Surface and Ground Water Geochemistry Near the Donlin Creek Gold Deposit, Southwestern Alaska

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INTRODUCTION

Hydrogeochemical investigations were undertaken during July 2002 near the Donlin Creek gold deposit, southwestern Alaska (Fig. 1). The study represented a collaborative effort by the U.S. Geological Survey, the University of Alaska-Anchorage, Calista Native Corporation, and NovaGold Resources Inc. The objectives of this work were to: 1) comprehensively define current baseline conditions of surface and ground water at and proximal to the Donlin Creek gold deposit; 2) examine spatial variability of the composition of surface and ground waters with respect to local geology and mineralization; and 3) provide information regarding the mobility and behavior of trace elements of environmental concern, such as arsenic (As), copper (Cu), antimony (Sb), and selenium (Se) in the Donlin Creek area. Results of this study will be useful both for environmental planning purposes and for local exploration efforts. This report presents relevant background information, methodology, and analytical results for the surface and ground water samples taken during this study.

LOCATION AND CLIMATE

The Donlin Creek gold deposit (62° 01' N, 158° 12' W) is located in the Kuskokwim Mountains region of Alaska (Fig.1), where the landscape is dominated by rolling hills that reach maximum elevations of 1,000 m. Groundcover is fairly thick consisting of shrubs, moss, dwarf birch, blueberry and other low vegetation on most hilltops and slopes. Forested areas are confined to lower elevations in the drainage basins and consist of white spruce, tall birch, and black spruce, with alder and willow typically confined to stream drainages.

The water sampling locations include the headwaters, mid -stream parts and lower reaches, from south to north in Bell Creek, Anaconda Creek, American Creek, Lewis Gulch, Queen Gulch, Snow Gulch, Quartz Gulch, Dome Creek, and Ophir Creek (Fig. 2, Table 1.) Descriptions of the specific sampling locations are listed in Table 2. Samples from the middle and lower parts of the streams are classified as surface waters, in contrast, many of the headwater samples were from seeps or springs, and thus are best classified as ground water samples. Two additional ground water samples were from wells. The well sites are between American Creek and Lewis Gulch at elevations of approximately 150 meters above sea level.

GEOLOGY AND MINERALIZATION

Regional Geology

The Donlin Creek deposit lies within an area that is predominantly underlain by flysch of the Upper Cretaceous Kuskokwim Group (Cady and others, 1955). The rocks of the Kuskokwim Group were deposited in a northeast-trending, strike-slip basin that subsided between a series of amalgamated terranes (Miller and Bundtzen, 1994). These older basement terranes, which were assembled by mid-Cretaceous time (Patton and others, 1994; Decker and others, 1994), include Paleozoic-Mesozoic oceanic crust and subduction zone assemblages (Miller and Bundtzen, 1994), Late (?) Proterozoic to Paleozoic continental and continental margin rocks (Patton and others, 1994), and a fragment of Early Proterozoic continental basement (Decker and others, 1994; Miller and others, 1991). The waning stages of Kuskokwim Group deposition were accompanied by regional volcanism and intrusion (Miller and Bundtzen, 1994). A number of widely distributed volcanic-plutonic complexes of Late Cretaceous and early Tertiary age intrude and overlie the Kuskokwim Group; approximately coeval felsic and intermediate dikes also cut the sedimentary rocks (Miller and Bundtzen, 1994).

The Donlin Creek deposit lies between two major dextral strike-slip faults—the Holitna segment of the Denali fault system and the Iditarod-Nixon Fork fault system (Fig. 1). Miller and others (2002) summarized the tectonic history of these two regional structures in southwestern Alaska. The Denali fault system in the region shows about 130 km of right-lateral offset since initiation of basin sedimentation at approximately 85 Ma; the Iditarod-Nixon Fork fault has been offset >90 km right-laterally since about 58 Ma (Miller and Bundtzen, 1988), but was active at least as far back as 90 Ma. The Iditarod-Nixon fault system has a total length of 450 km. The Donlin Creek gold deposit is located along a splay about 10 km to the southeast of the main branch of the fault. High-angle, northeast-striking faults in this system form a broad belt about 10-20 km in width. Regional folds of a variety of orientations are recognized throughout southwestern Alaska. Most of the folding probably took place soon after basin sedimentation (Miller and others, 2002).

The Kuskokwim Group is primarily composed of lithic-rich sandstone and shale that were deposited by turbidity currents. The basinal sequence is successively overlapped by shoreline facies that are more quartz rich (Miller and Bundtzen, 1994) and reach a maximum thickness of >10 km (Decker and others, 1994). Although regional patterns are difficult to discern, sandstones are locally rich in chert, volcanic, or limestone clasts, indicating variable source terranes. Fossil ages constrain sedimentation to Cenomanian to probable Campanian, (about 95-77 Ma; Miller and others, 2002). Near the top of the section, volcanic tuffs and flows are locally interbedded with the sedimentary rocks and may represent initiation of volcanism that later culminated in widespread Late Cretaceous and early Tertiary igneous activity.

Late Cretaceous and early Tertiary igneous rocks of the region include volcanic-plutonic complexes, extensive sub aerial volcanic rocks, altered intermediate to mafic dikes, and hypabyssal granite porphyry dikes and plugs (Miller and Bundtzen, 1994). The calc-alkaline volcanic-plutonic complexes consist of monzonite to quartz monzonite plutons, and felsic to mafic flows and lesser tuffs. Most isotopic ages on the volcanic rocks of the complexes range between 76-63 Ma, whereas the associated intrusions are more restricted to a period between 71-66 Ma (Miller and Bundtzen, 1994; Decker and others, 1995; Bundtzen and Miller, 1997). The subaerial volcanic rocks of the region are mostly andesitic in composition, but commonly have dacite, rhyolite, and minor basalt. Ages range from about 71 to 54 Ma and, like the volcanic-plutonic complexes, major- and trace-element geochemistry indicates broad calc-alkaline trends. Although volumetrically minor, intermediate to mafic dikes of Late Cretaceous age are widely scattered throughout the Kuskokwim region. These dikes are characteristically silica-carbonate altered and not obviously related to any parent pluton. Finally, felsic to intermediate hypabyssal dikes, sills, and stocks crop out discontinuously across the Kuskokwim region and locally play a major role in the Donlin deposit. Similar to other intrusive rocks in the region, the hypabyssal felsic bodies are approximately 70-65 Ma (Miller and Bundtzen, 1994), but their overall genetic association with the other igneous rock suites is uncertain. These hypabyssal rocks are characterized by a distinctly peraluminous chemistry and commonly contain garnet phenocrysts, suggesting they represent melted continental crust (Miller and Bundtzen 1994).

Local Geology

The Donlin Creek deposit lies adjacent to an 8 km-long, NE-trending hypabyssal dike-sill complex (Bundtzen and Miller, 1997; Szumigala and others, 2000) (Fig 3). In this location the Kuskokwim Group country rocks strike roughly northwest and dip 35-50° to the southwest. The coarser-grained strata are graywacke sandstones rich in metamorphic lithic fragments, but igneous and sedimentary rock fragments are also locally abundant. The finer-grained units sometimes contain fine, syngenetic pyrite and coaly leaf and stem fragments (Miller and Bundtzen, 1994). The sedimentary rocks are slightly silicified close to the dikes and sills, and at the northern end of the deposit, in the vicinity of the Dome prospect, a well-developed biotite hornfels is found.

The swarm of mineralized, discordant granite porphyry dikes and sills were emplaced along local NE-trending strike-slip faults. Individual dikes average 10 to 20 m in width and contacts with the country rocks may be very irregular along strike (Fig 3). Phenocrysts are dominated by quartz, plagioclase, and K-feldspar, accompanied by lesser biotite and muscovite, and rare garnet (Miller and Bundtzen, 1994). Company geologists have attempted to visually classify the igneous rocks into five petrographic groups, which are summarized by Szumigala et al. (2000). Most of the sills and dikes are classified as either aphanitic rhyodacite porphyry or crystalline rhyodacite; less common are rhyolite, fine-grained rhyodacite porphyry, and rare lamprophyre dikes.

