	33	1	424	0.6	11	1.1	0.1	13	2591	2.91	1.18	4	0.8	246	74
91-78	221 HG		0.52	2.1	2.03	1	4	210	0.6	3	0.79	0.1	18	2530	2.72	0.79	3	0.92	223	58
91-78	223 HG		0.49	1.7	2.1	1	4	314	0.4	3	1.38	0.1	12	1849	2.91	0.77	3	1.02	302	49
91-78	225 HG		0.29	1.2	2.44	1	4	289	0.7	3	1	0.1	13	1527	3.15	0.96	3	1.14	248	36
91-78	227 HG		0.31	1.4	2.78	1	6	432	0.6	3	1.02	0.1	11	1519	3.38	1.08	4	1.18	270	130
91-78	229 HG		0.29	1.5	2.61	1	5	346	0.5	3	0.91	0.1	12	1331	3.46	0.98	4	1.21	231	90
91-78	231 HG		0.2	1.1	2.39	1	3	301	0.5	1	1.46	0.1	20	1433	3.67	0.86	4	1.09	276	18
91-78	233 HG		0.3	1.5	2.25	1	3	327	0.5	2	1.45	0.1	13	1698	3.14	0.86	3	0.82	210	45
91-78	235 HG		0.14	1.3	2	1	2	240	0.5	2	0.79	0.1	14	1146	3.12	0.69	3	0.89	160	34
91-78	237 HG		0.24	0.4	2.35	1	3	160	0.7	2	1	0.1	15	1119	4.8	0.75	5	1.16	229	37
91-78	239 HG		0.31	1.3	2.05	1	6	231	0.4	1	0.79	0.1	12	1654	3.08	0.72	3	0.69	168	185
91-78	241 HG		0.4	1.4	2.12	1	3	294	0.5	1	0.98	0.1	13	1757	2.68	0.73	3	0.77	178	83
91-78	243 HG		0.34	1.2	2.06	1	8	213	0.4	1	0.78	0.1	13	1668	3.04	0.81	1	0.53	87	273
91-78	245 HG		0.18	0.6	1.88	1	3	64	0.4	1	0.75	0.1	15	855	3.77	0.74	1	0.52	76	37
91-78	247 HG		0.16	1.1	2.11	1	2	251	0.4	1	1.67	0.1	12	1108	2.85	0.73	1	0.69	226	42
91-78	249 HG		0.2	1.1	1.52	1	2	169	0.3	1	3.61	0.1	13	1071	2.57	0.68	1	0.4	303	46
91-78	251 TRb		0.09	0.4	3.03	1	4	119	0.2	2	3.61	0.1	24	1324	5.52	0.51	8	2.13	813	40
91-78	253 TRb		0.1	0.1	3.05	1	3	156	0.1	6	3.18	0.1	31	1257	6.49	0.33	14	3.8	1190	44
91-78	255 TRb		0.12	0.2	2.51	1	3	187	0.1	5	2.93	0.1	24	884	5.62	0.24	11	3.32	995	46
91-78	257 TRb		0.14	0.1	2.55	1	5	113	0.1	6	3.23	0.1	39	1361	7.12	0.41	10	3.05	749	91
91-78	259 TRb		0.19	0.4	2.72	1	3	63	0.3	5	3.48	0.1	26	1099	5.32	0.49	10	2.8	716	37
91-78	261 TRb		0.08	1.6	0.98	1	2	170	0.1	1	3.48	0.1	7	753	1.52	0.28	1	0.57	332	91
91-82	6.1 Jrt		0.01	1.1	3.53	1	7	86	0.2	12	3.84	0.1	16	10	4.48	0.1	12	2.45	1316	1
91-82	8 Jrt		0.01	1.2	3.46	1	6	68	0.2	13	3.57	0.1	18	11	5.02	0.08	9	2.38	1418	1
91-82	10 Jrt		0.01	1.2	3.48	1	4	125	0.1	15	2.08	0.1	21	12	5.68	0.11	9	2.97	1656	1
91-82	12 Jrt		0.02	1.4	3.67	1	4	54	0.1	17	3.32	0.1	24	10	6.45	0.11	9	3.36	1912	1
91-82	14 Jrt		0.01	1.4	3.4	1	4	60	0.1	18	3.44	0.1	24	13	6.35	0.17	10	3.11	1923	1

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-82	16 Jrt		0.01	1.3	4.16	1	8	52	0.1	17	1.81	0.1	29	21	6.7	0.71	21	4.51	1759	1
91-82	18 Jrt		0.01	1.2	3.8	1	4	57	0.1	16	1.83	0.1	26	25	6.07	0.33	12	3.72	1456	1
91-82	20 Jrt		0.01	1.1	3.05	1	3	29	0.1	13	1.94	0.1	21	20	5.36	0.1	9	2.93	1467	1
91-82	22 Jrt		0.01	1	3.3	1	2	26	0.3	9	3.41	0.1	14	14	3.59	0.06	4	1.49	740	1
91-82	24 Jrt		0.01	1.2	2.91	1	2	65	0.1	14	1.86	0.1	20	20	5.1	0.11	10	2.53	1603	1
91-82	26 Jrt		0.01	1.3	3.11	1	2	73	0.1	15	1.8	0.1	21	23	5.21	0.08	13	2.89	1837	1
91-82	28 Jrt		0.01	1.1	2.82	1	3	65	0.1	13	2.41	0.1	21	19	5.35	0.26	12	2.49	1373	1
91-82	30 Jrt		0.01	1	3.81	1	3	74	0.1	13	2.28	0.1	23	24	5.65	0.34	7	1.99	960	1
91-82	32 Jrt		0.01	0.9	3.01	1	3	82	0.1	13	1.82	0.1	20	19	4.96	0.12	12	2.42	1327	1
91-82	34 Jrt		0.01	1.3	3.03	1	3	118	0.1	15	1.79	0.1	21	22	5.18	0.09	12	2.6	1663	1
91-82	36 Jrt		0.01	1.3	3.07	1	2	120	0.1	15	1.81	0.1	21	21	5.18	0.09	9	2.3	1561	1
91-82	38 Jrt		0.01	1.1	3.09	1	2	127	0.1	15	1.76	0.1	21	21	5.16	0.08	11	2.39	1588	1
91-82	40 Jrt		0.01	1.2	3.75	1	3	97	0.2	12	1.64	0.1	18	18	4.84	0.39	8	1.93	1023	1
91-82	42 Jrt		0.02	1.2	3.75	1	3	142	0.2	13	2.96	0.1	18	14	4.68	0.21	13	2.15	1219	1
91-82	44 Jrt		0.02	1.3	2.94	1	1	197	0.4	9	2.23	0.1	13	13	3.92	0.08	8	1.74	855	1
91-82	46 Jrt		0.02	1.2	3.75	1	4	265	0.2	12	2.27	0.1	18	24	4.75	0.54	13	2.28	999	1
91-82	48 Jrt		0.01	1.3	4.37	1	4	322	0.1	14	2.24	0.1	23	32	5.2	0.54	10	2.21	1093	1
91-82	50 Jrt		0.01	1.4	4.31	1	4	439	0.1	14	3.87	0.1	21	30	4.62	0.4	9	2.21	957	1
91-82	52 Jrt		0.01	1	5.02	1	3	291	0.7	9	3.64	0.1	15	11	3.61	0.46	5	1.36	454	1
91-82	54 Jrt		0.01	1.7	3.99	20	15	198	0.7	12	4.33	0.1	15	16	3.73	0.33	13	1.31	900	1
91-82	56 Jrt		0.01	1.3	3.99	1	11	207	0.6	12	3.43	0.1	16	21	3.87	0.32	12	1.64	802	1
91-82	58 Jrt		0.01	1.4	4.09	1	9	368	0.3	14	2.45	0.1	18	21	4.83	0.53	9	1.65	977	1
91-82	60 Jrt		0.01	1.3	3.9	1	7	108	0.3	11	4.16	0.1	19	29	4.7	0.28	10	1.56	632	1
91-82	62 Jrt		0.01	1.5	4.48	1	7	291	0.1	14	4.28	0.1	23	29	5.36	0.47	13	1.87	1042	1
91-82	64 Jrt		0.01	1.4	4.65	1	9	351	0.1	16	4.39	0.1	23	36	5.48	0.91	10	1.54	1025	1
91-82	66 Jrt		0.01	1.3	3.29	1	7	353	0.1	15	1.77	0.1	22	26	5.38	0.56	15	2.52	1194	1
91-82	68 Jrt		0.01	1.3	3.14	1	6	291	0.3	13	3.26	0.1	17	18	4.24	0.5	11	1.95	1121	1
91-82	70 Jrt		0.01	1.2	3.29	1	6	367	0.3	12	2.07	0.1	19	25	4.98	0.58	11	2	1203	1
91-82	72 Jrt		0.01	1.2	3.22	1	5	235	0.3	11	1.91	0.1	17	22	4.29	0.32	12	2.18	1130	1
91-82	74 Jrt		0.01	1.2	3	1	5	356	0.3	10	2.51	0.1	16	19	3.61	0.56	12	2.14	1341	1
91-82	76 Jrt		0.01	1.2	3.85	1	4	237	0.4	10	2.5	0.1	11	14	2.89	0.29	9	1.45	752	1
91-82	78 Jrt		0.01	1.1	3.2	1	16	138	0.2	11	2.95	0.1	16	12	4.23	0.26	10	1.83	1145	1
91-82	80 Jrt		0.01	1.3	3.13	1	5	270	0.2	12	1.99	0.1	16	15	4.27	0.35	11	1.79	1041	1
91-82	82 Jrt		0.01	1.1	2.67	1	4	257	0.2	12	1.28	0.1	17	13	4.68	0.3	16	2.63	1215	1
91-82	84 Jrt		0.01	1.1	2.28	14	3	313	0.2	11	2.11	0.1	17	17	4.04	0.38	11	1.87	1314	1
91-82	86 Jrt		0.01	1	2.81	1	3	801	0.5	8	1.66	0.1	13	7	3.07	0.3	9	1.7	936	1
91-82	88 Jrt		0.01	1.3	3.45	1	5	944	0.1	13	2.1	0.1	21	20	5.11	0.65	10	1.93	1184	1
91-82	90 Jrt		0.01	1.4	3.61	1	7	422	0.1	15	3.87	0.1	23	28	5.81	0.67	13	1.69	826	1

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-82	92 Jrt		0.01	1.4	3.38	1	6	378	0.1	16	2.43	0.1	22	22	5.47	0.67	9	1.62	841	1
91-82	94 Jrt		0.02	1.3	3.47	1	6	614	0.1	15	1.71	0.1	21	45	5.13	0.72	10	2.05	904	1
91-82	96 Jrt		0.01	1.4	4.22	1	6	469	0.1	13	4.42	0.1	20	18	4.69	0.65	9	1.48	914	1
91-82	98 Jrt		0.01	1.5	4.8	1	5	523	0.1	13	5.8	0.1	20	16	4.45	0.39	6	1.18	1019	1
91-82	100 Jrt		0.01	1	4.4	1	6	517	0.2	14	3.34	0.1	23	28	5.12	0.7	9	2	1178	1
91-82	102 Jrt		0.01	0.8	3.79	14	7	462	0.3	14	4.37	0.1	23	25	4.82	0.38	12	1.71	1541	1
91-82	104 Jrt		0.01	0.6	3.79	1	6	197	0.4	12	2.02	0.1	23	31	4.78	0.3	18	2.61	1151	1
91-82	106 Jrt		0.01	0.8	4.33	1	3	615	0.6	8	4.35	0.1	14	9	2.96	0.31	8	2.01	1069	1
91-82	108 Jrt		0.01	1	4.38	1	1	380	0.7	8	5.44	0.1	11	10	2.49	0.16	11	2.11	1020	1
91-82	110 Jrt		0.02	0.9	4.53	1	3	463	0.7	12	4.67	0.1	16	31	3.59	0.25	10	2.11	1207	1
91-82	112 Jrt		0.02	0.8	4.81	1	3	300	0.5	13	2.01	0.1	21	41	4.99	0.17	19	3.09	928	1
91-82	114 Jrt		0.01	0.9	3.42	1	1	136	0.5	13	3.41	0.1	19	19	4.89	0.14	15	2.21	607	1
91-82	116 Jrt		0.01	0.6	3.46	1	1	148	0.6	8	1.86	0.1	18	32	4.59	0.16	15	2.6	930	1
91-82	118 Jrt		0.01	1	4.56	1	1	123	0.5	13	2.37	0.1	20	12	5.29	0.31	15	2.45	671	1
91-82	120 Jrt		0.01	0.8	4.89	1	1	210	0.7	9	2.61	0.1	15	27	3.78	0.29	8	2.13	730	1
91-82	122 Jrt		0.01	0.7	4.9	1	1	194	0.8	8	2.78	0.1	16	20	3.93	0.4	10	2.39	912	1
91-82	124 Jrt		0.01	1	5.08	1	2	107	0.2	13	2.58	0.1	22	35	5.4	0.4	14	2.71	1039	1
91-82	126 Jrt		0.01	0.8	4.06	1	1	91	0.2	11	4.53	0.1	22	29	5.45	0.36	10	2.07	1115	1
91-82	128 Jrt		0.01	0.5	3.9	1	1	223	0.5	8	1.55	0.1	21	18	4.83	0.27	9	2.12	759	1
91-82	130 Jrt		0.01	0.5	3.54	1	1	289	0.6	7	2.26	0.1	18	13	4.28	0.19	14	2.55	1099	1
91-82	132 Jrt		0.01	0.5	4.3	1	1	439	0.6	10	2.15	0.1	24	20	5.98	0.16	24	3.98	1532	1
91-82	134 Jrt		0.01	0.6	4.27	1	1	100	0.6	9	3.93	0.1	21	17	5.4	0.19	18	3.23	1372	1
91-82	136 Jrt		0.01	0.4	4.87	1	1	325	0.9	7	2	0.1	20	14	4.94	0.21	21	3.5	970	1
91-82	138 Jrt		0.01	0.4	5.74	1	1	156	1	6	2.08	0.1	19	25	4.9	0.31	18	3.24	872	1
91-82	140 Jrt		0.01	0.5	5.43	1	1	178	0.6	7	4.7	0.1	21	43	4.66	0.32	13	2.52	1253	1
91-82	142 Jrt		0.02	0.4	4.77	1	2	316	0.7	6	5.39	0.1	19	48	4.76	0.41	2	1.2	1409	1
91-82	144 SG		0.22	0.1	0.62	44	23	1804	0.2	1	0.96	0.1	18	71	15	0.21	4	0.1	214	22
91-82	146 SG		0.26	0.2	1.29	14	8	248	1	1	0.66	0.1	9	51	6.18	0.2	3	0.22	59	19
91-82	148 SG		0.28	0.9	1.09	4	4	240	0.7	1	0.36	0.1	4	69	2.89	0.23	2	0.08	25	23
91-82	150 SG		0.31	0.9	1.27	1	3	299	0.5	1	0.27	0.1	3	74	3.06	0.35	2	0.08	7	17
91-82	152 SG		0.11	1	1.4	1	3	518	0.4	1	0.43	0.1	3	76	3.51	0.4	1	0.09	7	35
91-82	154 SG		0.09	0.8	1.37	1	3	342	0.5	1	0.71	0.1	4	56	4.41	0.38	1	0.07	1	45
91-82	156 SG		0.2	1.4	1.8	1	2	484	0.5	2	0.82	0.1	3	47	2.57	0.47	3	0.09	2	13
91-82	158 SG		0.13	1.2	1.56	1	2	206	0.5	1	0.7	0.1	3	66	3.04	0.38	2	0.07	1	16
91-82	160 SG		0.63	2	1.06	12	3	258	0.5	1	0.43	0.1	10	2498	3.95	0.28	1	0.05	1	111
91-82	162 HG		0.18	1	1.47	3	2	215	0.8	1	0.42	0.1	16	605	3.82	0.42	1	0.39	11	40
91-82	164 HG		0.21	1.2	2.09	1	2	238	0.9	1	0.57	0.1	17	845	4.45	0.45	1	0.78	53	46
91-82	166 HG		0.13	1.5	2.27	14	2	313	1.2	1	0.68	0.1	17	661	3.62	0.45	1	0.93	65	33

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-82	168 HG		0.08	1.1	2.3	1	8	192	1.1	1	0.95	0.1	17	394	4.24	0.43	2	1.11	120	391
91-82	170 HG		0.17	1.1	2.4	1	4	323	1.2	1	1.38	0.1	16	660	3.93	0.46	2	1.09	318	137
91-82	172 HG		0.16	1.1	1.88	3	1	213	1.1	1	1.04	0.1	15	469	4.06	0.37	1	0.85	186	44
91-82	174 HG		0.16	1.1	1.72	9	2	174	0.7	1	0.92	0.1	14	488	3.63	0.3	2	0.93	129	63
91-82	176		0.11	0.9	3.21	1	3	49	1	1	4.13	0.1	23	533	5.61	0.51	6	1.73	688	44
91-82	178 FRb		0.1	0.5	3.8	1	4	25	0.8	1	3.49	0.1	31	362	7	0.4	10	2.65	682	10
91-82	180 FRb		0.08	0.4	3.74	1	3	15	0.7	1	3.66	0.1	29	190	7.11	0.38	10	2.23	622	4
91-82	182 FRb		0.1	1	4.25	1	4	22	0.7	1	3.88	0.1	26	400	6.22	0.51	11	2.43	650	36
91-82	184 FRb		0.09	1.1	3.34	1	3	70	0.6	1	4.11	0.1	23	374	5.22	0.42	10	2.3	655	20
91-82	186 FRb		0.09	1	3.84	1	3	161	0.4	4	2.13	0.1	26	292	6.4	0.28	12	2.72	472	1
91-82	188 FRb		0.1	1.1	4.3	1	2	120	0.3	4	3.26	0.1	28	394	6.48	0.21	12	2.51	370	9
91-82	190 FRb		0.12	1.3	3.13	1	3	79	0.4	3	3.78	0.1	25	642	5.91	0.37	11	2.63	458	22
91-82	192 FRb		0.08	1.6	3.43	13	14	41	0.3	10	4.2	0.1	29	501	6.1	0.21	20	3.73	803	1
91-82	194 FRb		0.06	1.1	2.92	1	7	29	0.3	6	4.21	0.1	26	514	5.31	0.18	12	2.96	603	69
91-82	196 FRb		0.03	0.8	3.43	1	4	25	0.3	4	4.22	0.1	21	252	4.9	0.25	10	2.64	609	1
91-82	198 FRb		0.07	0.3	3	1	3	25	0.4	2	4.72	0.1	26	330	6	0.22	7	2.18	722	2
91-93	6.1 SG		0.38	1	0.9	116	15	752	0.8	4	0.56	0.1	7	87	2.61	0.25	7	0.14	62	17
91-93	8 SG		0.14	0.8	1.71	38	10	397	0.7	4	0.41	0.1	4	121	2.58	0.29	5	0.08	20	15
91-93	10 SG		0.17	0.8	1.47	12	7	435	0.6	3	0.53	0.1	4	99	3.06	0.29	4	0.12	41	20
91-93	12 SG		0.04	0.6	1.76	2	6	230	0.5	2	0.35	0.1	3	95	2.83	0.34	3	0.08	15	12
91-93	14 SG		0.04	0.7	1.6	2	5	219	0.5	2	0.34	0.1	3	90	2.53	0.32	3	0.08	13	10
91-93	16 SG		0.16	0.2	1.64	1	7	258	0.6	1	0.38	0.1	5	118	5.13	0.46	2	0.09	5	20
91-93	18 SG		0.16	0.5	1.27	1	5	185	0.4	2	0.33	0.1	4	83	3.18	0.3	2	0.06	9	10
91-93	20 SG		0.29	0.5	1.1	1	4	260	0.3	2	0.26	0.1	3	97	2.99	0.37	1	0.06	3	9
91-93	22 SG		0.3	0.5	0.64	1	3	117	0.3	1	0.18	0.1	3	96	2.61	0.21	1	0.04	1	11
91-93	24 SG		0.22	0.5	1.26	1	4	381	0.4	2	0.21	0.1	3	81	2.72	0.33	2	0.06	2	12
91-93	26 SG		0.31	0.4	0.66	1	3	135	0.2	2	0.23	0.1	4	69	2.93	0.14	1	0.02	1	16
91-93	28 SG		0.2	0.5	1.13	1	3	250	0.4	1	0.24	0.1	3	80	2.6	0.31	1	0.05	2	15
91-93	30 SG		0.18	0.7	0.91	2	3	345	0.4	1	0.25	0.1	3	69	2.5	0.22	1	0.04	1	11
91-93	32 SG		0.22	0.6	1.36	1	4	305	0.5	2	0.24	0.1	4	114	3.03	0.35	2	0.06	1	19
91-93	34 SG		0.19	0.4	0.88	1	3	400	0.4	2	0.25	0.1	4	75	3.36	0.22	1	0.04	1	15
91-93	36 SG		0.3	0.7	1.36	1	4	339	0.4	2	0.19	0.1	3	106	2.97	0.36	2	0.06	1	34
91-93	38 SG		0.28	0.8	1.11	6	3	195	0.5	1	0.18	0.1	3	109	2.69	0.26	2	0.05	1	31
91-93	40 SG		0.23	1.1	1.23	3	3	432	0.3	2	0.2	0.1	2	91	2.2	0.28	2	0.05	1	26
91-93	42 SG		0.37	0.9	0.91	6	3	637	0.4	2	0.18	0.1	2	181	2.37	0.22	2	0.04	1	32
91-93	44 SG		0.36	0.9	1.1	3	3	204	0.4	2	0.16	0.1	2	115	2.53	0.26	2	0.04	1	46
91-93	46 SG		0.24	1.3	1.09	4	2	192	0.4	2	0.1	0.1	3	1334	1.89	0.2	2	0.03	2	27
91-93	48 SG		0.32	0.2	1.82	1	5	348	0.8	1	0.23	0.1	17	1068	5.04	0.36	4	0.18	24	62

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Au ppm	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Bi ppm	Ca Wt %	Cd ppm	Co ppm	Cu ppm	Fe Wt %	K Wt %	Li ppm	Mg Wt %	Mn Wt %	Mo ppm
91-93	50 SG		0.22	1.2	1.31	1	3	296	0.7	1	0.25	0.1	10	3673	2.7	0.32	3	0.08	4	37
91-93	52 SG		0.3	1.9	1.72	3	4	173	0.6	1	0.1	0.1	6	2560	1.79	0.31	3	0.05	1	131
91-93	54 SG		0.31	0.4	1.56	118	3	183	0.7	1	0.44	0.1	18	1794	4.38	0.31	3	0.17	56	37
91-93	56 SG		0.31	1.2	1.94	37	3	281	1	1	0.52	0.1	14	2155	3.91	0.46	4	0.22	49	50
91-93	58 SG		0.24	0.8	1.99	19	2	321	1.3	1	0.74	0.1	15	1287	3.71	0.56	3	0.38	64	24
91-93	60 HG		0.21	1	2.77	20	3	254	1.1	1	0.97	0.1	17	545	3.55	0.61	6	1	217	47
91-93	62 HG		0.23	1	2.67	12	2	262	1	1	0.79	0.1	15	546	3.1	0.62	6	1.05	145	12
91-93	64 HG		0.28	0.9	2.43	9	3	413	1	2	0.79	0.1	17	673	3.58	0.64	5	0.71	139	23
91-93	66 HG		0.34	0.8	2.37	3	2	352	0.9	1	1.1	0.1	17	615	3.95	0.56	4	0.98	219	59
91-93	68 HG		0.23	0.8	2.04	11	2	261	1	1	0.98	0.1	18	558	4.24	0.55	4	0.79	178	20
91-93	70 HG		0.27	1	2.2	7	1	436	1	1	1.01	0.1	16	521	3.06	0.44	5	0.89	223	32
91-93	72 HG		0.28	1	2.68	1	1	540	1.2	2	1.04	0.1	15	747	3.19	0.52	5	1.04	281	18
91-93	74 HG		0.24	0.8	2.04	1	1	326	0.9	1	1.1	0.1	14	683	3.81	0.46	4	0.86	242	45
91-93	76 HG		0.34	0.8	2.18	8	1	287	0.8	1	1.01	0.1	15	701	3.85	0.49	4	0.96	225	57
91-93	78 HG		0.28	0.9	2.11	1	1	317	0.9	1	1.05	0.1	14	631	3.35	0.41	4	1.04	281	32
91-93	80 HG		0.21	1.1	1.84	42	1	326	0.8	1	0.73	0.1	12	810	3.1	0.5	3	0.68	110	31
91-93	82 HG		0.2	0.6	2.15	1	1	279	0.8	1	1.19	0.1	15	435	3.86	0.44	3	0.85	272	63
91-93	84 HG		0.18	0.6	2.51	1	2	317	0.9	1	1.41	0.1	19	487	4.44	0.47	4	0.96	393	28
91-93	86 HG		0.16	0.6	2.2	6	1	231	1.1	1	0.99	0.1	15	440	3.84	0.42	5	0.91	228	25
91-93	88 HG		0.14	0.6	2.56	7	1	350	1	1	0.83	0.1	15	339	3.97	0.49	6	0.91	221	15
91-93	90 HG		0.22	0.7	1.87	8	1	309	0.8	1	0.88	0.1	17	508	3.96	0.46	4	0.63	187	27
91-93	92 HG		0.13	0.4	2.31	1	1	273	1	1	0.78	0.1	18	308	4.6	0.4	5	0.69	195	10
91-93	94 HG		0.13	0.5	2.31	2	1	285	1.1	1	0.71	0.1	18	272	4.07	0.37	6	0.81	212	13
91-93	96 HG		0.11	0.7	1.77	3	1	316	0.8	1	0.61	0.1	15	356	3.64	0.4	4	0.41	127	24
91-93	98 HG		0.15	0.2	2.14	26	4	206	0.7	1	0.97	0.1	42	427	7.24	0.37	5	0.24	523	91
91-93	100 HG		0.11	0.3	1.93	24	2	216	0.7	1	0.99	0.1	34	330	5.2	0.33	6	0.18	456	42
91-93	102 HG		0.03	0.5	0.75	112	19	103	0.9	1	0.53	0.2	18	303	4.82	0.21	12	0.07	42	20
91-93	104 HG		0.02	0.3	2.13	41	11	29	0.6	1	0.94	0.1	34	207	6.33	0.23	10	1.27	1065	1
91-93	106 HG		0.02	0.5	2.7	7	7	15	0.5	1	4.73	0.1	28	272	5.54	0.29	9	1.87	1140	1
91-93	108 HG		0.01	0.2	3.42	1	7	9	0.5	1	4.56	0.1	28	175	6.02	0.2	18	2.54	1270	1
91-93	110 HG		0.03	0.2	2.85	1	6	9	0.5	1	4.55	0.1	26	135	6.16	0.21	14	2	1281	1
91-93	112 HG		0.02	0.6	3.67	1	6	11	0.4	3	4.12	0.1	23	190	5.5	0.21	16	2.57	1217	1
91-93	114 HG		0.04	0.8	3.69	1	6	16	0.3	3	3.89	0.1	19	195	5.08	0.17	18	2.38	1002	1
91-93	116 HG		0.03	0.9	4.1	1	7	78	0.1	6	4.38	0.1	26	206	6.15	0.17	19	3.05	1225	1

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-72	12.19 JRI		0.23	1	890	21	1	105	1	0.32	195.8	70	1	1	3	4	25
91-72	14 JRI		0.14	1	580	18	1	160	1	0.23	134.9	62	2	1	1	3	18
91-72	16 JRI		0.13	1	910	21	1	103	1	0.21	134.6	63	3	1	1	3	23
91-72	18 JRI		0.18	1	920	20	1	109	1	0.21	119.8	60	2	1	2	2	8
91-72	20 JRI		0.11	1	1100	22	3	104	1	0.1	75.1	61	4	1	2	17	2
91-72	22 JRI		0.21	1	870	22	1	110	1	0.17	126.1	63	3	1	2	11	4
91-72	24 JRI		0.18	1	790	20	3	100	1	0.12	102.1	54	4	1	2	20	3
91-72	26 JRI		0.16	1	980	22	2	150	1	0.13	115.8	60	4	1	2	18	1
91-72	28 JRI		0.14	1	760	24	3	96	1	0.14	150.3	61	3	1	2	13	2
91-72	30 JRI		0.15	1	700	25	5	88	1	0.15	176.2	60	2	1	3	21	4
91-72	32 JRI		0.1	1	890	26	4	76	1	0.12	148.9	57	4	1	2	20	3
91-72	34 JRI		0.11	1	480	26	5	107	1	0.08	96.4	50	6	1	2	15	2
91-72	36 JRI		0.11	1	430	24	6	114	1	0.08	100.8	49	6	1	2	16	2
91-72	38 JRI		0.07	1	430	20	2	71	1	0.04	50.2	31	7	1	2	15	2
91-72	40 JRI		0.16	1	500	31	8	249	1	0.03	63.6	49	7	1	1	9	4
91-72	42 JRI		0.14	1	720	29	9	216	1	0.06	101.3	54	7	1	2	10	1
91-72	44 JRI		0.11	1	510	26	8	119	1	0.07	111.2	57	6	1	2	9	2
91-72	46 JRI		0.11	1	410	27	9	118	1	0.07	139.3	63	6	1	2	12	2
91-72	48 JRI		0.1	1	420	25	9	96	1	0.06	128.7	64	6	1	2	10	1
91-72	50 JRI		0.09	1	480	29	9	87	1	0.06	133.2	75	4	1	2	9	2
91-72	52 JRI		0.07	1	480	21	1	72	1	0.05	111.4	62	1	1	3	32	1
91-72	53.5 JRI		0.06	1	470	24	2	71	1	0.05	114.3	55	1	1	2	10	16
91-72	55 SG		0.02	1	860	24	13	50	1	0.02	70.6	9	1	1	3	56	2
91-72	57 SG		0.02	1	860	22	20	28	1	0.02	61.3	11	1	1	3	62	1
91-72	59 SG		0.01	1	560	15	24	11	1	0.01	63.6	11	1	1	4	88	1
91-72	61 SG		0.01	1	880	27	42	10	1	0.02	84.7	9	1	1	3	66	1
91-72	63 SG		0.01	1	940	32	38	11	1	0.02	101.8	11	1	1	4	78	1
91-72	65 SG		0.01	1	1000	25	36	11	1	0.02	86.5	13	1	1	3	61	1
91-72	67 SG		0.01	1	690	18	43	12	1	0.01	70	13	1	1	5	125	1
91-72	69 SG		0.01	1	900	17	24	9	1	0.02	63.8	13	1	1	3	77	1
91-72	71 SG		0.01	1	660	20	21	10	1	0.02	69.9	13	1	1	5	105	1
91-72	73 SG		0.01	1	340	24	24	11	1	0.03	98.6	10	1	1	5	105	1
91-72	75 SG		0.03	1	360	22	23	16	1	0.02	73.6	13	1	6	5	105	1
91-72	77 SG		0.01	1	600	16	11	28	1	0.02	69.3	8	1	1	5	93	1
91-72	79 SG		0.01	1	630	16	13	52	1	0.02	55.9	11	1	1	4	89	1
91-72	81 SG		0.01	1	320	13	29	45	1	0.01	49.2	7	1	1	4	88	1
91-72	83 SG		0.01	1	240	11	15	26	1	0.02	39.4	9	1	1	5	115	1
91-72	85 SG		0.01	1	290	14	25	17	1	0.02	36.9	11	1	1	5	106	1

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-72	87	SG	0.01	0.01	1	560	22	24	23	1	0.03	59.2	14	1	1	5	114
91-72	89	SG	0.01	0.01	1	460	30	19	20	1	0.01	46.7	66	1	1	4	45
91-72	91	SG	0.02	0.02	1	870	21	11	17	1	0.01	30.6	41	1	1	4	40
91-72	93	SG	0.03	0.03	1	1240	46	34	38	1	0.03	48.1	297	2	1	3	34
91-72	95	HG	0.03	0.03	1	1090	25	10	35	1	0.02	40.2	245	2	1	2	33
91-72	97	HG	0.03	0.03	1	1120	23	12	31	1	0.02	44.3	139	3	1	3	45
91-72	99	HG	0.02	0.02	1	1030	27	18	22	1	0.01	17.2	87	1	2	3	59
91-72	101	HG	0.02	0.02	1	1090	20	8	27	1	0.01	27.4	80	1	1	3	45
91-72	103	HG	0.03	0.03	1	1130	22	7	30	1	0.01	24.2	56	1	2	4	81
91-72	105	HG	0.03	0.03	1	1000	27	37	29	1	0.01	29.3	119	2	1	3	55
91-72	107	HG	0.03	0.03	1	1010	29	24	29	1	0.01	24.2	77	2	1	3	59
91-72	109	HG	0.03	0.03	1	910	22	1	30	1	0.01	34.4	55	2	1	3	59
91-72	111	HG	0.04	0.04	1	960	20	1	32	1	0.03	45.2	37	3	1	3	41
91-72	113	HG	0.04	0.04	1	920	22	2	27	1	0.02	32.7	28	3	1	3	51
91-72	115	HG	0.03	0.03	1	940	59	8	29	1	0.01	25.4	81	1	1	3	72
91-72	117	HG	0.04	0.04	1	960	86	17	31	1	0.05	51.5	139	3	1	3	52
91-72	119	HG	0.04	0.04	1	780	21	5	24	1	0.02	35.4	25	3	1	4	79
91-72	121	HG	0.04	0.04	1	890	21	3	28	1	0.02	37.1	32	3	1	3	59
91-72	123	HG	0.05	0.05	1	970	21	9	32	1	0.05	54.9	32	3	1	3	50
91-72	125	HG	0.04	0.04	1	1140	29	14	30	1	0.02	38.1	33	3	1	4	76
91-72	127	HG	0.05	0.05	1	1060	21	4	31	1	0.03	47.2	32	3	2	3	51
91-72	129	HG	0.05	0.05	1	880	22	2	24	1	0.02	37.3	25	3	1	3	46
91-72	131	HG	0.04	0.04	1	880	21	2	22	1	0.02	33.5	23	3	1	4	67
91-72	133	HG	0.05	0.05	1	950	22	3	26	1	0.02	38.8	29	3	1	3	60
91-72	135	HG	0.05	0.05	1	910	20	1	27	1	0.04	49.1	31	3	1	3	58
91-72	137	HG	0.05	0.05	1	910	19	4	32	1	0.03	40	28	2	1	4	75
91-72	139	HG	0.04	0.04	1	830	21	2	23	1	0.02	30.1	31	1	1	2	41
91-72	141	HG	0.05	0.05	1	890	19	1	25	1	0.03	40.5	29	2	1	3	68
91-72	143	HG	0.05	0.05	1	890	18	4	32	1	0.03	42.7	29	3	1	3	48
91-72	145	HG	0.04	0.04	1	990	22	6	33	1	0.02	35.2	26	2	1	3	50
91-72	147	HG	0.06	0.06	1	1000	24	5	30	1	0.02	47.4	31	3	2	4	55
91-72	149	HG	0.05	0.05	1	990	27	10	35	1	0.02	43.4	31	5	2	3	45
91-72	151	HG	0.05	0.05	1	1020	21	2	32	1	0.01	33.6	28	2	1	3	60
91-72	153	HG	0.05	0.05	1	930	19	2	26	1	0.01	36.6	25	4	1	4	72
91-72	155	HG	0.04	0.04	1	950	20	32	28	1	0.01	18.5	33	2	1	2	42
91-72	157	HG	0.04	0.04	1	1140	18	7	20	1	0.01	22.6	19	2	1	5	95
91-72	159	HG	0.04	0.04	1	890	22	9	17	1	0.01	24.9	25	4	1	4	66
91-72	161	HG	0.06	0.06	1	1040	25	6	34	1	0.02	45.7	31	5	2	5	94

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Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-72	163 HG		0.05	1	1020	21	5	26	1	0.01	32.9	27		4	2	4	74
91-72	165 HG		0.05	1	970	31	40	32	1	0.01	35.9	56		5	2	4	73
91-72	167 HG		0.05	1	970	23	7	32	1	0.02	35.3	26		4	1	3	52
91-72	169 HG		0.07	1	1050	25	8	40	1	0.02	49.9	30		5	2	6	103
91-72	171 HG		0.05	1	990	27	6	37	1	0.02	38.4	38		5	2	3	45
91-72	173 HG		0.05	1	1050	21	7	28	1	0.01	34.4	42		5	2	3	59
91-72	175 HG		0.04	1	800	20	3	21	1	0.01	28	29		5	1	3	54
91-72	177 HG		0.04	1	1000	150	25	24	2	0.01	35.3	882		1	2	3	126
91-72	179 HG		0.05	1	1020	22	4	37	1	0.03	51.2	29		5	2	4	72
91-72	181 HG		0.06	1	1070	63	14	35	1	0.03	52.1	196		5	2	5	79
91-72	183 HG		0.06	1	1060	26	6	38	1	0.04	65.3	33		6	2	6	112
91-72	185 HG		0.06	1	1020	76	21	28	1	0.02	53	413		5	2	7	131
91-72	187 HG		0.06	1	1150	34	29	35	1	0.02	48.6	623		5	2	6	133
91-72	189 HG		0.05	1	970	28	2	30	1	0.01	32.2	62		4	1	4	90
91-73	4.8 JRI		0.03	1	720	21	3	70	1	0.12	129	58		1	3	3	13
91-73	7 JRI		0.03	1	420	24	3	116	1	0.08	101.7	58		3	3	3	12
91-73	9 JRI		0.03	1	1170	21	4	107	1	0.11	112.4	59		2	3	2	12
91-73	11 JRI		0.05	1	700	25	7	108	1	0.11	96.6	55		6	3	2	13
91-73	13 JRI		0.1	1	650	23	9	159	1	0.11	135.4	60		5	3	3	15
91-73	15.9 JRI		0.14	1	1430	27	8	112	1	0.16	156.5	67		3	4	3	12
91-73	24 JRI		0.14	1	2050	28	8	120	1	0.12	85.7	48		6	3	3	15
91-73	26 JRI		0.1	1	1490	25	8	152	1	0.1	161.4	51		6	3	3	14
91-73	28 JRI		0.1	1	620	22	8	99	2	0.04	109.7	58		6	2	3	15
91-73	30 JRI		0.07	1	710	27	10	78	1	0.06	120	57		6	3	3	12
91-73	32 JRI		0.06	1	490	23	3	70	1	0.04	113.9	62		5	2	2	9
91-73	34 JRI		0.05	1	690	21	4	108	1	0.08	132.4	74		4	1	2	14
91-73	36 JRI		0.06	1	910	25	1	80	1	0.08	128.5	90		1	1	2	9
91-73	38 JRI		0.06	1	630	27	1	82	1	0.05	105.2	84		1	1	1	6
91-73	40 JRI		0.05	1	440	35	2	57	1	0.05	97	105		1	1	1	6
91-73	42 JRI		0.05	1	490	39	3	63	1	0.05	106	110		1	1	1	7
91-73	44 SG		0.01	1	380	33	5	15	1	0.02	34.4	33		1	1	2	44
91-73	46 SG		0.01	1	210	43	6	10	1	0.03	50.6	42		1	1	5	93
91-73	48 SG		0.01	1	610	31	2	11	1	0.02	49.8	34		1	1	3	56
91-73	50 SG		0.01	1	400	34	3	10	1	0.02	40.6	27		1	1	4	65
91-73	52 SG		0.01	1	200	30	1	7	1	0.02	32.4	20		1	1	4	71
91-73	54 SG		0.01	1	200	26	1	8	1	0.03	44.9	24		1	1	3	60
91-73	56 SG		0.01	1	330	18	1	7	1	0.02	22.3	22		1	1	3	60
91-73	58 SG		0.01	1	160	36	1	8	1	0.02	39.6	23		1	1	7	160