Gold Mineralization

The gold at Donlin Creek was deposited between 75-69 Ma (Gray et al. 1997, Szumigala et al. 2000), and occurs in NNE-striking, steeply-dipping, narrow, veins and veinlets that fill brittle extensional fractures in dikes and sills (Fig 3). Veins are typically on the order of tens of millimeters wide, although rare veins may be a few tens of centimeters in width. The veins and veinlets are dominated by gray and clear quartz, lesser calcite, dolomite, and ankerite. Pyrite, arsenopyrite, and stibnite are the dominant sulfide minerals and may comprise as much as 3-5 percent of the gold-rich zones. The sulfide minerals are relatively fine-grained, and gold-rich arsenopyrite typically occurs as needles. The stibnite may occur as coarse laths exceeding 1 cm in length, but more commonly is observed as late, open space fillings and fracture coatings, along with occasional realgar and orpiment. Cinnabar, native arsenic, and graphite are rare, but are occasionally observed in veinlets or altered igneous rock. Base metal sulfide minerals are uncommon within the deposit except in the vicinity of the Dome prospect, where disseminated chalcopyrite and chalcopyrite-bearing quartz veinlets are abundant. Gold occurs almost exclusively as a refractory phase within the arsenopyrite. Wallrock alteration is well-developed where ore zones are hosted in igneous rocks. Sericitization is the most abundant form of alteration. Carbonization and sulfidation of igneous rocks are typical, and where disseminated arsenopyrite occurs, the altered rock adjacent to the gold-bearing veins is auriferous. In contrast, there is little visible alteration of the mineralized sedimentary rocks.

METHODS OF STUDY

Sample Collection, Preservation and Field Measurements

Twenty stream samples, six seeps, and two well water samples were collected between July 7th and July 10th, 2002 (Table 2). Four of the surface water samples were taken at pre-selected sampling sites from the current NovaGold Resources Inc. environmental sampling program. The remaining 22 samples represent new water sample sites that have no prior sampling record. The two well-water samples were also collected for the first time, and therefore, represent new measurements in the Donlin Creek area.

Stream and seep water samples were collected using a Masterflex 12 V portable peristaltic pump and 0.635 cm diameter flexible tubing. The tubing was pre-cut to 1 m lengths and then rinsed in dilute nitric acid, and rinsed again in deionized water. The tubing was pre-rinsed by pumping water from the sampling site through it for one minute. The following is a list of sample types collected:

1) an unacidified-filtered sample for anion analysis;
2) an unacidified-unfiltered sample for major, minor, and trace element analysis of both dissolved and suspended material;
3) an acidified-filtered sample for major, minor, and trace element analysis of dissolved species;
4) an acidified-filtered sample for iron speciation, and
5) an acidified-filtered sample for arsenic speciation.

Samples were filtered with 0.45-micron disposable capsule filters. All samples, except the anion sample, were collected in polyethylene acid rinsed bottles. Samples for major and trace element analyses, were acidified to a pH ~2 with ultra-pure nitric acid. Samples for both iron and arsenic speciation were acidified with ultra pure hydrochloric acid to a pH~2 and stored in amber bottles to avoid exposure to sunlight. All samples were kept cool in the field and refrigerated in the laboratory until analysis. A similar technique was used for the collection of the two groundwater samples with the exception that the groundwater was pumped from the dedicated pumping wells into a 4-liter bucket and then samples were collected.

During the collection of the samples, pH, specific electrical conductance, and dissolved oxygen were measured using a Fisher Accumet™ model AP85 meter and an all-in-one pH electrode, conductivity temperature probe and a model AP74 DO meter with a DO/temperature probe. The probes were directly submerged in the sample source immediately downstream of the sample collection point and measurements were taken after the readings stabilized. All of the above values were measured and recorded in the field along with latitude, longitude, elevation, and site description (Table 2).

ANALYTICAL TECHNIQUES

Several chemical elements were analyzed using a variety of quantitative analytical techniques. Table 3 shows the various elements determined and the analytical methods used for each. The following is a brief description, including references, for each analytical method. Descriptions for techniques, including quality assurance/quality control (QA/QC) protocol for most of the analytical methods, are found in Taggart (2002). All analyses were performed at the Denver laboratories of the U.S. Geological Survey, with the exception of the total organic carbon analyses, which were done at the Applied Science and Engineering Technology (ASET) laboratory, University of Alaska-Anchorage (UAA).

Limits of Detection, Reporting, and Quantification

Table 4 contains the limits of detection (LOD), Lower Limit of Determination (LLD), and Limit of Quantification (LOQ) for the various analytes. The limit of detection refers to a confidence range of three sigma above the average measured blank, which is regarded as the lowest level of the analyte that can be determined statistically as different from the analytical blank. The LLD refers to concentrations at or above five times the standard deviation; this is effectively the reporting limit. The LOQ refers to a value of ten times the standard deviation, which represents the lowest limit for quantitative measurements. At this level the risk of false positives and negatives is significantly decreased (Taggart, 2002).

Inductively Coupled Plasma Atomic Emission Spectrometry

This multi-element technique was used to analyze for 27 elements (Table 3) in both the acidified-filtered and acidified-unfiltered samples, using the method described by Briggs (2002), with an ICP-AES Perkin Elmer Optima 3000™. Six multi-element standards are used to calibrate the instrument for each element (Briggs, 2002). In addition, the WRD T-161 standard was also submitted as an extra standard. Collected field samples, one field blank and one field duplicate, along with three blind analytical duplicates, were submitted for analyses. In addition every 10th sample was duplicated during analysis. This method was selected because of its better performance at higher concentration ranges for all elements. The lower limits of determination, detection, and quantification are reported in Table 4.

Inductively Coupled Plasma Mass Spectrometry

Acidified-filtered and acidified-unfiltered water samples were analyzed for 44 elements (Table 3) by ICP-MS using a method developed by the U.S. Geological Survey (Lamothe et al., 2002). This method is used to determine elemental concentrations in the water samples without any pre-concentration or dilution. Elemental detection limits are in the parts per billion (µg/L) range, and the working linear range is six or more orders of magnitude. The instrument used was a Perkin-Elmer Elan 6000™ ICP-MS. This method is most useful for trace and minor elements in the parts per billion (ppb) range. As with the ICP-AES technique, six standards were used to calibrate for all of the elements, and the additional T-161 standard was added for these samples. A field blank, field duplicate, and three blind analytical duplicates were submitted for analyses. The lower limits of determination, detection, and quantification are reported in Table 4.

Ion Chromatography

The anions Cl^-, F^-, NO_3^-, and SO_4^{2-} were determined by ion chromatography on unfiltered-unacidified samples using the method of Theodorakos (2002a) of chemically suppressed Ion Chromatography. This technique is applicable to most waters. The four common anions are separated using a strongly basic anion exchange resin and analyzed using a Dionex™ Model DX-120 Ion Chromatograph and accompanying software. The lower limits of determination are reported in Table 4.

Alkalinity as $CaCO_3$ and HCO_3^-

Alkalinity was measured in the laboratory using the Preset Endpoint method described by Theodorakos (2002b), in which the sample is titrated with a specified concentration of H_2SO_4 until a pH of 4.5 is reached, using an Orion 960 Autochemistry™ system. The limit of determination is approximately 12 mg/l, whereas the lower reporting limit is approximately 20 mg/l, and the limit of quantitation is approximately 40 mg/L.

Arsenic Speciation

The concentration of arsenic (III) and arsenic (V) species were determined using a modification of the method used by Ficklin (1983). However, due to discrepancies between the As^{3+} plus As^{5+} totals as determined by the modified Ficklin method and the As totals from the ICP-MS method, the As^{5+} was determined by the difference between the ICP-MS total and the GFAAS As^{3+} concentrations. The acidified water samples were passed through ion exchange columns packed with a strong anion exchange resin (acetate form.) In this technique, the arsenite passes through the column, whereas arsenate is retained until eluted with 0.12 M hydrochloric acid. The concentrations of the species were then determined using graphite-furnace atomic absorption spectrometry with a detection limit of 3 μg/L for each species.

Iron Speciation

Total iron (Fe_T) and ferrous iron (Fe(II)) concentrations were determined using a modification of the FerroZine® method (Stookley, 1970, To et al., 1999) with a Hewlett Packard™ 8453 diode array UV/VIS spectrophotometer. The limits of detection for iron total dissolved iron and Fe(II) are 0.002 mg/L. Ferric iron (Fe(III)) was determined by taking the difference between Fe(T) and Fe(II).

Total Organic Carbon

Total organic carbon (TOC) analyses were performed in the ASET laboratory at UAA using the Environmental Protection Agency (EPA), American Society for Testing and Materials (ASTM) method 9060, which is suitable for determining the concentration of organic carbon in groundwater and surface water at levels above 1 mg/L (U.S. EPA, 1998). The procedure involves measurement of total carbon and inorganic carbon and determination of organic carbon by subtraction. The pH of the solutions were lowered to 2 and purged with nitrogen for 10 minutes and quadruplicate analysis performed.