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Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-73	60 SG		0.01	1	170	14	1	10	1	0.02	46.1	18	1	1	1	3	71
91-73	62 SG		0.01	1	170	18	1	11	1	0.02	50.9	19	1	1	1	6	129
91-73	64 SG		0.01	1	130	14	1	9	1	0.02	40.7	21	1	1	1	7	160
91-73	66 SG		0.01	1	100	17	1	11	1	0.02	45.7	25	1	1	1	6	154
91-73	68 SG		0.01	1	140	17	4	14	1	0.02	42.7	23	1	1	1	5	115
91-73	70 SG		0.01	1	250	18	2	15	1	0.02	34.7	30	1	1	1	4	86
91-73	72 SG		0.01	1	210	17	1	18	1	0.02	37.6	25	1	1	1	8	187
91-73	74 SG		0.01	1	310	25	7	20	1	0.02	32	54	1	1	1	7	126
91-73	76 SG		0.01	1	450	24	18	6	1	0.01	33.2	300	1	1	1	10	253
91-73	78 SG		0.01	1	530	31	3	12	1	0.01	34.3	210	1	1	1	7	173
91-73	80 SG		0.01	1	580	43	27	13	1	0.01	27.1	185	1	1	1	7	185
91-73	82 SG		0.01	1	310	22	23	8	1	0.01	17	105	1	1	1	14	340
91-73	84 SG		0.01	1	620	25	1	18	1	0.01	29.4	126	1	1	1	5	110
91-73	86 SG		0.01	1	590	24	3	18	1	0.01	37.1	112	1	1	1	5	112
91-73	88 SG		0.01	1	460	23	1	16	1	0.01	31.4	73	1	1	1	5	107
91-73	90 SG		0.01	1	640	40	30	20	1	0.01	30.9	253	1	1	1	4	96
91-73	92 SG		0.01	1	400	37	42	20	1	0.01	13.9	216	1	1	1	4	111
91-73	94 SG		0.02	1	670	24	36	38	1	0.03	30.5	113	1	1	1	5	103
91-73	96 SG		0.01	1	770	34	42	22	1	0.01	17.9	76	1	1	1	4	90
91-73	98 SG		0.02	1	1070	41	33	26	1	0.02	41.4	95	1	1	1	4	83
91-73	100 SG		0.01	1	970	24	9	21	1	0.02	39.1	51	1	1	1	4	73
91-73	102 SG		0.02	1	900	30	55	23	1	0.01	26.7	55	1	1	1	5	116
91-73	104 SG		0.02	1	900	25	4	36	1	0.03	41.1	44	1	1	1	3	44
91-73	106 SG		0.02	1	820	25	16	31	1	0.03	46.8	41	1	1	1	5	111
91-73	108 HG		0.03	1	1030	27	26	35	1	0.04	42	43	1	2	3	59	
91-73	110 HG		0.03	1	1000	28	8	37	1	0.05	50.4	34	2	2	4	73	
91-73	112 HG		0.04	1	970	23	2	37	1	0.1	68.8	34	3	2	3	46	
91-73	114 HG		0.06	1	960	30	19	32	1	0.08	61.8	37	3	2	5	61	
91-73	116 HG		0.06	1	970	25	6	35	1	0.09	63.7	42	3	2	3	45	
91-73	118 HG		0.05	1	950	389	38	35	1	0.04	44.7	581	3	1	4	73	
91-73	120 HG		0.06	1	970	42	13	35	1	0.05	50.3	54	2	1	3	46	
91-73	122 HG		0.06	1	810	53	24	34	1	0.04	54.1	94	2	1	4	75	
91-73	124 HG		0.07	1	1030	26	5	38	1	0.06	61.4	40	3	1	3	42	
91-73	126 HG		0.07	1	1000	33	8	36	1	0.02	41.9	34	3	1	4	65	
91-73	202 HG		0.1	1	990	18	2	39	1	0.09	59.5	34	4	2	4	50	
91-74	204 HG		0.12	1	960	14	2	40	1	0.07	54.9	32	3	1	3	46	
91-74	206 HG		0.1	1	960	20	2	42	1	0.05	47.1	34	3	1	3	44	
91-74	208 HG		0.18	1	1050	21	4	45	1	0.07	54.6	28	4	2	4	56	

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Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-74	210 HG		0.3	1	1040	24	5	49	1	0.09	62.6	26	4	4	4	5	61
91-74	212 HG		0.3	1	930	25	8	44	1	0.08	56.1	26	4	4	4	5	59
91-74	214 HG		0.28	1	950	22	5	41	1	0.07	53.7	25	4	3	3	5	72
91-74	216 HG		0.06	1	980	16	1	34	1	0.04	39.5	113	3	1	1	2	31
91-74	218 HG		0.07	1	930	19	1	36	1	0.04	47.6	46	3	1	1	3	31
91-74	220 HG		0.05	1	950	27	1	31	1	0.04	41.3	41	3	1	1	3	26
91-74	222 HG		0.08	1	1040	17	1	32	1	0.04	41.4	31	2	1	1	3	62
91-74	224 HG		0.06	1	840	16	1	35	1	0.05	45.2	26	3	1	1	3	34
91-74	226 HG		0.05	1	960	32	1	30	1	0.05	44.9	234	1	1	1	2	31
91-74	228 HG		0.05	1	880	16	1	31	1	0.05	49.5	30	2	1	1	3	31
91-74	230 HG		0.05	1	1050	19	1	31	1	0.04	40.6	25	2	1	1	4	67
91-74	232 HG		0.06	1	1100	14	1	32	1	0.04	40.2	28	2	1	1	3	48
91-74	234 HG		0.03	1	1500	13	1	27	1	0.04	35.8	73	2	1	2	2	21
91-74	236 HG		0.03	1	1040	18	3	29	1	0.04	37.6	282	2	1	1	2	25
91-74	238 HG		0.06	1	900	15	1	28	1	0.04	45.8	24	3	1	1	4	58
91-74	240 HG		0.03	1	910	15	1	28	1	0.04	51.3	23	3	1	1	2	31
91-74	241.8 FRb		0.08	4	920	12	1	35	1	0.21	194.3	83	1	1	1	5	58
91-78	3.59 Jrt		0.07	1	920	30	6	62	1	0.1	173.7	66	1	3	3	14	1
91-78	5 Jrt		0.09	1	590	35	12	89	1	0.16	166.5	64	1	3	3	13	2
91-78	7 Jrt		0.06	1	840	28	8	79	1	0.15	161.2	65	1	3	2	9	1
91-78	9 Jrt		0.09	1	550	32	14	108	1	0.14	169.6	75	1	3	3	9	1
91-78	11 Jrt		0.11	1	520	33	14	110	1	0.12	132.3	65	1	3	2	8	1
91-78	13 Jrt		0.12	1	660	29	14	102	1	0.11	149.9	68	1	3	2	13	7
91-78	15 Jrt		0.16	1	760	41	21	174	1	0.08	90.1	57	2	4	2	5	2
91-78	17 Jrt		0.17	1	770	41	19	173	1	0.09	123	56	1	3	2	5	2
91-78	19 Jrt		0.17	1	1150	37	17	122	2	0.13	128.9	66	1	3	2	3	2
91-78	21 Jrt		0.14	1	1310	32	16	113	1	0.11	166.8	65	1	3	3	10	1
91-78	23 Jrt		0.11	1	1090	32	14	98	1	0.06	150.8	62	2	2	2	8	9
91-78	25 Jrt		0.1	1	540	35	16	94	1	0.05	128.7	61	1	2	2	2	1
91-78	27 Jrt		0.07	1	370	30	11	82	1	0.07	157.4	64	1	2	2	4	1
91-78	29 Jrt		0.06	1	570	33	11	78	1	0.09	171.1	68	1	2	2	12	1
91-78	31 Jrt		0.06	1	570	35	15	76	1	0.09	168.8	65	1	5	3	19	1
91-78	33 Jrt		0.02	1	510	21	14	55	2	0.01	67.3	11	1	1	5	113	1
91-78	35 SG		0.03	1	520	26	22	28	1	0.01	71.5	14	1	1	1	8	210
91-78	37 SG		0.02	1	600	40	24	26	1	0.01	124.7	14	1	1	1	5	91
91-78	39 SG		0.03	1	1230	35	24	27	1	0.02	119	18	1	1	1	6	120
91-78	41 SG		0.02	1	730	30	32	28	1	0.02	107.2	17	1	1	1	3	60
91-78	43 SG		0.02	1	610	36	28	29	1	0.02	80.7	18	1	1	1	4	100

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-78	45 SG		0.02	1	340	54	39	18	1	0.02	91.8	16	1	1	1	3	61
91-78	47 SG		0.02	1	480	35	34	21	1	0.01	70.8	15	1	1	1	3	57
91-78	49 SG		0.01	1	480	36	38	16	1	0.01	63.1	14	1	1	1	3	82
91-78	51 SG		0.02	1	440	26	19	19	1	0.01	37.1	13	1	1	1	4	90
91-78	53 SG		0.02	1	430	64	22	17	1	0.01	39.1	14	1	1	1	4	93
91-78	55 SG		0.02	1	560	30	19	19	1	0.01	34.5	15	1	1	1	5	129
91-78	57 SG		0.01	1	380	29	18	17	1	0.01	37.2	12	1	1	1	5	117
91-78	59 SG		0.02	1	450	55	17	16	1	0.02	38.9	16	1	1	1	6	145
91-78	61 SG		0.01	1	620	85	42	23	1	0.02	50	17	1	1	1	5	124
91-78	63 SG		0.02	1	610	76	44	14	1	0.02	50.4	19	1	1	1	6	140
91-78	65 SG		0.02	1	890	52	53	25	1	0.01	47.4	24	1	1	1	4	100
91-78	67 SG		0.01	1	450	63	31	13	1	0.02	69.4	24	1	1	1	6	142
91-78	69 SG		0.01	1	520	63	49	27	1	0.02	63.5	40	1	1	1	5	121
91-78	71 SG		0.02	1	610	36	38	32	1	0.01	60.2	56	1	1	1	3	67
91-78	73 SG		0.02	1	590	33	28	31	2	0.01	66.2	42	1	1	1	3	50
91-78	75 SG		0.02	1	180	41	25	28	1	0.01	72.7	28	1	1	1	4	84
91-78	77 SG		0.01	1	90	31	14	12	1	0.02	71.4	24	1	1	1	10	235
91-78	79 SG		0.01	1	90	26	12	14	1	0.02	57.2	27	1	1	1	16	413
91-78	81 SG		0.01	1	140	27	30	18	1	0.02	77	26	1	1	1	6	139
91-78	83 SG		0.01	1	260	24	21	20	1	0.02	59.5	26	1	1	1	8	185
91-78	85 SG		0.01	1	370	40	40	21	1	0.02	49.7	30	1	1	1	13	323
91-78	87 SG		0.01	1	220	25	23	25	1	0.01	42.4	27	1	1	1	13	340
91-78	89 SG		0.01	1	210	28	23	28	1	0.01	52.6	21	1	1	1	7	162
91-78	91 SG		0.01	1	220	27	18	25	1	0.02	76	36	1	1	1	9	218
91-78	93 SG		0.01	1	370	35	19	12	1	0.02	76.8	78	1	1	1	14	325
91-78	95 SG		0.01	1	580	59	305	12	1	0.01	103.5	692	1	1	1	10	208
91-78	97 SG		0.01	1	420	42	100	11	1	0.01	72.9	352	1	1	1	5	133
91-78	99 SG		0.01	1	180	46	46	40	1	0.01	63.3	194	1	1	1	6	131
91-78	101 SG		0.01	1	190	36	28	60	1	0.01	51.5	365	1	1	1	7	184
91-78	103 SG		0.01	1	180	21	8	36	1	0.01	28.2	20	1	1	1	6	147
91-78	105 SG		0.01	1	360	32	11	23	1	0.01	33.5	120	1	1	1	6	110
91-78	107 SG		0.01	1	530	33	13	23	1	0.01	30.5	269	1	1	1	7	174
91-78	109 HG		0.02	1	930	26	2	39	1	0.01	49	248	1	1	1	5	121
91-78	111 HG		0.02	1	910	31	4	38	1	0.01	42.1	187	1	1	1	5	109
91-78	113 HG		0.02	1	1140	29	6	31	1	0.01	28.6	131	1	1	1	3	57
91-78	115 HG		0.03	1	1010	29	9	42	1	0.01	31.7	93	1	1	1	4	85
91-78	117 HG		0.03	1	1030	33	9	40	2	0.01	36.4	152	1	1	1	4	99
91-78	119 HG		0.03	1	930	90	17	38	1	0.01	34.1	113	1	1	1	6	145

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-78	121 HG		0.04	0.04	1090	30	5	48	1	0.03	41.8	97	2	1	1	3	39
91-78	123 HG		0.03	0.03	970	33	11	39	2	0.03	47.4	106	1	2	1	5	101
91-78	125 HG		0.04	0.04	960	33	8	39	1	0.06	55.4	77	1	3	1	4	73
91-78	127 HG		0.04	0.04	890	29	3	40	1	0.06	55.8	52	1	2	2	4	60
91-78	129 HG		0.04	0.04	990	32	5	39	1	0.07	61.9	48	2	2	3	3	33
91-78	131 HG		0.04	0.04	970	32	9	38	1	0.05	55.5	49	3	2	2	4	55
91-78	133 HG		0.04	0.04	1010	41	10	39	1	0.06	64.3	56	1	3	3	3	46
91-78	135 HG		0.05	0.05	1020	32	10	41	1	0.05	60	52	3	2	2	3	52
91-78	137 HG		0.04	0.04	950	34	29	42	1	0.02	35.7	37	1	2	2	4	65
91-78	139 HG		0.05	0.05	990	33	9	38	1	0.05	60.6	39	2	2	2	4	60
91-78	141 HG		0.05	0.05	970	30	16	34	1	0.05	59.7	42	3	2	2	5	78
91-78	143 HG		0.05	0.05	850	26	17	31	1	0.04	59	44	3	2	2	3	47
91-78	145 HG		0.05	0.05	920	31	18	30	1	0.07	61.7	39	3	2	3	3	59
91-78	147 HG		0.05	0.05	850	28	11	41	1	0.04	53.2	38	2	2	2	5	94
91-78	149 HG		0.05	0.05	960	29	11	31	1	0.04	56	38	2	2	2	4	81
91-78	151 HG		0.05	0.05	950	29	14	35	1	0.04	56	38	2	1	1	4	68
91-78	153 HG		0.05	0.05	990	30	21	30	1	0.03	54.3	44	1	1	1	3	54
91-78	155 HG		0.06	0.06	880	30	8	31	1	0.04	58.8	40	2	1	1	6	132
91-78	157 HG		0.05	0.05	880	50	13	35	1	0.02	46.8	116	2	1	1	5	104
91-78	159 HG		0.06	0.06	910	26	2	30	1	0.08	75.1	38	3	2	2	4	79
91-78	161 HG		0.05	0.05	920	24	2	27	1	0.09	78.7	39	2	2	2	3	44
91-78	163 HG		0.05	0.05	910	29	9	36	1	0.04	62.3	44	1	2	2	6	137
91-78	165 HG		0.06	0.06	940	27	15	35	1	0.05	67.3	47	3	2	2	6	131
91-78	167 HG		0.05	0.05	1080	29	8	43	1	0.05	67.1	47	2	2	2	4	63
91-78	169 HG		0.05	0.05	890	26	9	33	1	0.05	68	41	2	2	2	4	63
91-78	171 HG		0.07	0.07	920	27	8	31	1	0.05	67.9	38	2	2	2	7	143
91-78	173 HG		0.07	0.07	790	31	5	71	1	0.05	69.2	42	1	1	3	3	31
91-78	175 HG		0.09	0.09	790	21	1	30	1	0.05	54.7	32	1	3	3	2	29
91-78	177 HG		0.12	0.12	950	26	4	35	1	0.06	73.5	42	2	2	3	6	108
91-78	179 HG		0.17	0.17	980	26	3	35	1	0.1	87.2	40	1	1	3	4	72
91-78	181 HG		0.16	0.16	970	28	12	38	1	0.07	73.2	42	2	2	3	6	122
91-78	183 HG		0.11	0.11	820	30	17	37	1	0.05	66.3	45	3	3	3	4	61
91-78	185 HG		0.14	0.14	880	27	7	33	1	0.06	73.8	39	3	2	6	6	129
91-78	187 HG		0.1	0.1	1050	28	15	37	1	0.06	74.3	46	2	2	3	3	54
91-78	189 HG		0.12	0.12	980	27	3	34	1	0.06	73.7	39	1	1	2	4	92
91-78	191 HG		0.07	0.07	1080	24	9	37	1	0.08	82.5	44	2	2	2	4	65
91-78	193 HG		0.1	0.1	990	28	8	34	1	0.09	79.2	44	3	3	3	5	78
91-78	195 HG		0.09	0.09	900	29	29	38	1	0.07	71.3	46	1	1	2	4	78

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-78	197 HG		0.08	1	890	38	48	30	1	0.02	43.7	46	2	2	5	92	
91-78	199 HG		0.08	1	930	21	8	30	1	0.04	56.2	31	1	2	3	38	
91-78	201 HG		0.09	1	980	27	7	34	1	0.05	64	38	1	2	3	57	
91-78	203 HG		0.06	1	850	24	7	34	1	0.04	49.8	33	2	2	3	50	
91-78	205 HG		0.06	1	1000	30	9	38	1	0.03	52.6	40	2	2	4	61	
91-78	207 HG		0.05	1	1050	37	65	35	1	0.01	37.2	101	1	2	4	89	
91-78	209 HG		0.07	1	1000	32	14	38	1	0.03	55.5	36	1	2	3	41	
91-78	211 HG		0.09	1	830	30	15	34	1	0.03	52.3	32	1	2	7	145	
91-78	213 HG		0.11	1	960	29	5	35	1	0.06	80.3	36	1	2	4	70	
91-78	215 HG		0.09	1	930	29	6	27	1	0.04	56.4	31	1	2	4	85	
91-78	217 HG		0.13	1	930	31	8	30	1	0.06	74.1	32	1	3	4	67	
91-78	219 HG		0.12	1	940	33	17	25	1	0.04	59.2	29	2	3	8	168	
91-78	221 HG		0.05	1	960	29	3	22	1	0.02	46.4	40	1	1	2	55	
91-78	223 HG		0.04	1	850	26	1	23	1	0.04	59.3	37	1	1	3	67	
91-78	225 HG		0.05	1	930	29	1	22	1	0.04	61.1	39	1	1	2	35	
91-78	227 HG		0.06	1	990	31	1	27	1	0.05	66.2	44	1	1	3	62	
91-78	229 HG		0.05	1	1000	32	1	26	1	0.05	64.1	42	1	1	2	49	
91-78	231 HG		0.05	1	950	32	1	25	1	0.03	57	38	1	1	2	52	
91-78	233 HG		0.04	1	910	27	1	27	1	0.02	42.6	29	1	1	2	47	
91-78	235 HG		0.04	1	950	25	1	22	1	0.01	36.8	28	1	1	2	39	
91-78	237 HG		0.04	1	940	25	1	23	1	0.02	51	32	1	1	1	41	
91-78	239 HG		0.04	1	990	27	1	26	1	0.01	32.5	63	1	1	2	40	
91-78	241 HG		0.04	1	970	27	1	27	1	0.01	33.9	28	1	1	2	42	
91-78	243 HG		0.04	1	870	28	8	29	1	0.01	28.9	23	1	1	2	56	
91-78	245 HG		0.07	1	960	25	1	27	1	0.01	23.7	20	1	1	1	41	
91-78	247 HG		0.04	1	890	26	1	36	1	0.01	29.3	29	1	1	2	49	
91-78	249 HG		0.03	1	880	20	1	29	1	0.01	18.4	15	1	1	1	38	
91-78	251 TRb		0.07	16	890	22	1	41	1	0.07	187.4	80	1	1	3	66	
91-78	253 TRb		0.06	15	850	14	1	38	1	0.13	221.7	61	1	1	3	106	
91-78	255 TRb		0.07	14	790	15	1	56	1	0.11	227.2	55	1	1	3	79	
91-78	257 TRb		0.05	9	840	13	1	70	1	0.16	209	48	1	1	2	54	
91-78	259 TRb		0.06	10	940	18	1	54	1	0.13	195.8	52	1	1	3	71	
91-78	261 TRb		0.04	2	290	21	1	67	1	0.03	33.2	36	1	1	3	83	
91-82	6.1 JRI		0.18	1	1250	22	1	79	1	0.27	135.2	72	1	1	3	9	2
91-82	8 JRI		0.17	1	1200	22	1	65	1	0.31	160.6	79	1	1	3	9	1
91-82	10 JRI		0.25	1	1160	14	1	78	1	0.4	194.5	81	1	1	3	8	2
91-82	12 JRI		0.2	1	1040	11	1	54	1	0.45	230.6	87	1	2	3	7	1
91-82	14 JRI		0.11	1	1120	12	1	52	1	0.44	233	88	1	2	3	8	1