Quality Assurance

In addition to standards, quality control samples collected and submitted in this study include field duplicates, field blanks, and blind analytical duplicates. The field duplicate samples are considered to be identical in composition to the water samples and are used to determine combined sample site and analytical variability in environmental data. The field duplicate samples are shown in the data set associated with this report (these are indicated by the B at the end of the field sample number). In general, the field duplicates are within +/-10% of the water quality sample.

The field blank, or equipment blank is prepared using deionized water that has passed through all of the sampling and processing equipment. This type of sample is used to check for potential contamination of water quality samples during collection, handling, and analysis. The results of the field blanks are shown in Table 5. The blind analytical duplicates are splits of collected water samples submitted as additional samples. The use of the blind duplicates is to determine instrumental drift and contamination during analysis. In general, the blind analytical duplicates are within +/-10% of the associated water quality sample.

Data from all of the water samples collected were checked using the computer program WATEQ4f (Ball and Nordstrom, 1991), for charge balance using the following equation:

$$\text{C.I. (percent)} = \frac{100 \times (\text{meq cations} - \text{meq anions})}{(\text{meq cations} + \text{meq anions}) \div 2}$$

where C.I. is the charge imbalance. Charge imbalance for the water samples is shown in Table 6. Note that the results of these calculations are twice the value typically reported by an analytical laboratory. This is because this equation relates the difference between the cations and anions to their respective average rather than to their sum as is typically done.

Filtered vs. Total Recoverable

As mentioned above both a filtered-acidified (FA) and unfiltered-acidified (total recoverable or TR) sample were collected at each sampling site. Collection of both the FA and TR samples allows the determination of the concentration of dissolved and suspended analytes. Both samples were also collected because regulations regarding the concentration of certain elements, such as As, Cu, Fe, and Sb, in surface water that are generally determined based on filtered samples, whereas those for ground water are based often on unfiltered samples.

ORGANIZATION AND DESCRIPTION OF DATA FILES

The analytical results from this study can be found in Table 6. This table contains drainage names, field numbers within each drainage, and field parameters.

SUMMARY OF RESULTS

A statistical summary of the data for the FA and TR seep and stream samples can be found in Table 7. Given that there were only two ground water-well samples, the data for the FA and TR ground water samples are also presented in Table 7. The following is a brief description of the overall water chemistry, with emphasis on important geochemical trends, followed by a description of the two well water samples and associated geochemical signatures. The final section is dedicated to comparing the concentrations of elements of most interest, e.g. As, Fe, Mn, Sb, and Se, with current Environmental Protection Agency and Alaska Department of Natural Resources standards.

Stream and seep water chemistry

The stream waters and seeps are characterized by neutral to slightly alkaline pH (6.9-7.9), Ca-HCO_3^- type waters, with major element and anion abundances where Ca>Mg>Na>K and $HCO_3^->SO_4^{2-}>NO_3^->Cl^->F^-$, with the one exception that sample DC16 has $SO_4^{2-}>HCO_3^->NO_3^->Cl^->F^-$. The dissolved oxygen (D.O.) concentrations range from 6.9 to 12 mg/L, and specific conductance values range from 89 to 531 µS/cm. The dissolved concentrations of Ca (11-64 mg/L), Mg (1.8-25 mg/L), Na (0.7-5 mg/L), HCO_3^- (35-140 mg/L), NO_3^- (0.7-4.4 mg/L), and SO_4^{2-} (3-130 mg/L) have a wide range. In addition to the ions mentioned above, the minor elements range as follows in the filtered samples: Al (0.95-19 µg/L), Ba (18-100 µg/L), Fe (0.002-0.074 mg/L), Mn (0.04-39 µg/L), Si (1.7-4.1 mg/L), and Sr (36-380 µg/L). Trace elements concentration ranges were as follows: As (1-7.7 µg/L), Cr (1-6.4 µg/L), Co (0.02-10 µg/L), Cu (0.5-1.2 µg/L), Mo (0.2-2.4 µg/L), Ni (0.3-0.7 µg/L), Sb (0.1-4.1 µg/L), Se (1.0-4.2 µg/L), W (0.1-3.8 µg/L) and Zn (0.06-0.1 µg/L) (Table 7).

Calcium, Mg, Na, K, Mo, Sb, Se, and W concentrations for the unfiltered waters were +/- 10% of those observed in the filtered samples. In contrast, many of the other minor and trace elements were significantly higher in the unfiltered samples. Ions showing a significant increase in concentration were Al (17-15300 µg/L), As (1-274 µg/L), Ba (18-218 µg/L), Co (0.04-9.3 µg/L), Cr (1.7-16 µg/L), Cu (0.5-16 µg/L), Fe (0.02-18 mg/L), Mn (0.4-790 µg/L), Ni (0.6-21 µg/L), Si (1.8-14 µg/L), and Zn (0.6-59 µg/L) (Table 6).

Well water chemistry overview

Two well water samples, DC22 and DC23, were also collected during this investigation, and they were located between Lewis Gulch and American Creek on the lower southwestern slope of the ridge that separates these drainages (Fig 2). The two ground water well samples are notably different from the surface and seep waters in that the have higher pH (DC22=8.4, DC23=7.6), Na≥Ca>Mg>K, $HCO_3^->SO_4^{2}->NO_3^->Cl^->F^-$ (DC22 Na=154 mg/L, HCO_3^-=417 mg/L; DC23 Na=26 mg/L, HCO_3^-=182 mg/L), low dissolved oxygen (DC23 D.O.=0.02 mg/L, DC23 D.O.=0.49 mg/L), and high specific conductance (DC22=770 µS/cm , DC23=384 µS/cm).

Total and dissolved iron concentrations are elevated and similar (DC22 Fe_{diss}=0.31 mg/L , Fe_T=0.54 mg/L; DC23 Fe_{diss}=0.65 mg/L , Fe_T=0.061 mg/L.) Total and dissolved aluminum concentrations are higher in samples from DC22 (Al_{diss}=30 µg/L, Al_T=522 µg/L), whereas total and dissolved aluminum concentrations from site DC23 are similar to the surface water samples (Al_{diss}=1.7 µg/L, Al_T=21 µg/L). Total and dissolved arsenic concentrations are high in both DC22 (As_{diss}=564 µg/L As_T=544µg/L) and DC23 (As_{diss}=319 µg/L As_T=317 µg/L) and exceed EPA and AKDEC water quality standards. Boron, which is at or near detection in all of the surface water samples, is comparatively enriched in both groundwater samples. The dissolved boron concentrations at sites DC22 and DC23 are 188 µg/L and 72 µg/L respectively, while total concentrations are 160 µg/L and 59 µg/L, respectively. Dissolved manganese concentrations at DC22 (36 µg/L) and DC23 (99 µg/L) are not high in and of themselves, but are high compared to the surface water samples. Total manganese concentrations from DC22 (39 µg/L) and DC23 (98 µg/L) are nearly identical to the dissolved manganese. Samples from site DC22 contain high total antimony (24 µg/L) and high dissolved antimony (25 µg/L), whereas site DC23 contains total and dissolved antimony concentrations similar to surface waters (Sb_{diss}=<0.05µg/L, Sb_T=0.69 µg/L). Similarly, DC22 also contains anomalous dissolved and total tungsten concentrations (W_{diss}=36 µg/L and W_T=38 µg/L), whereas DC23 has tungsten concentrations similar to those in many surface waters (W_{diss}=0.92 µg/L and W_T=1.0 µg/L).

Arsenic Speciation

Only three samples had dissolved arsenic concentrations that were high enough for speciation measurements. Of these, two were the groundwater-well samples, DC22 and DC23, and one, DC01, was a seep located near the top of Lewis Gulch. The results show that the dissolved arsenic (6.5 µg/L) found in the water coming from the seep is probably all the oxidized, less mobile As(V) species. The two groundwater-well samples DC22 and DC23, (564 µg/L and 319 µg/L dissolved arsenic respectively) were in contrast, extremely reduced. Both were comprised of predominantly As(III), with DC22 having 534 µg/L as As(III) and DC23 having 313 µg/L as As(III).

Iron Speciation

Iron speciation was carried out on all samples with detectable iron in the filtered sample. In general, the filtered samples contain low concentrations of iron (<0.002-0.072 µg/L), predominantly as Fe(II), which is the more reduced species. However, total iron concentrations were significantly higher in most samples indicating that the bulk of the iron is most likely Fe(III) or an iron-hydroxide larger than 0.45 microns, and that only a small fraction of the remaining iron is Fe(II). This has important implications in the mobility of trace elements such as arsenic and antimony, because Fe(III) and the resulting iron-hydroxides are known be a natural sorbent of trace metals.

Spatial Variation

One of the goals of the study was to examine the spatial relationship between the water chemistry and the mineralized areas within the Donlin Creek deposit area. The following is a description of the spatial relationship of the field parameters, major and minor elements, anions, and trace elements of environmental and exploration significance (As, Fe, Sb, Se, and W). The total recoverable samples were used to determine the spatial distribution (see figs 2 and 3 for location reference).

- Calcium- Elevated calcium concentrations (41-60 mg/L) were found at sites DC01, 04, 05, 07, 12 and 17, with the highest calcium concentration at DC-17. These sites, with the exception of DC12, all follow a trend from the upper reaches of Snow Gulch to the southeast towards Anaconda VABM. Most of the remaining sites had calcium concentrations from 30-40 mg/L. The site with the lowest calcium concentration (11 mg/L) was DC18, which is located to the south of Anaconda VABM.
- Magnesium- The majority of samples had magnesium concentrations between 5 and 15 mg/L. Elevated concentrations are found scattered throughout the study area (sites DC01, 04, 05, 07, 08, 17, 25, and 27), with DC07 having the highest magnesium concentration (23 mg/L). These sites generally correspond to those with the highest calcium concentrations. The lowest magnesium concentrations are found south of the camp in the Anaconda drainage.
- Sodium- Samples from site DC19 in the Anaconda drainage had an anomalous sodium concentration of 5.1 mg/L, whereas all remaining sites were <2.6 mg/L.

- Potassium-Samples from two sites, DC01 and DC15, had potassium concentrations >0.5 mg/L. All remaining sites had <0.5 mg/L.
- Alkalinity-Seven sampling locations (DC04, 05, 07, 08, 12, 13, and 25) had bicarbonate alkalinity between 157 and 170 mg/L, with DC25 and DC05 both having 170 mg/L. Three of these sites are located in upper Snow Gulch (DC04, DC05, DC07), two in lower Snow Gulch (DC08 and 25) and two are located in Ophir Creek. Sites with the lowest alkalinity were DC02, DC03, and DC18, which had alkalinity <82 mg/L HCO_3^-. The remaining sites had alkalinities between 102 and 133 mg/L
- Sulfate-The highest sulfate concentration of all the waters sampled in this study came from site DC17, on the northeastern side of Anaconda VABM (130 mg/L.) The next highest concentration, 87 mg/L, was from site DC07, a seep, located along the southeastern side of Snow Gulch. The remaining sites has sulfate concentrations <47 mg/L, with the lowest concentrations being found at the two sites farthest to the south (DC18 and 19, on Anaconda Creek) and the furthest to the north (DC12 and 13, on Ophir Creek.)
- Aluminum-The highest aluminum concentrations were found in samples from DC01 (15 mg/L), DC10 (5.9 mg/L), DC26 (1.6 mg/L), and DC15 (1.1 mg/L), with the next highest concentrations found in samples from sites DC18 (0.66 mg/L), DC08 (0.48 mg/L), and DC14 (0.39 mg/L). All remaining sites had <0.22 mg/L total aluminum. The highest concentrations appear along the mineralized trend (NE-SW) and at some sites on the eastern edge of the study area.
- Iron-The locations with the highest iron concentrations were found in samples from sites DC01 (18 mg/L), DC10 (14 mg/L), DC26 (1.9 mg/L), DC15 (1.2 mg/L), with a group of three sites with moderate iron concentrations, DC18 (0.73 mg/L), DC08 (0.75 mg/L), and DC14 (0.52 mg/L). The remaining sites all have total iron concentrations <0.24 mg/L. Similar to the elevated aluminum concentrations, the sites with the highest iron are found along a northeast trend within the mineralized areas of Lewis Gulch, and Queen Gulch, with the exception of DC10 which is a seep located in upper Dome Creek east of the known mineralization.
- Manganese-Only two sites had elevated manganese concentrations, DC01 (0.79 mg/L) and DC10 (0.49 mg/L). All remaining sites had <0.04 mg/L total manganese. Note that sites DC01 and DC10 also have the highest iron and aluminum concentrations

- Specific Conductance-Spatial trends in specific conductance are similar to those observed for SO_4, Mg, and Ca, with a broad general trend of high concentrations towards the northwest from with the highest values at DC17 (Anaconda VABM) and DC07 (south side of Snow Gulch).
- Antimony-Five sampling sites had elevated antimony concentrations, sites DC01 (1.2 µg/L), DC02 (1.4 µg/L), DC03 (4.5 µg/L), DC26 (4.2 µg/L), and DC27 (2.8 µg/L). All remaining sites had < 5 µg/L of antimony. The sites with anomalous antimony are all located in the Lewis and Queen Gulches and concentrations increase generally toward the north.
- Arsenic-The highest total arsenic concentration was found in samples from site DC01 (0.27 mg/L), the next highest arsenic concentrations were in samples from sites DC15 (0.023 mg/L) and DC26 (0.026 mg/L), and all remaining sites had < 0.004 mg/L total arsenic. The highest arsenic concentrations are located in the Lewis Gulch and Queen Gulch area near the mineralization, similar to the high antimony concentrations.
- Selenium-Eight sampling locations yielded samples with selenium concentrations significantly above detection limits. Of these, samples at DC17 (4.4 µg/L) and DC07 (3.1 µg/L) had the highest concentrations, with a group of six other sites (DC01, 04, 05, 10, 20, and 21) containing selenium concentrations slightly above detection limits (e.g. 1.5-1.9 µg/L). These values trend in an east-west direction orthogonal to the mineralization.
- Tungsten-Tungsten concentrations were elevated in samples from the eastern side of the study area, e.g. DC10 (3.2 µg/L) and DC06 (1.4 µg/L). All remaining sites had tungsten concentrations < 1 µg/L.

Discussion of Spatial Trends

The observations of the significant spatial trends can be divided in to two broad patterns. A first group of anomalous samples is restricted to trends that would most likely reflect the hydrothermal mineralization. This area is characterized by increased arsenic, antimony, and other trace metals associated with the metalliferous veinlets within the ore zone (Fig. 3). Elevated concentrations of both arsenic and antimony consistently occur in water samples from Lewis Gulch, Queen Gulch, and Quartz Gulch. Together, the samples form a northeast trend that coincides with the northeast-trend of the ore zone. Weathering of arsenopyrite and stibnite are the most obvious sources of both anomalous arsenic and antimony.

Aluminum, iron, and, to a lesser extent, manganese, were also elevated along the same trend. However, Al, Fe, and Mn concentrations were also elevated at site DC10 located 2-3 km to the east of the trend. The elevated concentrations of Al, Fe, and Mn may be related to the weathering of minerals in the igneous rocks that are spatially associated with the gold deposit.

The second group of anomalies defining a trend are most likely associated with changes in lithology. For example an increase in calcium, magnesium and pH might indicate areas with local interbedding of limestone. Specific conductance as well as the analytes Ca, Mg, SO_4^{2-}, and Se all tend to be the anomalous along a northwest trend that is almost orthogonal to the mineralization.

Water Quality Information

Antimony and arsenic concentrations exceed drinking water and water quality standards in at least one sample. The only sample that exceeds any water quality standards for antimony is groundwater from site DC-22, which has an antimony concentration of 0.025 mg/L which exceeds the Alaska state drinking water standard of 0.006 mg/L. For arsenic there are five sites that exceed one or more of the Alaska Water Quality Standard (0.19 mg/L), Alaska drinking water Standards (0.05 mg/L), and USEPA drinking water standard (0.01 mg/L) (ADEC, 2000; U.S. EPA, 2000). Those sites are DC01 (0.27 mg/L), DC15 (0.022 mg/L), DC22 (0.56 mg/L), DC23 (0.320 mg/L), and DC26 (0.025 mg/L).

SUMMARY OF FINDINGS AND FUTURE WORK

The stream waters and seeps are characterized by neutral to slightly alkaline pH (6.9-7.9), Ca-HCO3- type waters, with major element and anion abundances where Ca>Mg>Na>K and $HCO_3^- > SO_4^{2-} > NO_3^- > Cl^- > F^-$, with the one exception that sample DC16 has $SO_4^{2-} > HCO_3^- > NO_3^- > Cl^- > F^-$. The dissolved oxygen (D.O.) concentrations range from 6.9 to 13 mg/l, and specific conductance values range from 89 to 531 μS/cm. The two ground water well samples are notably different from the surface and seep waters in that they have higher pH (DC22=8.4, DC23=7.6), Na≥Ca>Mg>K, $HCO_3^- > SO_4^{2}- > NO_3^- > Cl^- > F^-$ (DC22 Na=154 mg/L, HCO_3^-=417 mg/L; DC23 Na=26 mg/L, HCO_3^-=182 mg/L), low dissolved oxygen (DC23 D.O.=0.02 mg/L, DC23 D.O.=0.49 mg/L), and high specific conductance (DC22=770 μS/cm , DC23=384 μS/cm).