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-82	16 Jrt		0.06	1	870	5	1	44	1	0.45	273.2	82	1	2	2	15	2
91-82	18 Jrt		0.14	1	900	13	1	76	1	0.4	214.6	89	1	2	2	13	2
91-82	20 Jrt		0.15	1	890	14	1	51	1	0.34	172.7	80	1	1	3	17	3
91-82	22 Jrt		0.2	1	740	23	1	57	1	0.19	90.3	61	4	1	2	12	2
91-82	24 Jrt		0.14	1	990	19	1	73	1	0.33	158.2	81	1	1	3	20	1
91-82	26 Jrt		0.2	1	1020	15	1	58	1	0.36	172.4	85	1	1	3	21	2
91-82	28 Jrt		0.14	1	1000	18	1	49	1	0.33	144.9	81	1	1	2	12	2
91-82	30 Jrt		0.21	1	1100	23	1	78	1	0.34	196	84	1	1	3	9	1
91-82	32 Jrt		0.21	1	950	17	1	71	1	0.31	145.8	80	1	1	3	21	2
91-82	34 Jrt		0.24	1	1040	18	1	94	1	0.36	171	85	1	1	3	27	2
91-82	36 Jrt		0.27	1	1010	17	1	89	1	0.35	168.6	83	1	1	3	23	1
91-82	38 Jrt		0.2	1	980	15	1	73	1	0.35	171.1	82	1	1	3	22	1
91-82	40 Jrt		0.15	1	1150	19	1	81	1	0.29	153.4	73	1	1	3	14	1
91-82	42 Jrt		0.16	1	1350	21	1	79	1	0.28	103.3	81	1	1	2	14	3
91-82	44 Jrt		0.09	1	1140	22	1	51	1	0.22	85.5	75	3	1	2	6	2
91-82	46 Jrt		0.1	1	1030	22	1	60	1	0.26	112.1	81	1	1	2	12	2
91-82	48 Jrt		0.24	1	600	18	1	190	1	0.33	168.4	66	1	1	3	12	2
91-82	50 Jrt		0.17	1	410	20	1	385	1	0.31	134.9	60	1	1	2	13	1
91-82	52 Jrt		0.17	1	310	27	1	247	1	0.19	107.7	50	4	1	2	7	1
91-82	54 Jrt		0.15	1	1120	78	1	141	1	0.22	102	83	4	3	3	10	1
91-82	56 Jrt		0.15	1	770	54	1	132	1	0.23	113	65	3	2	3	14	2
91-82	58 Jrt		0.15	1	680	41	1	189	1	0.3	137.1	67	2	2	3	22	2
91-82	60 Jrt		0.19	1	580	31	1	78	1	0.24	131	63	3	1	3	23	2
91-82	62 Jrt		0.18	1	720	32	1	149	1	0.32	182.7	63	3	1	3	20	1
91-82	64 Jrt		0.32	1	610	32	1	134	1	0.34	173.8	72	2	1	4	24	2
91-82	66 Jrt		0.16	1	640	21	1	182	1	0.32	176.7	80	1	2	3	16	1
91-82	68 Jrt		0.14	1	940	22	1	151	1	0.26	115.7	67	2	2	2	11	3
91-82	70 Jrt		0.13	1	900	18	1	181	1	0.3	136	71	2	2	3	17	1
91-82	72 Jrt		0.11	1	740	25	1	126	1	0.25	119.6	65	3	2	3	16	1
91-82	74 Jrt		0.1	1	640	22	1	149	1	0.21	100.8	59	2	1	2	19	2
91-82	76 Jrt		0.17	1	510	28	1	137	1	0.17	71.2	60	5	1	2	18	2
91-82	78 Jrt		0.19	1	900	29	1	75	1	0.25	123.4	72	2	1	2	17	2
91-82	80 Jrt		0.21	1	940	25	1	112	1	0.26	120.9	69	2	2	2	13	1
91-82	82 Jrt		0.13	1	960	21	1	92	1	0.26	127	71	1	2	2	15	2
91-82	84 Jrt		0.11	1	820	19	1	104	1	0.23	117.9	62	2	1	3	24	3
91-82	86 Jrt		0.14	1	450	22	1	357	1	0.16	83.4	58	3	1	2	16	2
91-82	88 Jrt		0.21	1	650	23	1	139	1	0.3	151.8	71	1	1	3	17	1
91-82	90 Jrt		0.14	1	1000	18	1	87	1	0.35	132.1	72	1	1	2	13	6

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-82	92 JRT		0.13	1	910	19	1	75	1	0.36	143.4	70	2	1	1	3	15
91-82	94 JRT		0.17	1	680	17	1	102	1	0.33	144.9	69	1	2	2	3	28
91-82	96 JRT		0.16	1	690	23	1	96	1	0.27	139	55	3	1	1	3	16
91-82	98 JRT		0.21	1	730	26	1	99	1	0.27	130.4	52	3	1	1	3	19
91-82	100 JRT		0.21	1	840	22	1	114	1	0.3	163.6	66	1	1	1	2	13
91-82	102 JRT		0.26	1	650	14	1	142	1	0.24	166	61	1	1	1	3	21
91-82	104 JRT		0.15	1	460	6	1	73	1	0.21	159.8	64	1	1	2	19	1
91-82	106 JRT		0.13	1	310	19	1	177	1	0.1	89	49	1	1	1	1	13
91-82	108 JRT		0.11	1	390	16	1	120	1	0.08	57.5	42	3	1	1	1	4
91-82	110 JRT		0.14	1	650	26	1	136	1	0.13	109.9	64	1	1	1	1	14
91-82	112 JRT		0.11	1	650	9	1	102	1	0.23	166	75	1	1	1	1	12
91-82	114 JRT		0.07	1	1030	11	1	57	1	0.23	123.2	56	1	1	1	1	13
91-82	116 JRT		0.07	1	740	13	1	63	1	0.16	133.8	67	1	1	1	1	10
91-82	118 JRT		0.1	1	770	10	1	64	1	0.27	126.3	63	1	1	1	1	11
91-82	120 JRT		0.13	1	760	18	1	137	1	0.16	102.5	58	1	1	1	1	13
91-82	122 JRT		0.13	1	580	12	1	98	1	0.16	105.3	56	1	1	1	1	14
91-82	124 JRT		0.14	1	950	6	1	86	1	0.27	162.1	70	1	1	1	1	15
91-82	126 JRT		0.16	1	1090	11	1	72	1	0.24	186	70	1	1	2	16	1
91-82	128 JRT		0.13	1	570	16	1	127	1	0.17	114.2	71	1	1	1	1	10
91-82	130 JRT		0.08	1	510	10	1	63	1	0.13	118	63	1	1	1	1	12
91-82	132 JRT		0.07	1	460	5	1	62	1	0.21	199.6	80	1	1	1	1	15
91-82	134 JRT		0.09	1	560	7	1	108	1	0.18	168.1	70	1	1	1	1	13
91-82	136 JRT		0.09	1	600	5	1	101	1	0.13	149.9	66	1	1	1	1	12
91-82	138 JRT		0.09	1	400	14	1	83	1	0.12	150.6	70	1	1	1	1	12
91-82	140 JRT		0.09	1	610	14	1	76	1	0.13	145.4	58	1	1	1	1	16
91-82	142 JRT		0.09	1	750	18	1	94	1	0.08	131.3	71	4	1	1	1	15
91-82	144 SG		0.02	1	2570	8	9	41	1	0.07	153	36	1	1	2	47	2
91-82	146 SG		0.02	1	840	24	10	31	1	0.02	89.5	49	1	1	1	2	26
91-82	148 SG		0.02	1	210	19	8	16	1	0.01	70.4	14	1	1	2	49	1
91-82	150 SG		0.01	1	390	19	10	8	1	0.02	54	12	1	1	4	89	1
91-82	152 SG		0.02	1	1180	25	8	11	1	0.02	33.8	10	1	1	3	78	1
91-82	154 SG		0.06	1	2640	26	9	13	1	0.03	27.8	9	1	1	2	57	1
91-82	156 SG		0.02	1	3250	24	5	16	1	0.02	29.6	6	1	1	2	56	1
91-82	158 SG		0.02	1	2670	20	3	11	1	0.02	24	5	1	1	2	72	1
91-82	160 SG		0.01	1	1150	21	61	9	1	0.01	21	24	1	1	3	92	1
91-82	162 HG		0.02	1	1140	14	28	9	1	0.01	16.3	48	1	1	3	80	1
91-82	164 HG		0.02	1	1140	20	15	22	1	0.01	23.9	98	1	1	3	78	1
91-82	166 HG		0.03	1	1190	90	62	28	2	0.01	22.4	279	2	1	4	95	1

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-82	168 HG		0.03	1	1060	27	1	30	1	0.01	26.1	61	3	1	1	3	80
91-82	170 HG		0.03	1	1000	26	1	27	1	0.01	36.2	75	2	1	1	3	81
91-82	172 HG		0.03	1	1060	23	1	25	1	0.01	27.6	63	2	1	1	2	54
91-82	174 HG		0.03	1	1140	25	9	22	1	0.01	22.5	66	2	1	1	1	33
91-82	176		0.05	1	1090	23	1	40	1	0.02	132.7	112	1	1	1	6	141
91-82	178 FRb		0.08	1	1080	22	1	40	1	0.03	226.3	92	1	1	1	6	118
91-82	180 FRb		0.1	2	1010	21	1	47	1	0.01	200.9	70	1	1	1	3	46
91-82	182 FRb		0.13	3	1090	23	1	51	1	0.02	209.6	68	1	1	1	3	53
91-82	184 FRb		0.08	6	970	19	1	44	1	0.03	178	55	1	1	1	3	48
91-82	186 FRb		0.25	1	1020	18	1	57	1	0.1	229.1	50	1	1	1	4	57
91-82	188 FRb		0.42	1	980	16	1	90	1	0.11	211.7	46	1	1	1	4	64
91-82	190 FRb		0.1	1	980	15	1	52	1	0.12	201.8	52	1	1	1	3	39
91-82	192 FRb		0.2	1	950	12	1	68	1	0.25	220.3	68	1	3	4	4	51
91-82	194 FRb		0.21	1	750	22	1	69	1	0.17	189.1	53	1	1	1	3	34
91-82	196 FRb		0.27	1	700	21	1	71	1	0.11	181	58	1	1	1	3	35
91-82	198 FRb		0.21	1	860	22	1	62	1	0.08	174.4	52	1	1	1	3	36
91-93	6.1 SG		0.02	1	850	23	9	13	1	0.02	52.7	20	1	2	4	60	60
91-93	8 SG		0.01	1	690	19	7	12	1	0.02	53.4	17	1	1	1	3	53
91-93	10 SG		0.02	1	810	20	8	21	1	0.02	60.6	17	1	1	1	2	26
91-93	12 SG		0.01	1	620	17	5	24	1	0.02	49.1	14	1	1	1	3	58
91-93	14 SG		0.01	1	630	20	3	21	1	0.02	46	14	1	1	2	29	29
91-93	16 SG		0.02	1	860	23	6	23	1	0.03	72.5	18	1	1	1	3	48
91-93	18 SG		0.01	1	660	18	3	18	1	0.03	45.6	13	1	1	1	2	34
91-93	20 SG		0.02	1	520	14	2	18	1	0.02	32.9	12	1	1	1	4	77
91-93	22 SG		0.01	1	290	15	3	22	1	0.01	19	9	1	1	1	2	38
91-93	24 SG		0.01	1	340	18	5	41	1	0.02	37.8	13	1	1	1	2	40
91-93	26 SG		0.01	1	370	14	3	28	1	0.02	45.5	13	1	1	1	1	19
91-93	28 SG		0.02	1	400	14	2	28	1	0.02	49.2	13	1	1	1	3	48
91-93	30 SG		0.01	1	440	14	2	40	1	0.02	46.2	13	1	1	1	2	26
91-93	32 SG		0.01	1	450	17	5	33	1	0.02	53.9	17	1	1	1	3	51
91-93	34 SG		0.01	1	480	15	2	27	1	0.02	36.1	15	1	1	1	2	30
91-93	36 SG		0.01	1	290	21	5	45	1	0.02	43.1	10	1	1	1	3	52
91-93	38 SG		0.01	1	310	20	4	81	1	0.02	28.3	8	1	1	1	2	37
91-93	40 SG		0.01	1	420	18	9	81	1	0.02	31.6	7	1	1	1	2	53
91-93	42 SG		0.01	1	400	12	4	73	1	0.02	26.6	6	1	1	1	2	39
91-93	44 SG		0.01	1	370	17	3	87	1	0.02	23.7	6	1	1	1	2	49
91-93	46 SG		0.01	1	180	15	4	63	1	0.01	28.2	5	1	1	1	2	33
91-93	48 SG		0.01	1	330	21	1	23	1	0.01	30.8	97	1	1	1	3	54

Appendix B: Geochemical Data-Open-pit

Hole Number	Depth	Rock Type	Na Wt %	Ni ppm	P Wt %	Pb ppm	Sb ppm	Sr ppm	Th ppm	U ppm	V ppm	Zn ppm	Ga ppm	Sn ppm	W ppm	Cr ppm	Au ppm
91-93	50 SG		0.01	1	390	17	4	21	1	0.01	27.1	27	1	1	1	2	36
91-93	52 SG		0.01	1	140	18	5	67	1	0.01	35.8	6	1	1	1	2	38
91-93	54 SG		0.01	1	480	12	1	12	1	0.01	17.6	74	1	1	1	2	36
91-93	56 SG		0.01	1	1000	23	1	15	1	0.01	26.6	87	1	1	1	3	73
91-93	58 SG		0.02	1	1720	35	3	40	1	0.01	28.3	80	1	1	1	2	31
91-93	60 HG		0.02	1	1190	29	11	19	1	0.01	38.1	135	3	1	1	3	62
91-93	62 HG		0.03	1	1180	24	21	17	1	0.01	33.9	129	4	1	1	3	50
91-93	64 HG		0.02	1	1170	27	1	18	1	0.01	30.5	120	2	1	1	3	72
91-93	66 HG		0.03	1	1060	23	1	23	1	0.01	27.8	106	3	1	1	2	41
91-93	68 HG		0.03	1	1070	44	20	19	1	0.01	23.3	132	2	1	1	4	91
91-93	70 HG		0.03	1	1110	30	1	25	1	0.01	40.9	153	4	1	1	2	32
91-93	72 HG		0.04	1	1310	57	1	27	1	0.01	45	144	4	1	1	3	65
91-93	74 HG		0.03	1	1190	24	5	25	1	0.01	28.1	84	2	1	1	2	37
91-93	76 HG		0.04	1	1230	36	14	24	1	0.01	28.8	88	2	1	1	4	98
91-93	78 HG		0.03	1	1140	24	3	25	1	0.01	31.9	89	3	1	1	2	40
91-93	80 HG		0.03	1	1180	70	118	18	1	0.01	23.9	229	2	1	1	4	94
91-93	82 HG		0.03	1	1190	24	1	23	1	0.01	30.5	141	2	1	1	2	36
91-93	84 HG		0.03	1	1280	26	1	24	1	0.01	39.9	161	2	1	1	4	80
91-93	86 HG		0.02	1	1370	31	8	21	1	0.01	40.5	144	2	2	2	2	47
91-93	88 HG		0.02	1	1220	28	5	20	1	0.01	51.1	164	3	1	1	3	60
91-93	90 HG		0.02	1	1310	22	13	18	1	0.01	26.4	121	1	1	1	2	35
91-93	92 HG		0.02	1	1060	20	1	17	1	0.02	47.8	204	2	1	1	3	57
91-93	94 HG		0.02	1	1190	21	4	16	1	0.01	48	223	3	1	1	1	30
91-93	96 HG		0.02	1	1170	23	2	15	1	0.01	30.8	130	1	1	1	2	50
91-93	98 HG		0.01	1	1750	21	27	19	1	0.01	29	538	1	1	1	2	63
91-93	100 HG		0.01	1	780	22	52	10	1	0.01	26.5	653	1	1	1	3	68
91-93	102 HG		0.01	1	760	14	5	9	1	0.01	8.7	264	1	2	3	3	48
91-93	104 HG		0.03	2	910	19	3	35	1	0.01	95.5	84	1	1	1	3	35
91-93	106 HG		0.14	4	950	19	1	55	1	0.01	143.4	59	2	1	1	3	17
91-93	108 HG		0.08	9	900	23	1	56	1	0.01	143.9	71	1	1	1	4	52
91-93	110 HG		0.07	1	1000	22	1	53	1	0.01	120.4	68	1	1	1	2	18
91-93	112 HG		0.23	4	1060	26	1	55	1	0.05	188.3	83	1	1	1	5	51
91-93	114 HG		0.3	5	1200	26	1	63	1	0.05	171.6	89	1	1	1	4	33
91-93	116 HG		0.22	2	1080	21	1	79	1	0.14	219.8	96	1	1	1	4	50

Date	Number	Mineral	Analysis Type	Descrip.	Cu	Fe	Au	S	Ag	Total
19-Jan-99	1	Bor	Point	130-1	64.8	10.24	0	25.64	0	100.68
19-Jan-99	2	Bor	Point	130-1	64.92	10.49	0	25.15	0	100.56
19-Jan-99	3	Bor	Point	130-1	65.22	10.24	0	24.68	0	100.14
19-Jan-99	4	Bor	Point	130-1	66.01	9.61	0	24.81	0	100.43
19-Jan-99	5	Cte	Point	130-10	78.18	0.93	0	20.75	0	99.86
19-Jan-99	6	Bor	Point	130-11	65.63	9.77	0	24.73	0	100.13
19-Jan-99	7	Cpy	Point	130-2	35.17	29.74	0	34.28	0	99.19
19-Jan-99	8	Cte	Point	130-4	80.7	0.49	0	20.22	0	101.41
19-Jan-99	9	Py	Point	130-5	1.84	46.94	0	55.51	0	104.29
19-Jan-99	10	Cpy	Point	130-6	34.83	30.42	0	35.06	0	100.31
19-Jan-99	11	Bor	Point	130-6	65.47	9.68	0	25.25	0	100.4
19-Jan-99	12	Cpy	Point	130-8	35.13	29.24	0	34.84	0	99.21
19-Jan-99	13	Cu	Point	130-9	99.27	0.74	0	0.01	0	100.02
19-Jan-99	14	Cte	Point	1300-1	80.91	1.11	0	19.87	0	101.89
19-Jan-99	15	Cte	Point	1300-2	78.99	0.75	0	20.25	0	99.99
19-Jan-99	16	Cpy	Point	1300-3	35.69	29.29	0	34.67	0	99.65
19-Jan-99	17	Cte	Point	1300-4	79.8	0.68	0	19.96	0	100.44
19-Jan-99	18	Cte	Point	1300-5	79.64	1.4	0	20.16	0	101.2
19-Jan-99	19	Bor	Point	1300-6	71.48	8	0	21.07	0	100.55
19-Jan-99	20	Cpy	Point	1300-7	34.87	29.98	0	34.45	0	99.3
19-Jan-99	21	Bor	Point	1300-8	63.27	9.81	0	25.74	0	98.82
19-Jan-99	22	Cte	Point	13000-1	82.16	1.04	0	0.23	0	83.43
19-Jan-99	23	Cpy	Point	CPYSTD	34.51	30.14	0	34.15	0	98.8
22-Jan-99	24	Cu	Point	CUSTD	98.84	0	0	0.02	0	98.86
22-Jan-99	25	Cu	Point	CUSTD	99.16	0	0.03	0.02	0	99.21
22-Jan-99	26	Cu	Point	CUSTD	98.66	0	0.02	0.02	0	98.7
22-Jan-99	27	Cu	Point	CUSTD	99.4	0	0.01	0.02	0	99.43
22-Jan-99	28	Cu	Traverse	CU1	98.31	0	0	0.8	0	99.11
22-Jan-99	29	Cu	Traverse	CU1	97.59	0	0.02	0.74	0.01	98.36
22-Jan-99	30	Cu	Traverse	CU1	98.19	0	0	0.75	0	98.94
22-Jan-99	31	Cu	Traverse	CU1	98.18	0	0	0.75	0	98.93
22-Jan-99	32	Cu	Traverse	CU1	98.6	0	0	0.63	0	99.23
22-Jan-99	33	Cu	Traverse	CU1	98.41	0	0	0.69	0	99.1
22-Jan-99	34	Cu	Traverse	AU1	101.53	0	0.01	0.56	0	102.1
22-Jan-99	35	Cu	Traverse	AU1	99.3	0	0.01	0.28	0.01	99.6
22-Jan-99	36	Cu	Traverse	AU1	98.66	0	0	0.46	0.01	99.13
22-Jan-99	37	Cu	Traverse	AU1	98.88	0	0.01	0.42	0.03	99.34
22-Jan-99	38	Cu	Point	CUSTD	98.21	0	0.02	0.48	0	98.71
22-Jan-99	39	Cu	Point	CUSTD	99.95	0	0	0.03	0.02	100
22-Jan-99	40	Cu	Point	CUSTD	98.75	0	0.01	0.02	0	98.78
26-Jan-99	41	Cu	Point	cro49.1	97.319	0	0.029	0.129	0.013	97.49
26-Jan-99	42	Cu	Point	cro49.1	97.771	0.012	0	0.143	0.026	97.952
26-Jan-99	43	Cu	Point	cro49.1	97.842	0.013	0	0.183	0.005	98.043
26-Jan-99	44	Cu	Point	cro49.1	98.04	0.113	0	0.14	0.051	98.344
26-Jan-99	45	Cu	Point	cro49.1	98.075	0.006	0	0.138	0.011	98.23
26-Jan-99	46	Cu	Point	cro49.1	98.334	0.016	0	0.022	0.013	98.385
26-Jan-99	47	Cu	Point	cro49.1	98.911	0.014	0	0.103	0.015	99.043
26-Jan-99	48	Cu	Point	custd	99.019	0.006	0	0.023	0	99.048
09-Feb-99	50	Cpy	Point	D1- 5	33.202	32.675	0	33.742	0	99.877
09-Feb-99	51	Cpy	Point	D1- 6	34.593	31.563	0	35.648	0	102.113
09-Feb-99	52	Bor	Point	E1- 2	75.934	5.221	0	21.217	0	103.324
09-Feb-99	53	Cpy	Point	E1- 6	33.958	31.662	0	35.591	0	101.55
22-Feb-99	54	Cu	Traverse	CU1	99.09399	0.002	0.008	0	0	99.104
22-Feb-99	55	Cu	Traverse	CU2	97.097	0.006	0	0	0.019	97.12199
22-Feb-99	56	Cu	Point	CUSTD	100.69099	0	0	0.037	0	100.728
22-Feb-99	57	Cu	Traverse	TRAV1	96.257	0	0.004	0	0	96.261
22-Feb-99	58	Cu	Traverse	TRAV1	96.937	0.006	0.037	0	0.013	96.993
22-Feb-99	59	Cu	Traverse	TRAV1	97.088	0.006	0	0.002	0.032	97.12799
22-Feb-99	60	Cu	Traverse	TRAV1	97.849	0	0.006	0.013	0	97.868
22-Feb-99	61	Cu	Traverse	TRAV1	98.034	0	0.05	0.005	0.012	98.101
22-Feb-99	62	Cu	Traverse	TRAV1	98.062	0.007	0.032	0.005	0.001	98.107
22-Feb-99	63	Cu	Traverse	TRAV1	98.087	0.005	0.012	0.006	0.001	98.11099
22-Feb-99	64	Cu	Traverse	TRAV1	98.446	0.009	0	0.008	0.024	98.48701
22-Feb-99	65	Cu	Traverse	TRAV1	98.985	0.002	0	0.001	0.002	98.99
22-Feb-99	66	Cu	Traverse	TRAV1	99.62099	0	0	0.003	0.001	99.62499
22-Feb-99	67	Cu	Traverse	TRAV2	97.241	0	0	0.004	0	97.245
22-Feb-99	68	Cu	Traverse	TRAV2	97.415	0	0	0.001	0.006	97.422
22-Feb-99	69	Cu	Traverse	TRAV2	97.744	0.001	0	0.006	0.003	97.754
22-Feb-99	70	Cu	Traverse	TRAV2	98.011	0.004	0	0.006	0.02	98.04099
22-Feb-99	71	Cu	Traverse	TRAV2	98.32	0.008	0.027	0.005	0.001	98.361

Date	Number	Mineral	Analysis Type	Descrip.	Cu	Fe	Au	S	Ag	Total
22-Feb-99	72	Cu	Traverse	TRAV2	98.505	0	0	0	0.007	98.51201
22-Feb-99	73	Cu	Traverse	TRAV2	98.68501	0.003	0.017	0.013	0	98.718
22-Feb-99	74	Cu	Traverse	TRAV2	98.937	0.006	0	0.003	0.011	98.95699
22-Feb-99	75	Cu	Traverse	TRAV2	99.334	0.006	0.013	0	0.021	99.374
22-Feb-99	76	Cu	Traverse	TRAV2	99.592	0.001	0.009	0.014	0	99.616
22-Feb-99	77	Cu	Traverse	TRAV2	100.101	0	0.029	0.007	0.02	100.157
29-Nov-99	78	Cpy	Point	1.3-4	35.434	29.161	0	32.978	0	97.573
29-Nov-99	79	Bor	Point	1.3-5	63.367	11.24	0	23.664	0	98.271
29-Nov-99	80	Cpy	Point	1.3-6	35.625	29.138	0	33.808	0	98.571
29-Nov-99	81	Bor	Point	1.3-7	68.642	8.822	0	23.683	0	101.147
29-Nov-99	82	Cle	Point	1.3-8	80.221	1.578	0	19.511	0	101.31
29-Nov-99	83	Cle	Point	1.3-9	81.423	1.209	0	19.519	0	102.151
29-Nov-99	84	Cle	Point	1.3-1	79.959	0.353	0	20.241	0	100.553
29-Nov-99	85	Bor	Point	1.3-10	68.354	10.919	0	26.544	0	105.817
29-Nov-99	86	Cpy	Point	1.3-11	37.543	31.925	0	37.654	0	107.122
29-Nov-99	87	Bor	Point	1.3-12	63.118	11.329	0	25.515	0	99.962
29-Nov-99	88	Py	Point	1.3-13	6.273	37.582	0	44.364	0	88.219
29-Nov-99	89	Cle	Point	1.3-14	79.88	0.527	0	19.998	0	100.405
29-Nov-99	90	Cle	Point	1.3-18	83.069	0.902	0	20.744	0	104.715
29-Nov-99	91	Bor	Point	1.3-19	65.524	11.498	0	25.889	0	102.911
29-Nov-99	92	Bor	Point	1.3-20	61.344	15.864	0	22.17	0	99.378
29-Nov-99	93	Cle	Point	1.3-21	81.118	3.236	0	21.687	0	106.041
29-Nov-99	94	Bor	Point	1.3-22	67.354	12.001	0	26.951	0	106.306
29-Nov-99	95	Cle	Point	1.3-23	83.813	2.309	0	21.642	0	107.764
29-Nov-99	96	Cle	Point	0.13-3	79.968	3.353	0	19.742	0	103.063
29-Nov-99	97	Cle	Point	0.13-4	80.441	1.655	0	21.327	0	103.423
29-Nov-99	98	Bor	Point	0.13-6	61.824	15.533	0	22.241	0	99.598
29-Nov-99	99	Cpy	Point	0.13-7	35.836	30.608	0	35.94	0	102.384
29-Nov-99	100	Bor	Point	0.13-8	63.825	10.823	0	26.219	0	100.867
29-Nov-99	101	Cle	Point	0.13-9	81.533	1.773	0	20.313	0	103.619
29-Nov-99	102	Cle	Point	0.13-1	80.63	1.241	0	20.21	0	102.081
29-Nov-99	103	Cle	Point	0.13-10	83.223	0.237	0	20.665	0	104.125
29-Nov-99	104	Bor	Point	0.13-11	65.103	15.235	0	15.992	0	96.33
29-Nov-99	105	Cle	Point	0.13-12	83.015	1.059	0	21.106	0	105.18
29-Nov-99	106	Bor	Point	0.13-5	73.843	6.747	0	22.595	0	103.185
	107	Cu	Point	CUSTD	101.359	0.009	0	0.017	0.019	101.404
	108	Cu	Point	CUSTD	101.897	0.004	0	0.021	0.012	101.934
	109	Cu	Point	POINT 2	97.182	0.001	0.049	0	0.013	97.245
	111	Cu	Traverse	TRAV1	94.624	0	0	0.008	0.003	94.635
	112	Cu	Traverse	TRAV1	97.319	0.005	0.05	0.004	0	97.378
	113	Cu	Traverse	TRAV1	97.38	0	0.075	0.004	0.029	97.488
	114	Cu	Traverse	TRAV1	97.425	0.005	0	0	0	97.43
	115	Cu	Traverse	TRAV1	97.625	0.001	0	0	0.035	97.661
	116	Cu	Traverse	TRAV1	98	0.001	0	0.004	0	98.005
	117	Cu	Traverse	TRAV1	98.412	0.003	0.053	0.007	0	98.475
	118	Cu	Traverse	TRAV1	98.7	0	0	0.001	0	98.701
	119	Cu	Traverse	TRAV1	98.751	0	0	0.009	0.007	98.767
	120	Cu	Traverse	TRAV1	98.845	0.008	0	0.002	0.011	98.866
	121	Cu	Traverse	TRAV2	96.3	0.002	0	0.004	0	96.306
	122	Cu	Traverse	TRAV2	96.824	0.001	0.009	0	0.003	96.837
	123	Cu	Traverse	TRAV2	97.04	0	0	0	0	97.04
	124	Cu	Traverse	TRAV2	97.793	0.009	0	0.004	0.015	97.821
	125	Cu	Traverse	TRAV2	98.379	0.008	0.04	0	0	98.427
	126	Cu	Traverse	TRAV2	99.67	0.009	0	0.002	0	99.681
	127	Cu	Traverse	TRAV3	87.99	0	0.034	0	0	88.024
	128	Cu	Traverse	TRAV3	90.526	0	0.064	0	0	90.59
	129	Cu	Traverse	TRAV3	91.754	0.004	0.048	0	0.028	91.834
	130	Cu	Traverse	TRAV3	92.263	0	0.006	0.006	0	92.275
	131	Cu	Traverse	TRAV3	92.548	0.012	0	0.005	0.032	92.597
	132	Cu	Traverse	TRAV3	92.747	0	0.003	0	0.013	92.763
	133	Cu	Traverse	TRAV3	92.779	0	0	0	0.007	92.786
	134	Cu	Traverse	TRAV4	97.15	0.009	0	0.008	0	97.167
	135	Cu	Traverse	TRAV4	98.179	0.011	0.021	0.003	0	98.214
	136	Cu	Traverse	TRAV4	98.427	0.006	0	0.003	0.019	98.455
	137	Cu	Traverse	TRAV4	98.785	0	0	0.005	0	98.79
	138	Cu	Traverse	TRAV5	93.532	0	0	0.006	0.007	93.545
	139	Cu	Traverse	TRAV5	98.675	0.012	0.026	0.008	0	98.721
	140	Cu	Traverse	TRAV6	97.179	0	0.022	0.016	0	97.217
	141	Cu	Traverse	TRAV6	97.34	0	0.087	0.011	0	97.438
	142	Cu	Traverse	TRAV7	97.368	0	0.007	0.013	0	97.388

Date	Number	Mineral	Analysis Type	Descrip.	Cu	Fe	Au	S	Ag	Total
	143	Cu	Traverse	TRAV7	98.049	0.002	0	0.021	0	98.072
	144	Cu	Traverse	TRAV7	98.171	0	0	0.002	0.011	98.184
	145	Cu	Traverse	TRAV7	98.428	0	0	0.005	0	98.433
	146	Cu	Traverse	TRAV7	98.434	0.047	0.002	0.004	0	98.487
	147	Cu	Traverse	TRAV7	98.635	0.003	0.027	0.015	0.007	98.687
	148	Cu	Traverse	TRAV8	97.71	0	0	0.006	0.024	97.74
	149	Cu	Traverse	TRAV8	98.371	0.005	0	0.004	0	98.38
	150	Cu	Traverse	TRAV8	99.712	0.002	0.007	0.008	0.013	99.742
	151	Cu	Traverse	TRAV8	100.498	0	0	0	0.022	100.52
	152	Cu	Traverse	TRAV9	98.496	0.01	0	0.006	0	98.512
	153	Cu	Traverse	TRAV9	98.779	0.002	0	0.01	0.011	98.802
	154	Cu	Traverse	TRAV9	98.956	0.001	0	0.007	0	98.964

Appendix B: Probe/SEM Data

Date	Number	Mineral	SAMPLE	SiO2	Al2O3	TiO2	CR2O3	FeO	MnO	MgO	K2O	CaO	Na2O	CL	F	NiO	ZnO	P2O5	BAO	SO3	TOTAL
16-Jun-01	110	Pyr	13-S-C1	50 141	4 34	0 796	0 023	8 546	0 318	14 521	0	20 226	0 483	0	0	0	0	0	0	0	99 394
16-Jun-01	111	Pyr	13-S-C2	50 549	3 836	0 709	0 034	8 967	0 271	14 538	0	20 084	0 479	0	0	0	0	0	0	0	99 465
16-Jun-01	112	Pyr	13-S-C2	51 465	3 068	0 559	0	9 189	0 281	15 69	0	19 328	0 363	0	0	0	0	0	0	0	99 944
16-Jun-01	113	Fel	13-S-C2	54 229	29 228	0	0	0 709	0	0	0 212	11 932	4 653	0	0	0	0	0	0	0	100 962
16-Jun-01	114	Fel	13-S-C2	68 951	20 243	0	0	0 03	0	0	0 041	6 068	11 773	0	0	0	0	0	0	0	101 644
16-Jun-01	115	Fel	13-S-C3	53 302	30 308	0	0	1 072	0	0	0	12 94	4 223	0	0	0	0	0	0	0	101 845
16-Jun-01	116	Fel	13-S-C3	50 737	31 767	0	0	0 916	0	0	0	14 982	2 995	0	0	0	0	0	0	0	101 398
16-Jun-01	117	Pyr	13-S-C3	49	5 547	1 201	0 035	9 094	0 178	13 629	0	21 342	0 368	0	0	0	0	0	0	0	100 395
16-Jun-01	118	Pyr	21-1-C1	52 59	1 957	0 424	0 104	6 856	0 137	16 256	0	21 101	0 268	0	0	0	0	0	0	0	99 693
16-Jun-01	119	Pyr	21-1-C1	50 494	3 858	0 894	0 054	8 946	0 288	13 832	0 022	20 848	0 328	0	0	0	0	0	0	0	99 462
16-Jun-01	120	Pyr	21-1-C1	52 273	2 137	0 464	0	9 104	0 311	16 913	0	18 582	0 228	0	0	0	0	0	0	0	100 013
16-Jun-01	121	Fel	21-1-C1	69 854	20 056	0	0	0	0	0	0 141	0 277	11 73	0	0	0	0	0	0	0	102 058
16-Jun-01	124	Pyr	21-1-C2-1	52 969	2 589	0 49	0 276	6 326	0 097	15 905	0	22 567	0 275	0	0	0	0	0	0	0	101 093
16-Jun-01	125	Pyr	21-1-C2-2	52 657	2 513	0 459	0 246	6 672	0 12	15 579	0	22 22	0 26	0	0	0	0	0	0	0	100 926
16-Jun-01	126	Bio	21-1-C2-3	51 448	2 946	0 744	0 038	8 127	0 341	14 843	0	21 47	0 345	0	0	0	0	0	0	0	100 301
16-Jun-01	127	Fel	21-1-C2-4	68 748	19 595	0	0	0 131	0	0	0 073	0 525	11 754	0	0	0	0	0	0	0	100 827
16-Jun-01	128	Fel	21-1-C3-1	70 716	19 977	0	0	0 053	0	0	0 159	0 333	11 557	0	0	0	0	0	0	0	102 795
16-Jun-01	129	Bio	21-1-C3-2	51 452	3 766	0 952	0 012	8 024	0 231	14 361	0 002	21 642	0 342	0	0	0	0	0	0	0	100 764
16-Jun-01	130	Bio	21-1-C3-3	51 533	3 359	0 844	0	9 351	0 35	14 125	0 006	20 655	0 349	0	0	0	0	0	0	0	100 573
16-Jun-01	131	Bio	21-1-C4-1	53 21	2 42	0 465	0 038	6 995	0 182	15 661	0	21 626	0 232	0	0	0	0	0	0	0	100 829
16-Jun-01	132	Chl	73-78-C1-1	24 909	21 3	0 075	0	37 653	0	1 776	0 569	0 063	0 031	0	0 034	0	0	0	0	0	86 259
16-Jun-01	133	Bio	73-78-C2-1	51 084	29 362	0 065	0 02	2 456	0	2 073	8 768	0 055	0 133	0	0 02	0 555	0	0	0	0	94 591
16-Jun-01	134	Bio	73-78-C2-2	49 529	29 675	0 062	0	2 754	0	1 819	10 021	0 101	0 144	0	0 009	0 34	0	0	0	0	94 454
16-Jun-01	135	Mus	15-106C1-1	46 994	31 973	0 34	0 031	2 774	0	2 413	10 414	0	0 419	0 044	0 222	0	0	0	0	0	95 623
16-Jun-01	136	Bio	15-106C1-2	47 466	32 139	0 357	0 019	3 036	0 067	2 733	10 39	0 017	0 443	0 065	0 286	0	0	0	0 308	0	97 329
16-Jun-01	137	Bio	15-106C2-1	46 412	32 3	0 4	0	3 445	0	2 963	10 488	0 024	0 431	0 013	0 173	0	0	0	0 385	0	97 035
16-Jun-01	138	Bio	15-106C4-1	46 658	32 676	0 267	0 023	3 023	0 004	1 565	10 786	0	0 505	0 038	0 103	0	0	0	0 401	0	96 252
16-Jun-01	139	Bio	15-74-C1-1	39 333	20 96	1 379	0 038	11 585	0 325	12 669	4 043	0 161	0 007	0 131	0 813	0	0	0	0 006	0	91 47
16-Jun-01	140	Bio	15-74-C1-2	53 031	27 142	0 06	0	3 378	0	3 925	7 253	0 248	0 036	0 013	0 576	0	0	0	0	0	95 662
16-Jun-01	141	Bio	15-74-C1-3	33 18	17 681	2 612	0 026	15 505	0 495	16 528	3 298	0 095	0 097	0 158	0 841	0	0	0	0 082	0	90 598
16-Jun-01	142	Bio	15-74-C1-4	46 356	29 651	0 098	0 057	4 793	0	3 451	11 006	0	0 231	0 021	0 416	0	0	0	0 313	0	96 393
06-Jul-01	143	Fel	105C12	22 14					1 22	0 41			62 23	0	1 8						97 2
06-Jul-01	144	Fel	22-C1-2	36 21					0 35	0 75			64 08	0	14 91						121 23
06-Jul-01	145	Fel	22-C1-1	31 76					0 34	1			59 05	0	13 66						110 49
06-Jul-01	146	Fel	22-C2-1	30 47					0 27	0 98			51 62	0	13 16						100 42
06-Jul-01	147	Fel	22-C2-3	28 76					0 34	0 87			53 29	0	11 66						99 53
06-Jul-01	148	Fel	22-C2-4	29 07					0 31	0 66			53 12	0	11 65						99 36
06-Jul-01	149	Pyr	22-C1-1	4 52	0 29			0 16		11 6	18 35	0 62	62 55		23 24						121 33
06-Jul-01	150	Pyr	22-C2-2	3 05	0 29			0 17		9 64	14 73	0 74	51 8		20 23						101 36
06-Jul-01	151	Pyr	22-C2-1	5 08	0 32			0		10 02	14 28	0 81	49 9		18 91						99 32
06-Jul-01	152	Zeo	22-C1-3	20 32	0			0	0 17	0	0	0	52 99		10 62						84 1
06-Jul-01	153	Zeo	22-C2-2	20 33	0			0	0 35	0	0	0	53 83		9 84						84 83
06-Jul-01	154	Zeo	22-C2-3	20 2	0			0	0 26	0	0	0	53 85		10 24						84 55
06-Jul-01	155			2	4 5	0 33	0	0 33	0	30 78	0	19 66	23 33		16 88						95 81

Appendix B: XRF Geochemistry

Sample Analysis	Rock	SiO2 XRF %	TiO2 XRF %	Al2O3 XRF %	Fe2O3 XRF %	MnO XRF %	MgO XRF %	CaO XRF %	Na2O XRF %	K2O XRF %	P2O5 XRF %	LOI XRF %	V XRF ppm	Cr XRF ppm	Co XRF ppm
Location Mill		OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate	OttawaU Agate
91-122-10	Pxb	49.5	0.898	18.09	8.488	0.1717	3.433	9.325	3.07	0.932	0.332	4.85	190	26	23
98-CRo-1-1	Mdyke	49.37	1.041	14.43	11.135	0.2292	5.049	5.487	4.36	0.43	0.235	8.18	280	80	27
98-CRo-1-1b	Mdyke	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
98-CRo-2-7	Mdyke	47.72	0.886	13.02	11.239	0.2347	10.031	10.307	2.46	0.922	0.185	3.43	307	326	40
98-CRo-3-1	Pb	52.62	1.065	15.29	10.832	0.2021	5.7	6.846	4.99	0.596	0.297	1.99	266	80	22
98-CRo-3-3	TRb	49.39	0.879	13.42	10.884	0.1947	7.864	11.385	2.13	1.478	0.26	2.55	303	237	39
98-CRo-5-2	TRb	48.3	1.143	14.3	11.257	0.2217	7.134	10.691	2.29	1.826	0.274	3.16	340	130	26
98-CRo-5-7	TRb	45.01	1.047	15.92	11.64	0.2076	7.041	9.459	1.84	2.013	0.219	6.96	381	38	34
98-CRo-6-2	Int	66.95	0.348	16.22	3.34	0.0261	0.881	3.237	3.83	2.719	0.126	1.65	42	12	BDL
98-CRo-7-1	Int	68.87	0.286	15.6	2.195	0.0508	0.979	1.376	3.08	4.239	0.115	2.28	50	21	3
98-CRo-8-4	Int	64.55	0.413	16.18	4.319	0.0654	1.646	3.331	3.56	3.324	0.155	5.66	81	10	6
98-CRo-10-5	Pb	51.01	0.743	18.09	9.024	0.1984	2.82	6.409	3.729	1.554	0.228	10	179	19	16
98-CRo-10-5	Pb	51.43	0.752	18.31	9.09	0.1995	2.826	6.44	3.83	1.561	0.23	-23.72	173	16	19
98-CRo-11-1	Pt	53.93	1.008	18.61	7.485	0.108	5.336	4.393	3.46	1.394	0.247	4.55	189	90	25
98-CRo-11-1b	Pt	53.74	1.003	18.6	7.4	0.108	5.337	4.375	3.43	1.39	0.247	3.53	184	91	25
98-CRo-11-4	Pa	58.61	0.822	17.64	5.749	0.1062	3.038	5.034	3.14	1.849	0.252	3.72	143	48	14
98-CRo-13-2	JRt	55.03	0.488	16.22	5.228	0.0721	4.036	3.196	1.41	1.609	0.113	12.71	75	14	13
98-CRo-13-2b	JRt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
98-CRo-13-5	Pxb	47.12	0.932	18.18	10.498	0.1876	5.449	4.547	5.88	0.404	0.214	7.90	293	24	27
98-CRo-13-9	JRt	46.38	0.974	17.99	8.379	0.1315	2.937	9.043	3.13	0.721	0.284	10.94	233	27	21
98-CRo-14-2	Mdyke	47.83	0.952	17.54	8.55	0.1723	1.681	12.076	2.594	0.833	0.281	8	231	24	27
98-CRo-14-2	Mdyke	47.84	0.954	17.61	8.542	0.1718	1.663	12.02	2.63	0.831	0.283	-8.48	224	33	23
98-CRo-18-4	Int	68.38	0.487	14.36	3.024	0.0393	1.314	2.715	3.99	2.402	0.105	1.66	63	23	5
98-CRo-21-5	Mdyke	47.69	1.015	18.46	8.771	0.1912	4.698	6.709	3.38	2.391	0.172	5.65	231	37	22
98-CRo-26-6	Int	48.32	1.128	17.69	10.602	0.2014	4.126	9.172	2.81	1.657	0.272	3.03	330	29	26
98-CRo-26-7	TRb	64.63	0.381	14.95	3.599	0.1096	1.111	3.633	2.86	3.628	0.161	3.48	61	12	5