A group of anomalous samples is restricted to trends that would most likely reflect the hydrothermal mineralization. The trend is characterized by increased arsenic, antimony, and other trace metals associated with the metalliferous veinlets within the mineralized zone. Elevated concentrations of both arsenic and antimony consistently occur in water samples from Lewis Gulch, Queen Gulch, and Quartz Gulch. A second group of waters samples form a trend of anomalies that are most likely associated with changes in lithology. Specific conductance as well as the analytes Ca, Mg, SO_4^{2-}, and Se all tend to be the anomalous along a northwest trend that is almost orthogonal to the mineralization.

Future work around the Donlin Creek prospect and within a 30 km radius of Donlin Creek will include:

- studies on the use of sulfur isotopes measured from water sulfate as a tool for exploration in this region
- a more detailed study of the mobility of trace elements within the mineralized area at Donlin Creek
- and further characterization of background geochemical signatures of ground and surface water near the Donlin Creek prospect.

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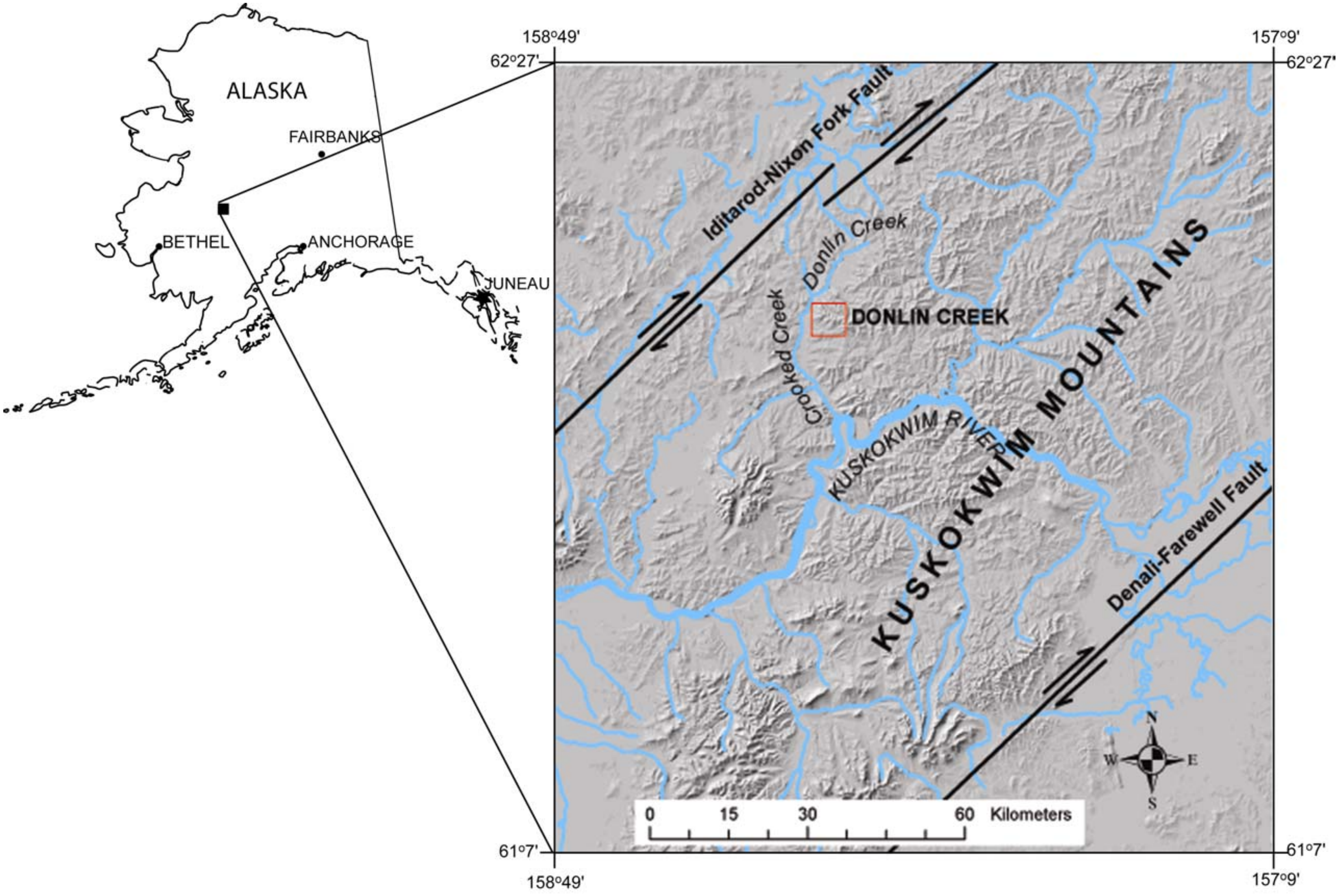

Figure 1. Location map of the study area, Kuskokwim Mountains region, Alaska.

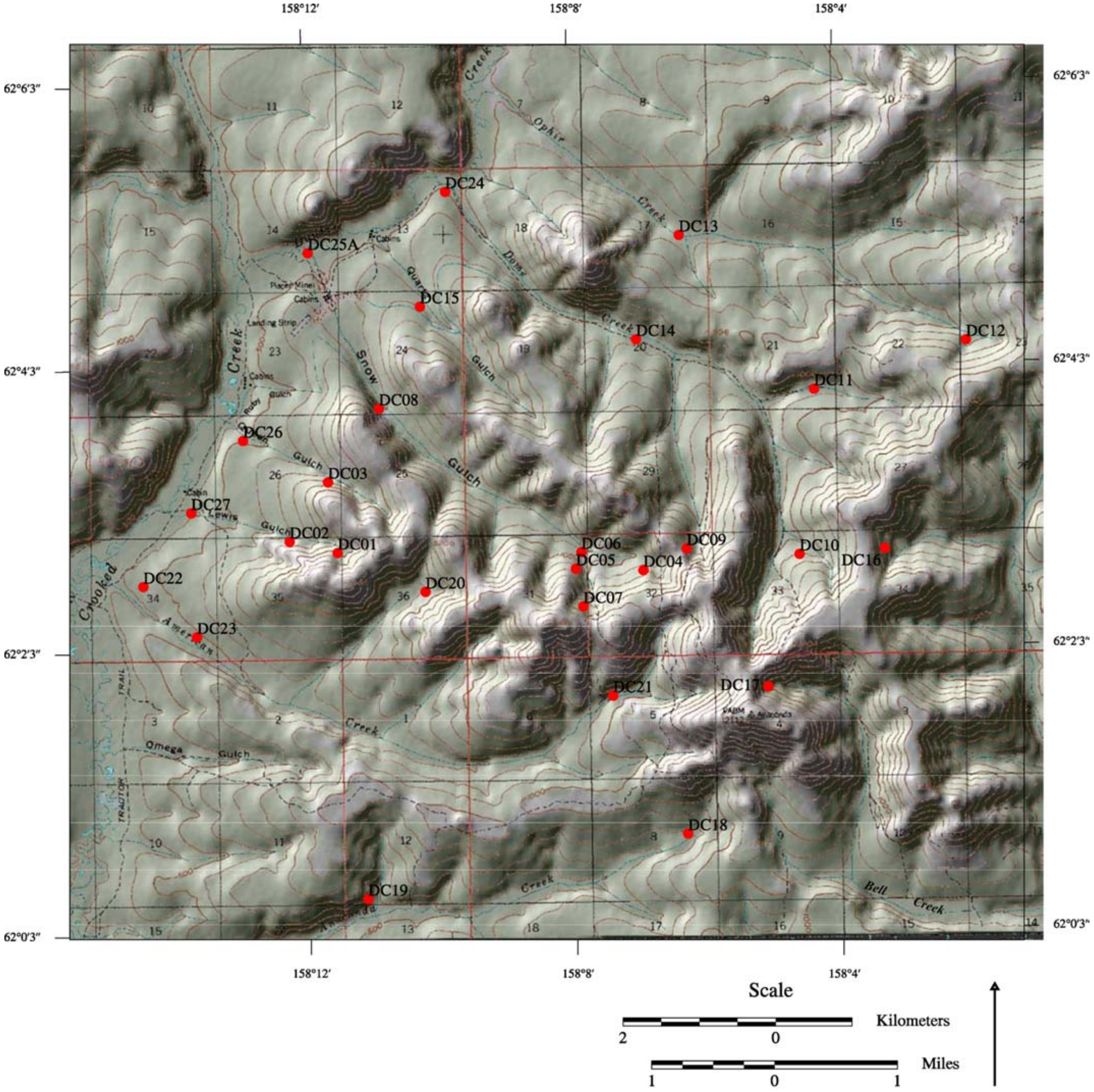

Figure 2. Shaded relief and topographic map of the study area show sampling locations and major streams.

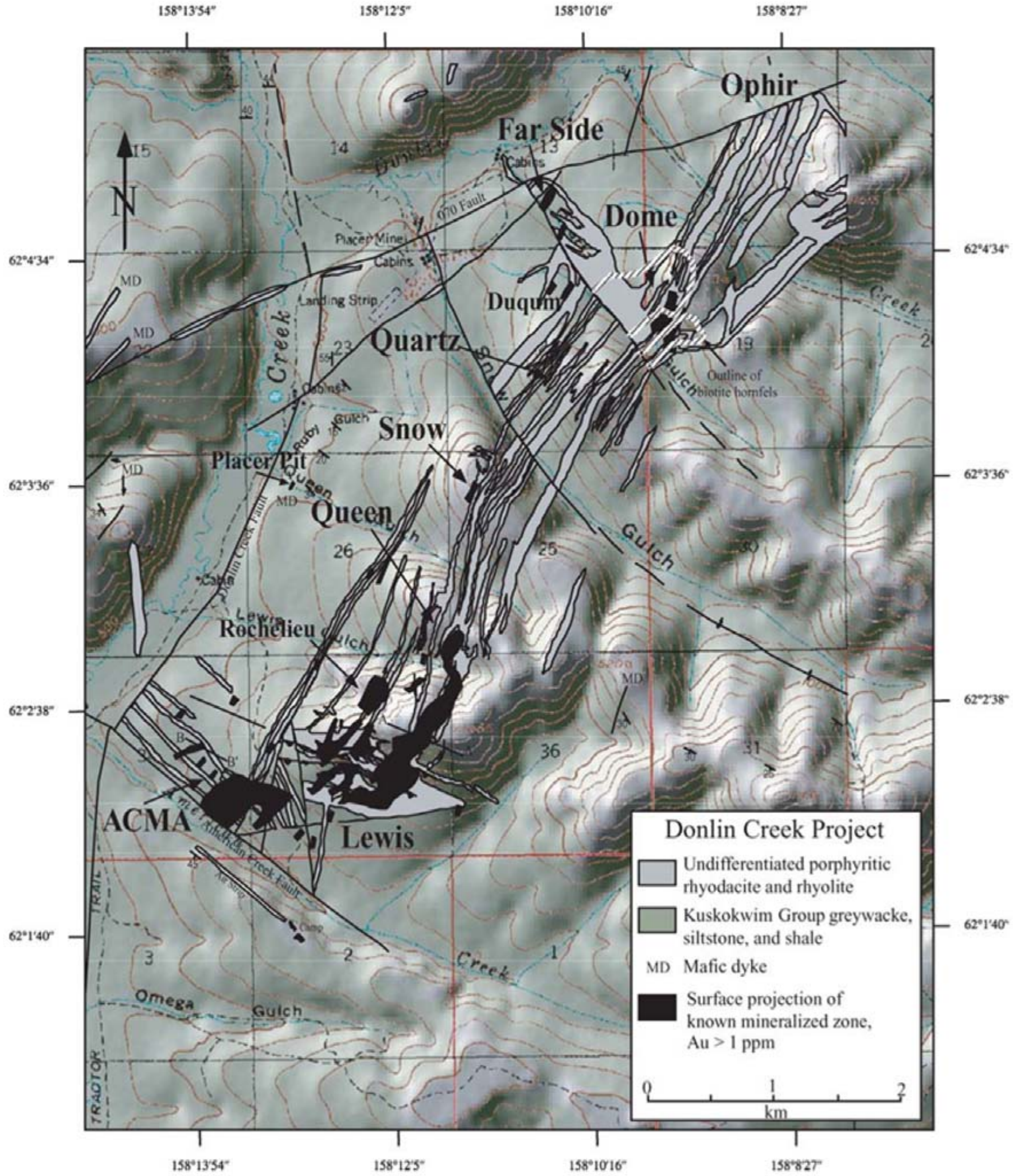

Figure 3. Shaded relief topographic map with an overlay of the local geology, inlcuding faults dikes, and know surface mineralization.

Table 1. Drainage name, abbreviation for data tables, and approximate drainage area.

Drainage	**Drainage Abbreviation**	**Approximate Drainage Area (km^2)**
American Creek	AMER	16.65
Anaconda Creek	ANAC	19.81
Bell Creek	BELL*	26.71
Dome Creek	DOME	17.07
Lewis Gulch	LEWIS	2.15
Ophir Creek	OPHIR	17.04
Quartz Gulch	QUARTZ	3.03
Queen Gulch	QUEEN	2.25
Snow Gulch	SNOW	8.57

* This is an approximate drainage area for Bell Creek within only the Iditiarod A-5 quadrangle.

Table 2. Sample location information and sample site description. (LAT (DD)=latitude, decimal degress, LON(DD)=Longitude, decimal degrees)

Drainage	Field_No	LAT_DD[1]	LON_DD[1]	ELEV (m)[2]	COORDINATE SOURCE	DESCRIPTION[3]
AMER	DC21	62.02861	-158.12361	300	hand held GPS	Upper American Creek 0.6 m wide by 13 cm deep
AMER	DC20	62.04111	-158.17028	300	hand held GPS	American Creek north side tributary
ANAC	DC18	62.01222	-158.10528	250	hand held GPS	Upper Anaconda Creek, sub-surface stream-visible through holes in vegetation/sediment cover
ANAC	DC19	62.00500	-158.18556	150	hand held GPS	Anaconda creek north side tributary, 0.6 m wide by 13 cm deep
BELL	DC16	62.04556	-158.05500	350	hand held GPS	Donlin Creek VABM Anaconda Headwaters of Bell Creek, 0.5 m wide by 13 cm deep
BELL	DC17	62.02944	-158.08472	430	hand held GPS	Bell Creek, tributary draining east side of VABM Anaconda, 1 m wide by 6 cm deep
DOME	DC09	62.04583	-158.10472	350	hand held GPS	Upper Dome Creek, tributary from south, but not highest one, bedrock seep, slimey, brown algae coating
DOME	DC10	62.04500	-158.07639	330	hand held GPS	Upper Dome Creek Central Drainage, no surface water above this point
DOME	DC11	62.06444	-158.07222	270	hand held GPS	Dome Creek northernmost tributary, 1 m wide by 9 cm deep
DOME	DC14	62.07056	-158.11667	200	hand held GPS	Dome Creeklower main drainage, 2 m wide by 0.6 m deep
DOME	DC24	62.08822	-158.16410	150	hand held GPS	Dome Creek, Montoring site on winter trail beneath wood bridge
GW	DC22	62.04209	-158.24100	130	hand held GPS	Groundwater well DC02-732 off main road heading up ridge near drilling pad, 290 m deep
GW	DC23	62.03609	-158.22770	150	hand held GPS	Groundwater well DC98-528, dedicated well located on south side of Lewis ridge, 260 m deep
LEWIS	DC01	62.04583	-158.19222	300	hand held GPS	Upper Lewis Gulch, minor rubble from Kuskokwim sequence, very minor porphery dike, slow seep
LEWIS	DC02	62.04722	-158.20417	330	hand held GPS	Lower Lewis Gulch, seep
LEWIS	DC27	62.05057	-158.21560	130	hand held GPS	Lewis Gulch monitoring site 2 m wide by 1 m deep
OPHIR	DC12	62.07000	-158.03389	330	hand held GPS	Ophir Creek highest water, vigorous flow, 0.3 m wide by 6 cm deep
OPHIR	DC13	62.08278	-158.10556	200	hand held GPS	Ophir Creek-mid drainage, 2 m wide by 17 cm deep
QUARTZ	DC15	62.07472	-158.17083	200	hand held GPS	Lower Quartz Creek, 0.5 m wide by 9 cm deep
QUEEN	DC03	62.05417	-158.19444	250	hand held GPS	Queen Gulch off main drainage on south side of valley, seep
QUEEN	DC26	62.05916	-158.21560	150	hand held GPS	Queen Gulch monitoring site, 2 m wide by 10 cm deep
SNOW	DC07	62.03917	-158.13083	400	hand held GPS	S.Side of Snow Gulch above DC05, bedrock seep
SNOW	DC04	62.04333	-158.11556	350	hand held GPS	Snow Gulch, small stream, 0.3 m wide by 13 cm deep
SNOW	DC05	62.04361	-158.13250	300	hand held GPS	Snow Gulch side drainage from south, 0.6 m wide by 9 cm deep
SNOW	DC06	62.04556	-158.13111	300	hand held GPS	Snow Gulch Main Drainage, valley bottom, meandering stream, 1m by 7 cm deep
SNOW	DC08	62.06278	-158.18139	190	hand held GPS	Snow Gulch lower on drainage, deeply incised stream, 2 m wide by 2 m deep
SNOW	DC25A	62.08119	-158.19880	150	hand held GPS	Snow Gulch monitoring site, just up stream from Donlin Creek
SNOW	DC25B	62.08119	-158.19880	150	hand held GPS	Snow Gulch monitoring site, just up stream from Donlin Creek, duplicate sample

1. Coordinates shown using NAD27 datum and Clark 1886 spheriod
2. Elevations were determined using 30 m USGS DEM combined with field measurements using hand held GPS and topographic map these numbers are only good to +/-30 m.
3. Sizes of streams and seeps are approximate, and only given for reference

Table 3. Analytical techniques and their corresponding abbreviation.(PESP= Preset Endpoint, IC= Ion Chromatography, ICP-MS= Inductively coupled plasma-mass spectrometry, ICP-AES= Inductively coupled plasma-atomic emission spectrometry, GFAAS= Graphite furnace atomic adsorption spectrometry.)