Appendix B: XRF Geochemistry

Ni	Zn	Rb	Sr	Y	Zr	Nb	Ba	La	Ce	Nd	Pb	Th	U	Ga	TOTAL
XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%
OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU	OttawaU
Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate	Agate
14	93	13	633	23	111	6	683	BDL	BDL	11	3	BDL.00	BDL	20.2	94.475
26	75	9	267	16	99	6	536	BDL	BDL	15	4	BDL	BDL	18.7	91.958
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
74	129	13	356	13	44	4	2172	BDL	BDL	16	6	BDL	BDL	15.4	97.447
27	103	6	358	21	109	7	390	BDL	BDL	37	30	2	BDL	19.3	98.639
53	94	33	692	14	56	5	434	12	BDL	34	BDL	18	BDL	16.5	98.15
36	89	39	417	16	58	6	810	18	BDL	BDL	BDL	BDL	BDL	17.8	97.698
16	97	59	507	15	41	2	551	BDL	BDL	17	BDL	BDL	BDL	17.4	94.625
15	22	49	531	16	117	6	1773	21	BDL	27	10	BDL	1.25	19.4	97.984
7	54	122	249	6	89	4	996	13	BDL	BDL	BDL	12	BDL.00	19.2	96.991
3	39	87	524	13	99	5	1939	24	BDL	34	16	BDL	4.26	17.1	97.872
8	90	31.7	618.3	18.6	68.6	1.5	1269	12	BDL	22	4	<0.0	3.9	15	94.091
5	91	36	616	17	77	3	1336	16	BDL	45	16	2	BDL	18.9	94.973
67	82	27	515	17	115	8	870	BDL	BDL	BDL	16	BDL	BDL	18.8	96.22
72	82	27	510	17	112	8	871	BDL	BDL	24	BDL	BDL	BDL	19.7	95.882
22	102	54	636	13	114	9	1138	17	BDL	BDL	13	BDL	1.13	18.3	96.524
6	60	46	695	19	118	4	1555	BDL	BDL	BDL	7	BDL	BDL	17.8	87.706
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	91	6	560	17	59	2	289	BDL	BDL	BDL	BDL	BDL	BDL	19.2	93.592
17	103	8	417	21	93	6	391	BDL	BDL	35	17	BDL	BDL.00	18.5	90.147
15	89	10.4	536.6	21.5	85.4	3.3	521	15	BDL	2	2	<0.0	6.1	15	92.713
33	91	12	532	21	91	5	543	18	BDL	41	18	BDL	1.77	18.4	92.754
15	25	44	271	21	199	13	1396	14	BDL	26	BDL	BDL	6.69	16	97.076
32	121	88	760	7	38	BDL	1379	BDL	BDL	BDL	21	BDL	BDL	17.1	93.818
11	93	24	603	20	63	4	849	BDL	BDL	40	22	BDL	BDL	17.9	96.241
5	60	110	331	13	113	7	1534	36	BDL	38	16	BDL	5.14	17.2	95.332

Appendix B: XRF Geochemistry

Sn	Sb	Ba	La	W
ICP90	ICP90	ICP90	ICP90	ICP90
ppm	ppm	ppm	ppm	ppm
XRAL	XRAL	XRAL	XRAL	XRAL
Agate	Agate	Agate	Agate	Agate
50	50	10	10	50
BDL	BDL	719	18	BDL
BDL	BDL	467	BDL	BDL
BDL	BDL	537	14	BDL
BDL	BDL	2180	BDL	BDL
BDL	BDL	393	67	106
BDL	BDL	460	10	BDL
BDL	BDL	719	17	BDL
BDL	BDL	472	14	BDL
BDL	BDL	1590	18	BDL
BDL	BDL	901	20	BDL
BDL	BDL	1720	20	BDL
BDL	BDL	1240	16	BDL
BDL	BDL	763	19	BDL
NA	NA	NA	NA	NA
BDL	BDL	1150	20	BDL
BDL	BDL	1440	BDL	BDL
BDL	BDL	1500	BDL	BDL
BDL	BDL	329	11	BDL
BDL	BDL	435	17	BDL
BDL	BDL	570	15	BDL
BDL	BDL	1430	21	BDL
BDL	BDL	1150	BDL	BDL
BDL	BDL	1370	28	BDL
BDL	BDL	971	17	BDL

Appendix C: Sample List

Table C.1 Sample Type Abbreviations

Sample Type Abbreviations	
Cu(1)	Native Copper Bathed in Distilled Deionized water
Cu(2)	Native Copper Bathed in HCl
DC	Drill Core
Float Grab	Sample (from float) Collected for its mineralization
Grab	Sample Collected for its mineralization
HS	Hand Specimen
ICP-FA	ICP and Fire Assay
NA	Collected but not analysed
SMC	Supergene Mill Concentrate

Table C.2 Unit Abbreviations

Unit Abbreviations	
Cu	Native Copper
HG	Maple Leaf Pluton Hypogene Ore
HiSG	Supergene enriched in Gold
Idyke	Felsic Dyke
Int	Black Lake Suite Intrusives
JRct	Jurassic Kemess Member Dacitic Crystal Tuff
JRt	Jurassic South Kemess Member Tuffs
LMSG	Lower-Middle Supergene Zone
LSG	Lower Supergene Zone
Mdyke	Mafic Dykes
MQFP	Mega-Quartz-Feldspar-Porphyry
Pa	Permian Asitka Group Andesite
Pbx	Pyroxene Basalt
Pc	Permian Asitka Group Chert
Pl	Permian Asitka Group Limestone
Pr	Permian Asitka Group Rhyolite
QFPI	Quartz-Feldspar-Porphyry
SG	Maple Leaf Pluton Supergene Ore
TRb	Triassic Savage Mountain Formation Basalt
UMSG	Upper-Middle Supergene Zone
USG	Upper Supergene Zone

Sample Number	Unit	Thin Section	Geochemistry	Eastings	Northings	Sample Type	Collector
90 - 15 - 44	SG	None	None			DC	Chris Rogers
90 - 15 - 46	SG	None	None			DC	Chris Rogers
90 - 15 - 63	SG	None	None			DC	Chris Rogers
90 - 15 - 74	HG	Polished	NA			DC	Chris Rogers
90 - 15 - 96	HG	None	None			DC	Chris Rogers
90 - 15 - 106	HG	Polished	NA			DC	Chris Rogers
90 - 15 - 122	HG	Polished	NA			DC	Chris Rogers
90 - 15 - 128	Pb	None	None			DC	Chris Rogers
90 - 15 - 153	HG	Polished	NA			DC	Chris Rogers
90 - 17 - 11	HG	Polished	NA			DC	Chris Rogers
90 - 17 - 19	HG	None	None			DC	Chris Rogers
90 - 17 - 27	HG	None	None			DC	Chris Rogers
90 - 17 - 32	HG	Polished	NA			DC	Chris Rogers
90 - 17 - 57	HG	Polished	NA			DC	Chris Rogers
90 - 17 - 69	HG	None	None			DC	Chris Rogers
90 - 17 - 76	HG	None	None			DC	Chris Rogers
90 - 17 - 82	HG	Polished	NA			DC	Chris Rogers
90 - 17 - 88	HG	None	None			DC	Chris Rogers
90 - 17 - 96	HG	None	None			DC	Chris Rogers
90 - 17 - 105	HG	Polished	NA			DC	Chris Rogers
90 - 17 - 122	HG	None	None			DC	Chris Rogers
90 - 17 - 133	Pb	None	None			DC	Chris Rogers
90 - 17 - 145	Pb	Polished	None			DC	Chris Rogers
91 - 73 - 46	SG	Polished	None			DC	Chris Rogers
91 - 73 - 78	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 89	SG	None	None			DC	Chris Rogers
91 - 73 - 99	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 107	HG	None	None			DC	Chris Rogers
91 - 73 - 113	HG	None	None			DC	Chris Rogers
91 - 73 - 125	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 148	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 175	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 180	HG	None	None			DC	Chris Rogers
91 - 73 - 200	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 219	HG	Polished	NA			DC	Chris Rogers
91 - 73 - 243	Pb	None	None			DC	Chris Rogers
91 - 75 - 10	SG	Polished	None			DC	Chris Rogers
91 - 75 - 13	HG	Polished	NA			DC	Chris Rogers
91 - 75 - 21	HG	None	None			DC	Chris Rogers
91 - 75 - 33	HG	Polished	NA			DC	Chris Rogers
91 - 75 - 62	HG	Polished	NA			DC	Chris Rogers
91 - 75 - 91	HG	Polished	NA			DC	Chris Rogers
91 - 75 - 98	HG	None	None			DC	Chris Rogers
91 - 75 - 113	HG	Polished	NA			DC	Chris Rogers
91 - 75 - 120	HG	None	None			DC	Chris Rogers
91 - 75 - 121	HG	None	None			DC	Chris Rogers
91 - 82 - 12	Pxb	Polished	NA			DC	Chris Rogers
91 - 82 - 38	Pxb	Polished	None			DC	Chris Rogers
91 - 82 - 85	TRss	Polished	None			DC	Chris Rogers
91 - 82 - 146	SG	Polished	None			DC	Chris Rogers
91 - 82 - 153	HG	Polished	NA			DC	Chris Rogers
91 - 82 - 162	HG	None	None			DC	Chris Rogers
91 - 82 - 168	HG	None	None			DC	Chris Rogers
91 - 82 - 174	HG	Polished	NA			DC	Chris Rogers
91 - 82 - 188	Pb	None	None			DC	Chris Rogers
91 - 92 - 6	Pxb	Polished	ICP90			DC	Chris Rogers
91 - 93 - 10	SG	None	None			DC	Chris Rogers
91 - 93 - 16	SG	Polished	None			DC	Chris Rogers
91 - 93 - 27	SG	None	None			DC	Chris Rogers
91 - 93 - 67	HG	Polished	NA			DC	Chris Rogers
91 - 93 - 79	HG	Polished	NA			DC	Chris Rogers
91 - 93 - 90	HG	None	None			DC	Chris Rogers
91 - 93 - 104	HG	Polished	NA			DC	Chris Rogers
91 - 93 - 115	Pb	Polished	None			DC	Chris Rogers
91 - 96 - 5	HG	Polished	NA			DC	Chris Rogers

Sample Number	Unit	Thin Section	Geochemistry	Eastings	Northings	Sample Type	Collector
91 - 96 - 16	HG	None	None			DC	Chris Rogers
91 - 96 - 29	HG	Polished	NA			DC	Chris Rogers
91 - 96 - 42	HG	None	None			DC	Chris Rogers
91 - 96 - 48	HG	Polished	NA			DC	Chris Rogers
91 - 96 - 64	HG	None	None			DC	Chris Rogers
91 - 96 - 67	HG	None	None			DC	Chris Rogers
91 - 96 - 78	HG	Polished	NA			DC	Chris Rogers
91 - 96 - 84	HG	None	None			DC	Chris Rogers
91 - 96 - 103	HG	Polished	NA			DC	Chris Rogers
91 - 96 - 119	HG	None	None			DC	Chris Rogers
91 - 96 - 125	HG	Polished	NA			DC	Chris Rogers
91 - 96 - 140	Pb	Polished	None			DC	Chris Rogers
91 - 96 - 153	HG	None	NA			DC	Chris Rogers
91 - 96 - 169	HG	None	None			DC	Chris Rogers
91 - 96 - 178	HG	Polished	NA			DC	Chris Rogers
91 - 96 - 187	Pb	None	None			DC	Chris Rogers
91 - 96 - 215	Pb	Polished	None			DC	Chris Rogers
91 - 113 - 20	TRs	None	None			DC	Chris Rogers
91 - 113 - 68	SG	None	None			DC	Chris Rogers
91 - 113 - 78	SG	None	None			DC	Chris Rogers
91 - 113 - 101	SG	Polished	None			DC	Chris Rogers
91 - 113 - 122	HG	Polished	NA			DC	Chris Rogers
91 - 113 - 142	SG	Polished	None			DC	Chris Rogers
91 - 113 - 151	SG	None	None			DC	Chris Rogers
91 - 113 - 157	HG	None	None			DC	Chris Rogers
91 - 113 - 170	HG	Polished	NA			DC	Chris Rogers
91 - 113 - 195	HG	Polished	NA			DC	Chris Rogers
91 - 113 - 218	HG	Polished	NA			DC	Chris Rogers
91 - 113 - 228	SG	None	None			DC	Chris Rogers
91 - 113 - 246	HG	Polished	NA			DC	Chris Rogers
91 - 113 - 246	HG	None	None			DC	Chris Rogers
91 - 113 - 259	HG	None	None			DC	Chris Rogers
91 - 113 - 270	HG	Polished	NA			DC	Chris Rogers
91 - 117 - 18	TRs	None	None			DC	Chris Rogers
91 - 117 - 22	TRs	None	None			DC	Chris Rogers
91 - 117 - 23	TRs	None	None			DC	Chris Rogers
91 - 117 - 29	TRs	Polished	None			DC	Chris Rogers
91 - 117 - 85	TRs	None	None			DC	Chris Rogers
91 - 117 - 94	SG	Polished	None			DC	Chris Rogers
91 - 117 - 106	HG	Polished	NA			DC	Chris Rogers
91 - 117 - 107	HG	None	None			DC	Chris Rogers
91 - 117 - 115	HG	Polished	NA			DC	Chris Rogers
91 - 122 - 10	Pxb	Polished	None			DC	Chris Rogers
91 - 122 - 59	TRs	Polished	None			DC	Chris Rogers
91 - 122 - 79	TRs	None	None			DC	Chris Rogers
91 - 122 - 90	Pxb	None	None			DC	Chris Rogers
91 - 122 - 116	SG	Polished	None			DC	Chris Rogers
91 - 122 - 128	SG	None	None			DC	Chris Rogers
91 - 122 - 144	SG	Polished	None			DC	Chris Rogers
91 - 122 - 151	HG	Polished	NA			DC	Chris Rogers
91 - 122 - 175	HG	Polished	NA			DC	Chris Rogers
91 - 122 - 180	HG	None	None			DC	Chris Rogers
91 - 122 - 196	HG	None	None			DC	Chris Rogers
91 - 122 - 196	HG	Polished	NA			DC	Chris Rogers
91 - 122 - 213	HG	None	None			DC	Chris Rogers
91 - 122 - 225	HG	Polished	NA			DC	Chris Rogers
91 - 122 - 232	HG	None	None			DC	Chris Rogers
91 - 122 - 250	HG	Polished	NA			DC	Chris Rogers
91 - 122 - 275	HG	Polished	NA			DC	Chris Rogers
91 - 125 - 34	TRs	None	None			DC	Chris Rogers
91 - 125 - 46	SG	None	None			DC	Chris Rogers
91 - 125 - 168	SG	None	None			DC	Chris Rogers
91 - 125 - 169	HG	None	None			DC	Chris Rogers
91 - 125 - 175	HG	Polished	NA			DC	Chris Rogers
91 - 125 - 180	HG	None	None			DC	Chris Rogers

Sample Number	Unit	Thin Section	Geochemistry	Eastings	Northings	Sample Type	Collector
91 - 125 - 183	HG	None	None			DC	Chris Rogers
91 - 125 - 200	HG	Polished	NA			DC	Chris Rogers
91 - 125 - 219	HG	None	None			DC	Chris Rogers
91 - 125 - 232	HG	Polished	NA			DC	Chris Rogers
91 - 125 - 241	HG	None	None			DC	Chris Rogers
91 - 129 - 5	HG	Polished	None			DC	Chris Rogers
91 - 129 - 12	TRs	None	None			DC	Chris Rogers
91 - 129 - 22	TRs	Polished	None			DC	Chris Rogers
91 - 129 - 23	TRs	None	None			DC	Chris Rogers
91 - 129 - 29	SG	None	None			DC	Chris Rogers
91 - 129 - 125	SG	None	None			DC	Chris Rogers
91 - 129 - 174	SG	None	None			DC	Chris Rogers
91 - 129 - 194	HG	None	None			DC	Chris Rogers
91 - 129 - 198	HG	None	None			DC	Chris Rogers
91 - 129 - 203	HG	Polished	NA			DC	Chris Rogers
91 - 129 - 216	HG	None	None			DC	Chris Rogers
91 - 129 - 225	HG	Polished	NA			DC	Chris Rogers
91 - 129 - 250	HG	None	NA			DC	Chris Rogers
91 - 129 - 266	HG	None	None			DC	Chris Rogers
91 - 129 - 275	HG	Polished	NA			DC	Chris Rogers
91 - 129 - 300	HG	Polished	NA			DC	Chris Rogers
91 - 129 - 317	HG	None	None			DC	Chris Rogers
91 - 129 - 325	HG	Polished	NA			DC	Chris Rogers
91 - 129 - 332	HG	None	None			DC	Chris Rogers
91 - 129 - 350	HG	Polished	NA			DC	Chris Rogers
91 - 129 - 360	HG	None	None			DC	Chris Rogers
91 - 129 - 375	HG	Polished	NA			DC	Chris Rogers
98 - CRo - 1 -	1 Mdyke	Polished	ICP90	636597	6320587	HS	Chris Rogers
98 - CRo - 1 -	1 Pc	Polished	None	636597	6320587	HS	Chris Rogers
98 - CRo - 2 -	1 Pc	None	None	636597	6320595	HS	Chris Rogers
98 - CRo - 2 -	1 Mdyke	None	None	636597	6320595	HS	Chris Rogers
98 - CRo - 2 -	2 Pc	None	None	636591	6320594	HS	Chris Rogers
98 - CRo - 2 -	2 Mdyke	None	None	636591	6320594	HS	Chris Rogers
98 - CRo - 2 -	3 Pc	None	None	636561	6320589	HS	Chris Rogers
98 - CRo - 2 -	4 Pc	Polished	None	636540	6320578	HS	Chris Rogers
98 - CRo - 2 -	4 Mdyke	Polished	None	636540	6320578	HS	Chris Rogers
98 - CRo - 2 -	5 Pc	None	None	636418	6320594	HS	Chris Rogers
98 - CRo - 2 -	6 Mdyke	None	None	636531	6320577	HS	Chris Rogers
98 - CRo - 2 -	6 Pc	None	None	636531	6320577	HS	Chris Rogers
98 - CRo - 2 -	7 Pc	None	None	636409	6320562	HS	Chris Rogers
98 - CRo - 2 -	7 Mdyke	Polished	ICP90	636409	6320562	HS	Chris Rogers
98 - CRo - 2 -	8 Idyke	Polished	None	636363	6320550	HS	Chris Rogers
98 - CRo - 2 -	8 Mdyke	Polished	None	636363	6320550	HS	Chris Rogers
98 - CRo - 2 -	8 Pc	None	None	636363	6320550	HS	Chris Rogers
98 - CRo - 3 -	1 Pb	Polished	ICP90	635880	6320820	HS	Chris Rogers
98 - CRo - 3 -	1 QFPs	Polished	None	635880	6320820	HS	Chris Rogers
98 - CRo - 3 -	2 PI	Polished	None	635731	6320833	HS	Chris Rogers
98 - CRo - 3 -	2 PI	Polished	None	635786	6320890	HS	Chris Rogers
98 - CRo - 3 -	3 TRb	Polished	ICP90	635906	6321167	HS	Chris Rogers
98 - CRo - 3 -	4 TRs	Polished	None	635923	6321364	HS	Chris Rogers
98 - CRo - 3 -	5 TRb	Polished	None	636375	6321710	HS	Chris Rogers
98 - CRo - 3 -	6 TRb	None	None	636442	6321435	HS	Chris Rogers
98 - CRo - 3 -	7 QFP	None	None	636587	6321531	HS	Chris Rogers
98 - CRo - 3 -	7 TRb	None	None	636587	6321531	HS	Chris Rogers
98 - CRo - 3 -	8 TRb	Polished	None	636469	6321710	HS	Chris Rogers
98 - CRo - 3 -	9 TRb	None	None	636347	6321836	HS	Chris Rogers
98 - CRo - 3 -	10 TRmd	None	None	636091	6321873	HS	Chris Rogers
98 - CRo - 4 -	1 TRb	None	None	636244	6320794	HS	Chris Rogers
98 - CRo - 4 -	2 TRb	None	None	636486	6320830	HS	Chris Rogers
98 - CRo - 4 -	3 TRb	None	None	636189	6320839	HS	Chris Rogers
98 - CRo - 5 -	1 TRb	None	None	636730	6321232	HS	Chris Rogers
98 - CRo - 5 -	2 TRb	Polished	ICP90	636750	6321524	HS	Chris Rogers
98 - CRo - 5 -	3 TRb	None	None	636302	6321376	HS	Chris Rogers
98 - CRo - 5 -	4 TRmd	Polished	None	636091	6321873	HS	Chris Rogers
98 - CRo - 5 -	5 TRb	None	None	635906	6322012	HS	Chris Rogers