Element Name	**Abbrevation**	**Method**
Alkalinity as CaCO3	Alk_CaCO3	PSEP
Alkalinity as HCO3	Alk_HCO3	Conversion
chloride	Cl	IC
fluoride	F	IC
nitrate	NO3	IC
sulfate	SO4	IC
silver	Ag	ICP-MS
aluminum	Al	ICP-AES
arsenic	As	ICP-MS
arsenite	As(III)	modified Ficklin, GFAAS
arsenate	As(V)	by difference
boron	B	ICP-AES
barium	Ba	ICP-AES
beryllium	Be	ICP-MS
bismuth	Bi	ICP-MS
calcium	Ca	ICP-AES
cadmiun	Cd	ICP-MS
cobalt	Co	ICP-MS
chromium	Cr	ICP-MS
copper	Cu	ICP-MS
iron	Fe	Fe_SPEC
ferrous iron	Fe(II)	Fe_SPEC
ferric iron	Fe(III)	by difference
potassium	K	ICP-AES
lithium	Li	ICP-AES
magnesium	Mg	ICP-AES
manganese	Mn	ICP-AES
molybdenum	Mo	ICP-MS
sodium	Na	ICP-AES
nickle	Ni	ICP-MS
phosphorus	P	ICP-MS
lead	Pb	ICP-MS
rhubidium	Rb	ICP-MS
antimony	Sb	ICP-MS
selenium	Se	ICP-MS
silica	Si	ICP-AES
strontium	Sr	ICP-AES
titanium	Ti	ICP-MS
total organic carbon	TOC	
uranium	U	ICP-MS
vanadium	V	ICP-MS
tungsten	W	ICP-MS
zinc	Zn	ICP-MS
zirconium	Zr	ICP-MS

Table 4. Method of analysis limits of detection (LOD), lower limit of determination (LLD), and limit of quantification (LOQ). (IC= Ion chromatography, ICP-MS= Inductively coupled plasma-mass spectrometry, ICP-AES= inductively coupled plasma-atomic emission

Element	**IC_LOD**	**IC_LLD**	**IC_LOQ**	**ICP-MS_LOD**	**ICP-MS_LLD**	**ICP_MS_LOQ**	**ICP-AES_LOD**	**ICP-AES_LLD**	**ICP-AES_LOQ**
(mg/L)									
Cl^-	0.04	0.07	0.1						
F^-	0.08	0.1	0.2						
NO_3^-	0.08	0.1	0.2						
SO_4^{2-}	2	3	6						
Ca				0.05	0.08	0.2	0.01	0.02	0.03
Mg				0.01	0.02	0.03	0.1	0.2	0.3
Na				0.6	1	2	0.005	0.008	0.02
K				0.03	0.05	0.1	0.1	0.2	0.3
(µg/L)									
Ag				3	5	10	1	2	3
Al				1	2	5	0.01	0.02	0.03
As				1	2	3	100	170	330
B							5	8	20
Ba				0.1	0.2	0.3	1	2	3
Be				0.05	0.08	0.2	10	20	30
Bi				0.005	0.008	0.2			
Cd				0.02	0.03	0.07	5	8	20
Co				0.02	0.03	0.07	10	20	30
Cr				1	2	3	10	20	30
Cu				0.5	0.8	1.7	10	20	30
Fe				50	80	160	0.02	0.03	0.07
Li				0.1	0.2	0.3	1	2	3
Mn				0.03	0.05	0.1	0.3	0.5	1.0
Mo				0.2	0.3	0.7	20	30	70
Ni				0.3	0.5	1.0	10	20	30
P				0.01	0.02	0.03	0.1	0.2	0.3
Pb				0.05	0.08	0.2	50	80	170
Rb				0.01	0.02	0.03			
Sb				0.1	0.2	0.3	50	80	170
Se				1	2	3			
Si				0.2	0.3	0.7	0.1	0.2	0.3
Sr				0.5	0.8	2	1	2	3
Ti				0.1	0.2	0.3	50	80	170
U				0.1	0.2	0.5			
V				0.1	0.2	0.3	10	20	30
W				0.1	0.2	0.3			
Zn				0.5	0.8	2	10	20	30
Zr				0.05	0.08	0.2			

Table 5. Chemical analyses for sample blanks. (FA= acidified-filtered, TR=acidified-

Analyte	FA	TR
mg/L		
Cl^-	0.08	
F^-	-	
NO_3^-	0.2	
SO_4^{2-}	<2	
Ca	<0.1	<0.1
Mg	<0.1	<0.1
Na	0.1	0.2
K	<0.1	<0.1
Fe(T)	<0.02	<0.02
µg/L		
Ag	<3	<3
Al	1	5
As	2	2
B	<5	<5
Ba	<1	<1
Be	<0.05	<0.05
Bi	0.005	< 0.005
Cd	<0.02	<0.02
Co	<0.02	<0.02
Cr	<1	<1
Cu	<0.5	0.5
Li	< 0.1	< 0.1
Mn	0.01	0.2
Mo	0.4	0.4
Ni	0.2	0.3
P	< 0.01	< 0.01
Pb	<0.05	0.08
Rb	0.01	0.02
Sb	0.2	0.2
Se	< 1	< 1
Si	<0.1	<0.1
Sr	<1	<1
Ti	< 0.1	< 0.1
U	0.02	0.01
V	<0.1	<0.1
W	<0.2	<0.2
Zn	4	7
Zr	< 0.05	< 0.05

Table 6. Results of water analyses.(Field_No=Field number, Date_Coll=collection date, Time_Coll=collection time, T_{water}=Temperature of the water, SC= Specific Electrical Conductance, D.O.= Dissolved Oxygen, T.O.C.=Total organic carbon, Alk= Alkalinity. For Sum Cations, Sum Anions, and Charge Imbalance please see p.13-14 of accompanying text.)