Sample Number			Unit	Thin Section	Geochemistry	Eastings	Northings	Sample Type	Collector
98 - CRo -	5 -	6	TRb	None	None	635268	6322263	HS	Chris Rogers
98 - CRo -	5 -	7	Mdyke	None	None	634926	6322698	HS	Chris Rogers
98 - CRo -	5 -	7	TRb	Polished	ICP90	634926	6322698	HS	Chris Rogers
98 - CRo -	5 -	8	JRI	Polished	None	634536	6322709	HS	Chris Rogers
98 - CRo -	5 -	9	TRb	None	None	635551	6321858	HS	Chris Rogers
98 - CRo -	6 -	1	Idyke	None	None	634886	6323053	HS	Chris Rogers
98 - CRo -	6 -	1	Int	Polished	None	634886	6323053	HS	Chris Rogers
98 - CRo -	6 -	2	Int	Polished	ICP90	634821	6322914	HS	Chris Rogers
98 - CRo -	6 -	3	Pc	None	None	634437	6322669	HS	Chris Rogers
98 - CRo -	6 -	4	LQFP	Polished	None	634315	6322644	HS	Chris Rogers
98 - CRo -	6 -	4	Pb	None	None	634315	6322644	HS	Chris Rogers
98 - CRo -	6 -	5	Pb	None	None	634011	6323010	HS	Chris Rogers
98 - CRo -	6 -	6	Idyke	Polished	None	634059	6322752	HS	Chris Rogers
98 - CRo -	6 -	6	JRI	None	None	634059	6322752	HS	Chris Rogers
98 - CRo -	6 -	7	JRI	Polished	None	634045	6322908	HS	Chris Rogers
98 - CRo -	6 -	8	JRI	Polished	None	634113	6322723	HS	Chris Rogers
98 - CRo -	6 -	8	QFPI	Polished	None	634113	6322723	HS	Chris Rogers
98 - CRo -	6 -	9	JRI	None	None	634164	6322615	HS	Chris Rogers
98 - CRo -	6 -	10	Pc	Polished	None	635619	6321950	HS	Chris Rogers
98 - CRo -	7 -	1	Int	Polished	ICP90	631374	6326320	HS	Chris Rogers
98 - CRo -	8 -	1	JRI	None	None	634630	6322164	HS	Chris Rogers
98 - CRo -	8 -	2	Pc	None	None	634718	6322124	HS	Chris Rogers
98 - CRo -	8 -	3	JRI	None	None	634212	6322316	HS	Chris Rogers
98 - CRo -	8 -	4	Int	Polished	ICP90	634256	6321966	HS	Chris Rogers
98 - CRo -	8 -	4	JRI	None	None	634256	6321966	HS	Chris Rogers
98 - CRo -	8 -	5	TRb	None	None	634432	6321935	HS	Chris Rogers
98 - CRo -	8 -	7	TRb	None	None	633964	6322453	HS	Chris Rogers
98 - CRo -	8 -	8	JRI	None	None	633817	6322580	HS	Chris Rogers
98 - CRo -	8 -	9	TRb	Polished	None	633188	6322519	HS	Chris Rogers
98 - CRo -	8 -	10	TRb	None	None	633206	6322314	HS	Chris Rogers
98 - CRo -	8 -	11	TRb	Polished	None	633220	6322097	HS	Chris Rogers
98 - CRo -	8 -	12	JRt	None	None	633603	6321887	HS	Chris Rogers
98 - CRo -	9 -	1	Idyke	Polished	None	637837	6321333	HS	Chris Rogers
98 - CRo -	9 -	1	PI	None	None	637837	6321333	HS	Chris Rogers
98 - CRo -	9 -	2	JRt	Polished	None	636348	6318480	HS	Chris Rogers
98 - CRo -	9 -	3	JRt	None	None	635859	6318496	HS	Chris Rogers
98 - CRo -	9 -	4	JRt	None	None	635627	6318522	HS	Chris Rogers
98 - CRo -	9 -	5	OB	None	None	635382	6318382	HS	Chris Rogers
98 - CRo -	9 -	6	OB	None	None	635116	6317391	HS	Chris Rogers
98 - CRo -	10 -	1	Pb	None	None	634274	6320403	HS	Chris Rogers
98 - CRo -	10 -	2	JRt	None	None	633737	6320723	HS	Chris Rogers
98 - CRo -	10 -	3	PI	None	None	633592	6320988	HS	Chris Rogers
98 - CRo -	10 -	4	JRt	None	None	633547	6321152	HS	Chris Rogers
98 - CRo -	10 -	5	Pb	Polished	ICP90	633686	6321296	HS	Chris Rogers
98 - CRo -	10 -	6	Pa	Polished	None	633834	6321569	HS	Chris Rogers
98 - CRo -	10 -	7	TRb	None	None	633712	6321969	HS	Chris Rogers
98 - CRo -	10 -	8	TRb	None	None	633652	6321677	HS	Chris Rogers
98 - CRo -	10 -	9	Pa	None	None	633479	6321293	HS	Chris Rogers
98 - CRo -	10 -	10	Pa	Polished	None	633412	6321017	HS	Chris Rogers
98 - CRo -	10 -	11	Pa	None	None	633301	6320791	HS	Chris Rogers
98 - CRo -	10 -	12	PI	None	None	634245	6320225	HS	Chris Rogers
98 - CRo -	11 -	1	Pa	None	None	631339	6321966	HS	Chris Rogers
98 - CRo -	11 -	1	Pt	Polished	ICP90	631339	6321966	HS	Chris Rogers
98 - CRo -	11 -	2	Pa	None	None	631328	6322036	HS	Chris Rogers
98 - CRo -	11 -	2	Pt	None	None	631328	6322036	HS	Chris Rogers
98 - CRo -	11 -	3	Pa	None	None	631284	6322136	HS	Chris Rogers
98 - CRo -	11 -	4	Pa	Polished	ICP90	631522	6322590	HS	Chris Rogers
98 - CRo -	11 -	5	Pa	Polished	None	631613	6322458	HS	Chris Rogers
98 - CRo -	11 -	6	Pa	None	None	631728	6322372	HS	Chris Rogers
98 - CRo -	11 -	7	Pa	None	None	632248	6322978	HS	Chris Rogers
98 - CRo -	11 -	8	Pa	None	None	631587	6322865	HS	Chris Rogers
98 - CRo -	12 -	1	JRt	None	None	636352	6320560	HS	Chris Rogers
98 - CRo -	12 -	2	JRt	None	None	636294	6320561	HS	Chris Rogers
98 - CRo -	12 -	3	Idyke	Polished	None	636252	6320560	HS	Chris Rogers
98 - CRo -	12 -	3	Pc	None	None	636252	6320560	HS	Chris Rogers

Sample Number	Unit	Thin Section	Geochemistry	Eastings	Northings	Sample Type	Collector
98 - CRo - 12 - 4	Int	None	None	636196	6320566	HS	Chris Rogers
98 - CRo - 12 - 5	Idyke	Polished	None	636113	6320517	HS	Chris Rogers
98 - CRo - 12 - 5	Pc	None	None	636113	6320517	HS	Chris Rogers
98 - CRo - 12 - 6	Pc	None	None	636043	6320499	HS	Chris Rogers
98 - CRo - 12 - 7	Pc	None	None	636035	6320475	HS	Chris Rogers
98 - CRo - 12 - 8	JRt	Polished	None	636028	6320296	HS	Chris Rogers
98 - CRo - 12 - 9	Pc	None	None	636138	6320454	HS	Chris Rogers
98 - CRo - 12 - 10	JRt	None	None	636040	6320327	HS	Chris Rogers
98 - CRo - 13 - 1	HG	Polished	None	636735	6319880	HS	Chris Rogers
98 - CRo - 13 - 2	JRt	Polished	ICP90	636478	6319964	HS	Chris Rogers
98 - CRo - 13 - 3	JRt	None	None	636409	6320064	HS	Chris Rogers
98 - CRo - 13 - 4	JRt	None	None	636482	6320103	HS	Chris Rogers
98 - CRo - 13 - 5	OI	Polished	ICP90	636623	6319831	HS	Chris Rogers
98 - CRo - 13 - 6	JRt	None	None	636374	6319969	HS	Chris Rogers
98 - CRo - 13 - 6	OI	None	None	636374	6319969	HS	Chris Rogers
98 - CRo - 13 - 7	JRt	Polished	None	636129	6320013	HS	Chris Rogers
98 - CRo - 13 - 8	JRt	None	None	636158	6320088	HS	Chris Rogers
98 - CRo - 13 - 9	JRt	Polished	ICP90	636067	6320219	HS	Chris Rogers
98 - CRo - 14 - 1	SG	Polished	None	636693	6319935	HS	Chris Rogers
98 - CRo - 14 - 2	JRt	Polished	None	636325	6320338	HS	Chris Rogers
98 - CRo - 14 - 2	Mdyke	Polished	ICP90	636325	6320338	HS	Chris Rogers
98 - CRo - 14 - 3	JRt	None	None	636035	6320320	HS	Chris Rogers
98 - CRo - 14 - 3	LC	None	None	636035	6320320	HS	Chris Rogers
98 - CRo - 15 - 1	TRb	None	None	634698	6322766	HS	Chris Rogers
98 - CRo - 15 - 2	JRI	Polished	None	634429	6322472	HS	Chris Rogers
98 - CRo - 15 - 2	QFPI	Polished	None	634429	6322472	HS	Chris Rogers
98 - CRo - 15 - 3	JRI	None	None	634775	6322546	HS	Chris Rogers
98 - CRo - 15 - 4	Pb	None	None	635342	6321098	HS	Chris Rogers
98 - CRo - 17 - 1	Pa	Polished	None	634047	6317737	HS	Chris Rogers
98 - CRo - 17 - 2	Int	None	None	633873	6317984	HS	Chris Rogers
98 - CRo - 17 - 3	Int	None	None	634022	6318193	HS	Chris Rogers
98 - CRo - 17 - 4	Int	None	None	633134	6317895	HS	Chris Rogers
98 - CRo - 17 - 5	Pa	None	None	632040	6319299	HS	Chris Rogers
98 - CRo - 18 - 1	Pa	None	None	633393	6317726	HS	Chris Rogers
98 - CRo - 18 - 2	Pa	None	None	631362	6321509	HS	Chris Rogers
98 - CRo - 18 - 3	Pa	None	None	631136	6320685	HS	Chris Rogers
98 - CRo - 18 - 4	Mdyke	None	None	631813	6319674	HS	Chris Rogers
98 - CRo - 18 - 4	Int	Polished	ICP90	631813	6319674	HS	Chris Rogers
98 - CRo - 18 - 5	Int	None	None	632086	6319352	HS	Chris Rogers
98 - CRo - 18 - 6	Int	None	None	632124	6319717	HS	Chris Rogers
98 - CRo - 18 - 6	Mdyke	Polished	None	632124	6319717	HS	Chris Rogers
98 - CRo - 19 - 1	PI	None	None	634676	6320010	HS	Chris Rogers
98 - CRo - 19 - 2	Pa	None	None	634035	6320057	HS	Chris Rogers
98 - CRo - 19 - 3	JRa	None	None	634300	6319689	HS	Chris Rogers
98 - CRo - 19 - 4	JRa	Polished	None	634193	6319202	HS	Chris Rogers
98 - CRo - 20 - 1	Pb	Polished	None	635028	6320642	HS	Chris Rogers
98 - CRo - 20 - 2	Pb	None	None	634668	6320717	HS	Chris Rogers
98 - CRo - 20 - 3	Pb	None	None	634954	6320478	HS	Chris Rogers
98 - CRo - 20 - 4	Pb	Polished	None	634974	6320495	HS	Chris Rogers
98 - CRo - 20 - 5	Pb	Polished	None	635098	6320468	HS	Chris Rogers
98 - CRo - 20 - 6	PI	None	None	634820	6320508	HS	Chris Rogers
98 - CRo - 21 - 1	OI	Polished	None	636299	6320118	HS	Chris Rogers
98 - CRo - 21 - 2	Pb	None	None	637100	6321130	HS	Chris Rogers
98 - CRo - 21 - 3	Mdyke	None	None	636640	6320661	HS	Chris Rogers
98 - CRo - 21 - 4	Pc	None	None	636555	6320584	HS	Chris Rogers
98 - CRo - 21 - 4	Mdyke	Polished	None	636555	6320584	HS	Chris Rogers
98 - CRo - 21 - 5	Mdyke	Polished	ICP90	636625	6320559	HS	Chris Rogers
98 - CRo - 21 - 6	HG	None	None	636599	6320444	HS	Chris Rogers
98 - CRo - 21 - 7	HG	None	None	636724	6320338	HS	Chris Rogers
98 - CRo - 21 - 8	HG	None	None	636543	6320333	HS	Chris Rogers
98 - CRo - 21 - 9	LC	None	None	636404	6320174	HS	Chris Rogers
98 - CRo - 21 - 9		None	None	636404	6320174	HS	Chris Rogers
98 - CRo - 22 - 1	Pa	None	None	631587	6322386	HS	Chris Rogers
98 - CRo - 22 - 2	Pa	None	None	631946	6322366	HS	Chris Rogers
98 - CRo - 22 - 2	Pa	None	None	631946	6322366	HS	Chris Rogers

Sample Number			Unit	Thin Section	Geochemistry	Eastings	Northings	Sample Type	Collector
98 - CRo - 22 - 3 Pr			3 Pr	Polished	None	631582	6322142	HS	Chris Rogers
98 - CRo - 22 - 4 Pr			4 Pr	None	None	631843	6321882	HS	Chris Rogers
98 - CRo - 22 - 5 Pr			5 Pr	None	None	632165	6321780	HS	Chris Rogers
98 - CRo - 22 - 6 Pr			6 Pr	Polished	None	632360	6321546	HS	Chris Rogers
98 - CRo - 22 - 7 Pa			7 Pa	None	None	632492	6321252	HS	Chris Rogers
98 - CRo - 22 - 8 Pa			8 Pa	None	None	632398	6320836	HS	Chris Rogers
98 - CRo - 23 - 1 Pa			1 Pa	None	None	632022	6322001	HS	Chris Rogers
98 - CRo - 25 - 2 Pa			2 Pa	Polished	None	632461	6322267	HS	Chris Rogers
98 - CRo - 25 - 3 JRt			3 JRt	None	None	632461	6322267	HS	Chris Rogers
98 - CRo - 25 - 3 Pa			3 Pa	None	None	632461	6322267	HS	Chris Rogers
98 - CRo - 25 - 3 TRb			3 TRb	Polished	ICP90	632461	6322267	HS	Chris Rogers
98 - CRo - 25 - 4 Pa			4 Pa	Polished	None	632680	6322435	HS	Chris Rogers
98 - CRo - 25 - 4 TRb			4 TRb	None	None	632680	6322435	HS	Chris Rogers
98 - CRo - 25 - 5 TRb			5 TRb	Polished	ICP90	632900	6322411	HS	Chris Rogers
98 - CRo - 25 - 6 PI			6 PI	None	None	633922	6320332	HS	Chris Rogers
98 - CRo - 26 - 1 PI			1 PI	None	None	632457	6321058	HS	Chris Rogers
98 - CRo - 26 - 2 Pa			2 Pa	Polished	None	632802	6321370	HS	Chris Rogers
98 - CRo - 26 - 3 Pa			3 Pa	None	None	632954	6321965	HS	Chris Rogers
98 - CRo - 26 - 4 Idyke			4 Idyke	None	None	633001	6322046	HS	Chris Rogers
98 - CRo - 26 - 4 Pa			4 Pa	None	None	633001	6322046	HS	Chris Rogers
98 - CRo - 26 - 4 PI			4 PI	None	None	633001	6322046	HS	Chris Rogers
98 - CRo - 26 - 5 Pa			5 Pa	None	None	633450	6321568	HS	Chris Rogers
98 - CRo - 26 - 5 TRb			5 TRb	None	None	633450	6321568	HS	Chris Rogers
98 - CRo - 26 - 6 TRb			6 TRb	Polished	ICP90	633428	6321475	HS	Chris Rogers
98 - CRo - 26 - 7 Pt			7 Pt	Polished	None	632962	6321510	HS	Chris Rogers
98 - CRo - 26 - 7 Pa			7 Pa	None	None	632962	6321510	HS	Chris Rogers
98 - CRo - 26 - 7 Int			7 Int	Polished	ICP90	632962	6321510	HS	Chris Rogers
98 - CRo - 26 - 8 Pa			8 Pa	None	None	632834	6321551	HS	Chris Rogers
98 - CRo - 26 - 8 Idyke			8 Idyke	None	None	632834	6321551	HS	Chris Rogers
98 - CRo - 49 - 1 USG			1 USG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 2 USG			2 USG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 3 USG			3 USG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 4 UMSG			4 UMSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 5 UMSG			5 UMSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 6 UMSG			6 UMSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 7 LSG			7 LSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 8 LSG			8 LSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 9 LSG			9 LSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 10 LMSG			10 LMSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 11 LMSG			11 LMSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 12 LMSG			12 LMSG	Polished	ICP-FA			HS	Chris Rogers
98 - CRo - 49 - 13a Cu			13a Cu	Polished	ICP-FA			Cu(1)	Chris Rogers
98 - CRo - 49 - 13b Cu			13b Cu	Polished	ICP-FA			Cu(1)	Chris Rogers
98 - CRo - 49 - 13c Cu			13c Cu	Polished	ICP-FA			Cu(2)	Chris Rogers
98 - CRo - 49 - 13d Cu			13d Cu	Polished	ICP-FA			Cu(2)	Chris Rogers
ROX 22040 (Kemess West)				None	ICP-FA	634886	6323053	Grab	Chris Rogers
ROX 22041 (Kemess West)				None	ICP-FA	634821	6322914	Chip	Chris Rogers
ROX 22042 (SW of RAT)				None	ICP-FA	634164	6322615	Grab	Chris Rogers
ROX 22043 (RAT)				None	ICP-FA	634315	6322644	Float Grab	Chris Rogers
ROX 22044 (SW of RAT)				None	ICP-FA	634045	6322908	Grab	Chris Rogers
ROX 22053 (Kemess Arch)	PI			None	ICP-FA			Grab	Chris Rogers
ROX 22054 (Kemess Arch)	PI			None	ICP-FA			HS	Chris Rogers
ROX 22055 (Pyrite)	Pa			None	ICP-FA	632398	6320863	Grab	Chris Rogers
ROX 22206	HiSG			Polished	ICP-FA			HS	Jacques Houle
ROX 22207	HiSG			Polished	ICP-FA			HS	Jacques Houle
ROX 22208	HiSG			Polished	ICP-FA			HS	Jacques Houle
ROX 22209	HiSG			Polished	ICP-FA			HS	Jacques Houle
ROX 22210	HiSG			Polished	ICP-FA			HS	Jacques Houle
ROX 22213	SG			Polished	ICP-FA			SMC	Jacques Houle
ROX 22214	SG			Polished	ICP-FA			SMC	Jacques Houle
ROX 22215	SG			Polished	ICP-FA			SMC	Jacques Houle

NOTE TO USERS

Oversize maps and charts are microfilmed in sections in the following manner:

LEFT TO RIGHT, TOP TO BOTTOM, WITH SMALL OVERLAPS

This reproduction is the best copy available.

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Minerals Division
Geological Survey Branch

Ontario-Carleton
Geoscience Centre

Kemess
Mines Inc.
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GEOLOGY OF THE KEMESS SOUTH Cu-Au PORPHYRY DEPOSIT, AND VICINITY FROM DUNCAN LAKE TO KEMESS CREEK.

NTS 94E/2

by Chris Rogers

SCALE 1:10 000

VOLCANIC AND SEDIMENTARY ROCKS

ERA

Lower Jurassic

Hazelton Group

Toodoggone Formation

Saunders Member

Tuff-Epiclastic Unit: Maroon to light green sandstone and/or pebble conglomerate, interbedded with maroon to blood red ash and lapilli tuff. Poorly indurated lithic tuffs form crudely layered, very thick beds that are maroon to brick red. The amount of lithic fragments in the tuff ranges from 5 to 50%. The dominant fragments are aphanitic, very light green and scale-like, between 5 and 20 cm long and 1 to 4 mm thick. Locally the tuff contains rare quartz and biotite crystals. There are also rare sub-angular to sub-rounded basaltic looking clasts that make up less than 1 % of the unit and are dark green; some have pyroxene phenocrysts. The contact between the supergene zone and the tuff-epiclastic unit is gradational over approximately 1 m with a decrease of quartz grain content from approximately 5% in the supergene zone to trace amounts in the tuff-epiclastic unit. The Plagioclase content increases from virtually none in the supergene zone to more than 5% in the tuff-epiclastic unit. The tuff-epiclastic unit is best exposed in the open pit. Other exposures include one west of the Duncan fault, where bedded epiclastic rocks crop out sporadically in a small area, approximately 100 by 200 m. They consist of a relatively flat-lying bedded sequence more than 25 m thick exposed along an unnamed creek. The other exposure is along Kemess Creek, below the Kemess Arch, to just west of the mill where the unit is covered by glacial till.

The epiclastic layers are composed mainly of sandstone and siltstone, and make up approximately 20% of the unit. Interbeds are thinly laminated to thickly bedded (1 mm to >100 cm thick) and can be up to several metres for both the tuffs and sandstones. Grey green and maroon epiclastic rocks comprise distinctive bedded intervals within the comparatively more massive, bedded maroon tuffs. They are typically medium to thickly bedded with thinner, parallel laminated and graded sections and are generally more competent than the friable tuffs. The epiclastic layers are about 60% reddish gray sandstone, with finer siltstone and conglomeratic layers. Approximately 90% of the grains are 1 to 5 mm in diam, reddish gray in color, sub-rounded to rounded, and compositionally similar to those of the tuffs. The epiclastic rocks also contain local quartz grains and small clasts of basalt. The matrix of the sediments consists of silt-sized material. Local brick red zones in the epiclastic units contain about 50% matrix material, these less mature units make up about 25% of the tuff-epiclastic unit. Locally, there are light green sandstone layers; these are generally the thickest of all the sedimentary layers, exceeding 1 m. They are uncommon and comprise approximately 5% of the tuff-epiclastic unit. Grains are predominately quartz and feldspar and less than 2 mm in diam. These layers are the most

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Early Jurassic

Maple Leaf Pluton: quartz monzonite approximately 10 to 15% quartz, 45% plagioclase, 10 to 15% potassium feldspar, and 20 to 25%, accessory minerals include chlorite and local hydrothermal biotite; quartz veins make up approximately 5% of the rock. The ore zone measures 1.7 km east to west, 650 m north to south, dips approximately 30 degrees to the southwest, and varies in thickness from approximately 50 m in the south to over 250 m.

1- Supergene Zone: a red oxidized zone containing chalcocite and two forms of native copper, as large sheets, and as tiny disseminated flecks of native copper termed "pin prick copper". This zone is subdivided into three sub-zones. The lowest sub-zone overlies hypogene ore and contains the pin prick copper, in which flakes are less than 2 mm in diameter and disseminated throughout the oxidized, highly clay and hematite-altered intrusive rock. This sub-zone also contains secondary sulphides, consisting of chalcocite and minor hypogene sulphides chalcopyrite and bornite. The middle sub-zone contains slightly larger leaves of native copper, some of them reaching 10 cm in diameter, and 3 mm in thickness. In the upper sub-zone the copper is associated with planes of weakness and sheets more than 3 metres long and 50 cm wide have been found. This sub-zone is more highly altered and contains up to 30% hematite stained clay.

2- Hypogene Zone: makes up approximately 75% of the Kameas South deposit and is mineralized with gold and copper. It contains approximately 1 to 5% disseminated pyrite, chalcopyrite, magnetite-hematite and bornite, with minor amounts of molybdenite and traces of gold and other minerals; hosted mainly within the intrusion. Mineralization occurs on fractures, in veins and interstitial to the feldspar crystals. Sericite is the dominant alteration mineral, the second most abundant alteration mineral is pink potassium feldspar. Silica alteration and weak quartz stockwork developed locally.

Dykes - Unknown Age

Mafic Dykes: Dark green to dark chloritic green 10 to 15% pyroxene phenocrysts that are 2 to 4 mm diameter and 15 to 20% plagioclase less than 2 mm diameter. Dykes are indistinguishable from the Upper Triassic-Tekla Group, Savage Mountain Formation basalts.

Felsic Dykes: These aphanitic brick red dykes are generally vertical in orientation and trend roughly north-south. They also contain calcite veins.

Quartz-feldspar Porphyry: 30-40% light green matrix 5-10% quartz 1-3 mm diameter; 10-15% plagioclase 1-3 mm diameter. Dykes are thin and only seen around and immediately north of the open pit.

*All modal mineralogy are reported as volume%. Terminology of volcanic, sedimentary, and volcanic rocks are defined in the glossary of the accompanying thesis.

SYMBOLS AND CONTACTS

Limit of outcrop, mapping, marshy area.....
Contact Defined, Approximate, Assumed.....
Normal Fault, Defined, Approximate, Assumed..... (Teeth are on the down-faulted side)
Unconformity Defined, Approximate, Assumed.....
Ominica Mining Access Road, Gravel Roads, Drill Roads.....
Age Determination (Ar-Ar; U-Pb) ② ④	Geochemistry Site
Assay Site	Drill Hole Collars
Bedding (Dip Known)	Marsh
Dyke	MINFILE, Showing

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6323500N

6323000N

1884

6322500N

6322000N

These massive units make up about 25% of the tuff-epiclastic unit. Locally, there are light green sandstone layers; these are generally the thickest of all the sedimentary layers, exceeding 1 m. They are uncommon and comprise approximately 5% of the tuff-epiclastic unit. Grains are predominately quartz and feldspar and less than 2 mm in diam. These layers are the most indurated and well sorted of the epiclastic rocks and grade upward into heterolithic conglomerate with up to 80% sub-rounded to sub-angular fragments. Fine- to coarse-grained sandstone contains rare (~1%) broken pyroxene crystals with a slightly calcareous cement. These beds generally form the thickest beds, usually exceeding 1 m in thickness. Rounded pebbles and cobbles, varying in composition from basalt to andesite, and limestone and chert from the underlying Asitka Group. Clasts range in size from 5 to 30 mm diam, with an average size of around 10 mm diam, and are randomly dispersed in some sandstone beds or form matrix-supported conglomeratic interbeds.

Duncan Member

Dacitic Lapilli-crystal Flowtuff: contains abundant (~5%) dark grey to colourless "quartz eyes" and minor biotite crystals in a light green massive matrix. Alteration is minor and consists of sericite and chlorite. Outcrops at one location to the south of Duncan Lake.

Upper Triassic

Takla Group

Savage Mountain Formation

Basaltic Flows: dark green, porphyritic basalt characterized by the presence of 1-5 mm diameter, black euhedral augite (5-20%) and 1-2 mm diameter, plagioclase phenocrysts (15-35%). Varieties include aphanitic and plagioclase-rich with minor augite all; flows weather tan to buff colour; flows cap the ridge immediately behind the open pit and occur on the south end of Duncan Ridge.

Dewar Formation

Epiclastic Volcanogenic Sandstones and Siltstones: Alternating dark and lighter green layered, cross-laminated and graded, thinly bedded (1-3 mm diameter) rock. Broken augite crystals (<1 mm diameter) are found in coarser grained sandy laminations. This unit/facies underlies augite-phyric basaltic flows of the Savage Mountain Formation and is found near the crest of the ridge behind the open pit in two isolated outcrops.

Black Calcareous Mudstone: fossiliferous, finely to thickly laminated (1-10 mm thick) black fossiliferous sandstone. Fossils resemble the Upper Triassic bivalve *Halobia* and broken ammonite shells. Rusty sections where pyrite has been oxidized. Found at one location near the top of Kemess ridge north of the open pit.

Mid-Pennsylvanian to Lower Permian

Asitka Group

Limestone: 1- weathers light grey, cream white with a fine-grained crystalline texture, and massive, without any discernable layering.

2-Limestone exposed between Kemess lake and Kemess creek has an uncharacteristic light green colour, contains fine-grained impurities and is mineralized with pyrite, chalcocopyrite, sphalerite, and galena.

Chert: interbedded with black argillite; varies in colour from grey-green, light to dark grey, light turquoise green to bluish-green or black and is interbedded with minor finely laminated grey-green siltstone. Thickly laminated to thinly bedded (1-5 mm thick) in parallel layers 0.5 to 15 cm thick. Black argillite contains interbeds of black carbonaceous fossiliferous mudstone; fossils are generally circular, 1 to 1.5 cm in diameter and have been highly altered due to heat and are unidentifiable. Locally, argillaceous layers form slip planes for minor faulting. At one location there are flow breccias with basalt and chert clasts. The chert unit is conformably overlain by augite-phyric basalt of the Savage Mountain Formation.

Rhyolite: Generally grey to dark grey in colour it can also have a creamy turquoise green colour; it weathers creamy tan to chalky white with a hackly texture. Fractures infilled with epidote give fresh surfaces a net-like texture. Exposure is limited to the knoll to the east of Bicknell Lake.

Porphyritic Andesite Interbedded with Fine-grained Sandstone: 1-light turquoise green to dark chloritic green with subhedral augite 1 to 3 mm in diameter and 10 to 30% blocky plagioclase 1 to 3 mm in diameter with minor (<5%) euhedral quartz grains 1 mm in diameter. Locally, thinly interbedded tuff and fine-grained sandstone layers containing light chloritic green and contain chloritic and rhyolitic flame which are approximately 1 to 8 cm long; rhyolitic fragments are very angular and smaller than 3 cm. Crystals within the andesitic matrix locally define flow lamination. The sandstone is intimately laminated with thinly to thickly bedded lapilli tuff, containing devitrified chloritic glass shards and xenoliths of the andesite.

2-Light turquoise green sandstone is generally laminated (1-2 mm) and forms beds about 0.5 m

Dyke

Fault

Fold Axis

Fold Hinge

Foliation

Fossil Loc. Identified

Minfile

Number

94D 132

94D 133

94E 025

94E 094

94E 114

94E 118

Not Listed

Sources

Field Data

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Ar-Ar: Mike

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Cann, R.M.

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lyke	MINFILE, Showing	☆
ault	Photograph Location	☆
old Axis	Sample Location	*
old Hinge	Stichenlines	✓
oliation	Thin Section Location	○
ossil Location (Macro Identified; Macro Unidentified)	Vein	✓

Mineral Occurrence

Profile	UTM Zone 9 (NAD 83)		Name	Commodity
Number	Easting	Northing		
4D 132	631841	6318710	NOR	Cu
4D 133	634234	6319186	RON	Cu, Ag, Pb
4E 025	634153	6322675	KEMESS WEST	Ag, Zn, Cu, Pb, Au
4E 094	636598	6320284	KEMESS SOUTH	Cu, Au, Mo
4E 114	631682	6322446	TUT	Cu, Zn, Ag
4E 118	634257	6321965	RAT 1	Cu, Au, Ag
Not Listed	632398	6320863	Pyrite Showing	Cu, Zn

Sources of Information

Field Data:

Field data were collected from May to October, 1998.

Airline Infrastructure:

Current as of October 1998.

Geochronology:

Collected by: C. Rogers and L. Diakow

J-Pb: Richard Friedman, Department of Earth and Ocean Sciences, University of British Columbia
Diakow et. al., 2001)

Ar-Ar: Mike Villeneuve, Geological Survey of Canada (Diakow et. al., 2001)

Supplementary Datasets:

Pit Geochemistry: supplied by Royal Oak Mines, analysed by MinEn Assayers

Regional Geochemistry: Analysed by Ron Hartree, University of Ottawa and XRAL Laboratories.

Map Base Information:

IRIM 1:20 000 scale topographic database produced by the B.C. Ministry of the Environment, Lands and Parks. North American Datum (NAD) 83 Zone 9. Elevations in metres above sea level.

Approximate mean magnetic declination (1998) between magnetic north and grid north is 23°16' decreasing 19.6' annually to 2005.

References

Cann, R.M. and Godwin, C.I. (1980): Geology and Age of the Kamess Porphyry Copper-Molybdenum Deposit, North-Central British Columbia; Canadian Institute of Mining and Metallurgy, Bulletin, Volume 73, pages 94-99.

Diakow, L.J., (2001) Geology of the Southern Toodoggone River and Northern McConnell Creek Map Areas, North-central British Columbia (Parts of NTS 94E/2, 94D/15 and 94D/16). B.C. Ministry of Energy and Mines, Geoscience Map 2001-1, 1:50 000 scale.

Diakow, L., and Metcalfe, P. (1997): Geology of the Swannell Ranges in the vicinity of the Kamess copper-gold porphyry deposit, Attycolley Creek (NTS 94E/2), Toodoggone River map area; in Geological Fieldwork for 1996, B.C. Ministry of Employment and Investment, Paper 1997-1 pages 101-116.

Diakow, L., Metcalfe, P., Rogers, C., and Whittles, J., 2001. Geology of the Southern Toodoggone River and Northern McConnell Creek Map Areas, North-Central British Columbia. B.C. Geological Survey Branch Geoscience Map 2001-1.

6321500N

6321000N

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dark chloritic green with subhedral augite 1 to 3 mm in diameter and 10 to 30% blocky plagioclase 1 to 3 mm in diameter with minor (<5%) euhedral quartz grains 1 mm in diameter. Locally, thinly interbedded tuff and fine-grained sandstone layers containing light chloritic green and contain chloritic and rhyolitic flame which are approximately 1 to 8 cm long; rhyolitic fragments are very angular and smaller than 3 cm. Crystals within the andesitic matrix locally define flow lamination. The sandstone is intimately laminated with thinly to thickly bedded lapilli tuff, containing devitrified chloritic glass shards and xenoliths of the andesite.

2-Light turquoise green sandstone is generally laminated (1-2 mm) and forms beds about 2 m thick. Sandstone beds are internally graded at one locality. Outcrops are rare and are generally only a few metres in size.

3-dark chloritic green andesites contain 10 to 30% blocky plagioclase phenocrysts approximately 1 to 3 mm in diameter, and trace amounts of quartz as subrounded phenocrysts about 1 mm in diameter. These andesite flows contain flow banding and a plagioclase mineral layering that is defined by the flattening plane. Flows are several metres thick.

Block and Lapilli Tuff: light to dark grey matrix with blocks of rhyolite. Lithic fragments (1-10 cm) have altered rims and have been flattened to define a fabric within the unit. Interstitial to the clasts are small pockets of brick red-aphanitic ash that also has been deformed to the orientation of layering. This unit is only exposed on the west side of the Duncan fault near the lowest elevation of the Kerness waste dump.

INTRUSIVE ROCKS

Jurassic or Cretaceous

Pyroxene Basalt: weathers light tan to light buff and contains approximately 30-35% plagioclase and up to 10% glassy pyroxene crystals. It is a fresh pyroxene basalt more than 30 m thick and overlies and interdigitates the tuff-epiclastic unit in the open pit. Outside of the open pit only a single outcrop to the east of the open pit was found.

Megaphyric Quartz Porphyry: contains 15 to 25% quartz phenocrysts (15 mm) and 35-40% plagioclase phenocrysts (3-8 mm). The original ground mass has been altered to a light green to beige mixture of clay minerals and silica that gives it a porcelaneous texture. The unit occurs approximately 1 km south of Duncan Lake, on the northwest end of the ridge that is immediately behind the Kerness South open pit where it covers an area of only 500 square metres.

Black Lake Suite

Unnamed Granitic Intrusions:

1- **Quartz-monzodiorite:** equigranular texture with interlocking crystals (2-4 mm diameter). The intrusion weathers tan to buff and is pinkish white on fresh surfaces. It is composed of approximately 15% quartz, 40% plagioclase, 25% potassium feldspar, and has accessory minerals of 15% hornblende and 5% biotite. Covering less than 1 square km on a knoll south of Bicknell Lake and east of the Omineca road, the intrusion is near the south end of the map area west of the Duncan fault.

2- **Quartz Syenite:** equigranular texture; interlocking of 2-4 mm diameter crystals the intrusion weathers tan to buff and is reddish brown on fresh surfaces. It consists of 10 to 15% quartz, 10 to 15% plagioclase, 50 to 60% potassium feldspar, and has accessory minerals of 10 to 15% biotite. Located approximately 1 km east of the southern tip of Bicknell Lake it is exposed over a distance of about 200 m.

3- **Quartz-monzodiorite:** equigranular texture; interlocking of 2-4 mm diameter crystals; the intrusion weathers tan to buff and is reddish brown on fresh surface. Consisting of 5 to 10% quartz, 50 to 60% plagioclase, 10 to 15% potassium feldspar, and accessory minerals of 10% hornblende and 5% biotite, 5% disseminated pyrite and 1 to 2% disseminated magnetite. Approximately 1 km south of Duncan Lake, on the northwest end of the ridge that is immediately behind the Kerness South open pit; it covers an area of approximately 1 km².

4- **Monzodiorite:** medium-grained, equigranular rock consists of 5-10% quartz, 50-60% plagioclase, 10-15% potassium feldspar, 10% hornblende and 5% biotite. Approximately 5% pyrite and 1-2% magnetite occur as disseminations in the outcrops. Disseminated pyrite is widespread in the intrusion and also throughout the adjacent country rocks of the Toadogone Formation and Takla Group.

5- **Quartz-Monzodiorite:** medium-grained equigranular granitic rock consists of 5-10% quartz, 50-60% plagioclase, 10-15% potassium feldspar, 10% hornblende and 5% biotite. 5% pyrite and 1-2% magnetite occur as disseminations in the intrusions and are widespread in the intrusion and also throughout the adjacent country rocks of the Toadogone Formation and Takla Group.

Diakow, L., Metcalfe, P., Rogers, C., and Whittles, J., 2001. *Geology of the Southern Toodoggone River and Northern McConnell Creek Map Areas, North-Central British Columbia*. B.C. Geological Survey Branch Geoscience Map 2001-1.

Diakow, L., and Rogers, C. (1996): Toodoggone-McConnell Project: Geology of the McConnell range - Serrated Peak to Jensen Creek, parts of NTS 92E/2 and 94D/15; in *Geological Fieldwork for 1996*, B.C. Ministry of Employment and Investment, Paper 1996-1, pages 8a-1 to 8a-14.

Diakow, L., Pantalev, A., and Schroeter, T. (1993): *Geology of the Early Jurassic Toodoggone Formation and gold-silver deposits in the Toodoggone River map area, northern British Columbia*; B.C. Ministry of Energy, Mines and Petroleum Resources, Bulletin 86, 72 pages

Gabriel, H., Dodds, C.J., Mansy, J.L. and Elebacher, G.H. (1977): *Geology of Toodoggone River (94E) and Ware West-Half (94F)*; Geological Survey of Canada, Open File 483.

Rebagliati, C.M., Bowen, B.K., Copeland, D.J. and Niosi, D.W.A. (1995): *Kernesse South and Kernesse North Porphyry Gold-Copper Deposits, Northern British Columbia*; in *Porphyry Deposits of the Northwestern Cordillera of North America*, Schroeter, T.G., Editor, Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46, pages 377-396.

Royal Oak Mines Inc. (1995): *Annual Report*; Kirkland, Washington U.S.A.

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No topographic map
coverage in this area.
Topographical and
geological features
were digitized onto the
map from arial
photographs.

631000E

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KEMESS AIRS

NOTE TO USERS

Oversize maps and charts are microfilmed in sections in the following manner:

LEFT TO RIGHT, TOP TO BOTTOM, WITH SMALL OVERLAPS

This reproduction is the best copy available.

UMI[®]

A'

1600
1500
1400
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Intersection of B-25'

42

51

47

140

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B'

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