Drainage	Field_No	Date_Coll	Time_Coll	T_{water} (°C)	pH	SC (µS/cm)	D.O. (mg/L)	Filtration	T.O.C (mg/L)	Alk (mg/L as $CaCO_3$)	Alk (mg/L as HCO_3^-)	CO_3^{2-} mg/L	mg/L	Ca	Mg	Na	K
AMER	DC21	7/9/02	16:40	3.6	8.0	275	12.2	0.45	1.3	100	121	0.54		29	12	1.6	0.3
								unfiltered		--	--	--		30	11	1.4	0.31
	DC20	7/9/02	15:15	5.1	7.2	312	9.2	0.45	3.1	110	134	0.1		31	15	1.4	0.46
								unfiltered		--	--	--		34	13	1.2	0.4
ANAC	DC18	7/9/02	13:00	2	7.2	89.9	10	0.45	2.5	35	43	0.03		11	1.8	2.6	0.27
								unfiltered		--	--	--		11	1.8	2.5	0.29
	DC19	7/9/02	14:20	2.6	7.7	192	11.9	0.45	2.3	86	104	0.25		22	6	5.3	0.42
								unfiltered		--	--	--		22	5.6	5.1	0.42
BELL	DC16	7/9/02	9:50	2	7.3	278	12.4	0.45	1.2	100	122	0.12		31	9.9	1.8	0.4
								unfiltered		--	--	--		35	9.7	1.6	0.36
	DC17	7/9/02	12:05	3.6	7.5	535	11.7	0.45	2.1	100	122	0.18		64	20	2.8	0.45
								unfiltered		--	--	--		61	17	2.6	0.43
DOME	DC09	7/8/02	10:20	2.5	4.5	200	10.8	0.45	1.1	100	122	0.17		32	8.7	1.1	0.29
								unfiltered		--	--	--		34	8.3	1.2	0.3
	DC10	7/8/02	12:15	4.2	7.1	237	8.9	0.45	1.1	82	100	0.07		27	8	1.6	0.32
								unfiltered		--	--	--		30	10	1.6	0.47
	DC11	7/8/02	14:15	4.8	7.8	247	12.2	0.45	1.9	99	120	0.38		29	8.5	1.9	0.35
								unfiltered		--	--	--		30	7.6	1.8	0.27
	DC14	7/8/02	17:20	7	7.9	289	11.6	0.45	2.2	110	133	0.55		29	11	1.7	0.33
								unfiltered		--	--	--		35	11	1.7	0.33
	DC24	7/10/02	10:25	5.6	7.8	287	11.9	0.45	--	110	133	0.4		32	13	1.9	0.4
								unfiltered		--	--	--		34	11	1.7	0.38
GW	DC22	7/9/02	18:30	5	8.4	770	0.02	0.45	--	350	417	4.9		8.4	6	150	2.2
								unfiltered		--	--	--		8.6	5	130	2.2
	DC23	7/9/02	8:05	4.7	7.6	384	0.5	0.45	--	150	182	0.39		26	16	26	1.2
								unfiltered		--	--	--		28	14	21	1.1
LEWIS	DC01	7/7/02	9:45	3	7.6	296	8.9	0.45	--	110	134	0.25		30	14	0.89	0.33
								unfiltered		--	--	--		41	16	1.5	1
	DC02	7/7/02	10:47	4.1	7.0	185	7	0.45	2.4	58	71	0.03		20	8.7	1.2	0.32
								unfiltered		--	--	--		20	8.1	1.2	0.32
	DC27	7/10/02	13:26	3.1	7.7	322	11.7	0.45	--	97	118	0.26		29	17	1.7	0.41
								unfiltered		--	--	--		31	16	1.5	0.39
OPHIR	DC12	7/8/02	15:20	3	8.0	338	12	0.45	1.5	140	169	0.79		41	12	1.8	0.35
								unfiltered		--	--			42	11	1.6	0.32
	DC13	7/8/02	16:35	7.6	7.9	304	11.3	0.45	2.6	130	157	0.68		34	14	1.7	0.37
								unfiltered		--	--	--		35	12	1.4	0.34
QUARTZ	DC15	7/8/02	17:50	3.5	7.5	259	11.6	0.45	2.8	89	108	0.15		26	11	1.6	0.66
								unfiltered		--	--	--		29	11	1.6	0.67
QUEEN	DC03	7/7/02	12:00	4.5	7.2	160	11.4	0.45	5.3	67	82	0.05		16	8.9	0.69	0.26
								unfiltered		--	--			16	8.5	0.78	0.18
	DC26	7/10/02	12:48	4	7.5	295	12	0.45	--	84	102	0.16		28	15	1.4	0.38
								unfiltered		--	--	--		31	14	1.4	0.47
SNOW	DC07	7/7/02	17:30	2.7	7.3	531	11.6	0.45	1.3	130	158	0.15		54	25	1.9	0.4
								unfiltered		--	--	--		55	23	1.9	0.39
	DC04	7/7/02	15:00	2.1	7.2	396	11.2	0.45	2.4	130	158	0.12		42	17	1.6	0.44
								unfiltered		--	--	--		44	16	1.3	0.38
	DC05	7/7/02	15:50	2.8	7.9	424	12.7	0.45	1.2	140	170	0.62		42	21	1.5	0.33
								unfiltered		--	--	--		44	20	1.4	0.36
	DC06	7/7/02	16:20	2.2	7.3	237	10.7	0.45	1.2	85	103	0.1		24	8.9	1.3	0.29
								unfiltered		--	--	--		27	8.5	1.2	0.29
	DC08	7/8/02	8:40	3	7.3	342	11.8	0.45	1.2	130	158	0.18		35	17	1.5	0.42
								unfiltered		--	--	--		38	16	1.5	0.42
	DC25A	7/10/02	11:37	5	7.7	344	9.8	0.45	--	140	170	0.38		37	19	1.7	0.49
								unfiltered		--	--	--		37	16	1.5	0.48
	DC25B	7/10/02	11:37	5	7.7	344	9.8	0.45	--	140	170	0.38		36	18	1.6	0.51
								unfiltered		--	--	--		39	17	1.5	0.5

Table 6. Cont

Drainage	Field_No	Fe	Fe(II)	Fe(III)	SiO_2	Cl^-	F	NO_3^-	SO_4^{2-}	µg/L	Ag	Al	As	As(III)	As(V)	B	Ba	Be	Bi	Cd	Co
AMER	DC21	0.018	0.010	0.008	5.9	0.5	0.09	3.4	15		<3	6	<1	--	--	<5	46	<0.05	< 0.005	<0.02	0.03
		0.02	--	--	5.6	--	--	--	--		<3	20	<1	--	--	<5	41	<0.05	< 0.005	<0.02	0.04
	DC20	0.002	<0.002	0.002	5.6	0.6	0.1	4.1	23		<3	4.4	4.9	--	--	<5	43	<0.05	0.05	<0.02	0.03
		0.083	--	--	5.6	--	--	--	--		<3	83	4.7	--	--	<5	39	<0.05	0.02	<0.02	0.06
ANAC	DC18	0.009	0.008	0.001	8.8	0.5	0.1	2	3		<3	17	<1	--	--	<5	35	<0.05	0.07	<0.02	0.02
		0.73	--	--	9.6	--	--	--	--		<3	664	1	--	--	<5	45	<0.05	< 0.005	<0.02	0.34
	DC19	0.041	0.036	0.005	8.1	0.7	0.1	0.9	4.1		<3	9.4	<1	--	--	6.3	68	<0.05	< 0.005	<0.02	0.05
		0.24	--	--	8.1	--	--	--	--		<3	144	<1	--	--	5.3	68	<0.05	< 0.005	<0.02	0.12
BELL	DC16	<0.002	<0.002	<0.002	5.9	0.7	0.08	4	13		<3	2.6	<1	--	--	<5	73	<0.05	< 0.005	<0.02	0.03
		0.16	--	--	5.9	--	--	--	--		<3	113	<1	--	--	<5	70	<0.05	< 0.005	<0.02	0.07
	DC17	0.004	0.001	0.003	4.9	0.6	<.08	4.2	130		<3	6.5	<1	--	--	<5	80	<0.05	< 0.005	<0.02	0.04
		<0.02	--	--	4.7	--	--	--	--		<3	17	<1	--	--	<5	74	<0.05	< 0.005	<0.02	0.06
DOME	DC09	<0.002	<0.002	<0.002	5.4	0.5	<.08	3.4	12		<3	3.7	<1	--	--	<5	57	<0.05	< 0.005	<0.02	0.03
		0.34	--	--	5.6	--	--	--	--		<3	330	<1	--	--	<5	62	<0.05	< 0.005	<0.02	0.12
	DC10	0.004	0.001	0.003	6.2	0.4	0.08	2.9	17		<3	0.95	<1	--	--	<5	55	<0.05	< 0.005	<0.02	0.03
		14	--	--	23	--	--	--	--		<3	5930	3	--	--	<5	147	0.2	< 0.005	0.1	7.05
	DC11	0.004	0.003	0.001	6.8	0.5	0.08	1.8	9		<3	8.4	<1	--	--	7.4	69	<0.05	< 0.005	<0.02	0.03
		0.058	--	--	6.4	--	--	--	--		<3	46	<1	--	--	5.5	62	<0.05	< 0.005	<0.02	0.05
	DC14	0.016	0.013	0.003	5.9	0.6	0.09	2	14		<3	12	2	--	--	<5	58	<0.05	< 0.005	<0.02	0.04
		0.56	--	--	7.3	--	--	--	--		<3	399	<1	--	--	<5	65	<0.05	< 0.005	<0.02	0.32
	DC24	0.072	0.045	0.027	7.1	0.5	0.1	1.7	15		<3	11	1	--	--	<5	58	<0.05	< 0.005	<0.02	0.08
		0.14	--	--	6.8	--	--	--	--		<3	44	2	--	--	<5	52	<0.05	< 0.005	0.02	0.1
GW	DC22	0.31	0.30	0.01	7.5	2.3	1.2	<.08	12		<3	30	564	534	30	188	168	<0.05	0.02	<0.02	0.09
		0.54	--	--	8.6	--	--	--	--		<3	522	544	--	--	160	196	0.06	< 0.005	<0.02	0.35
	DC23	0.65	0.57	0.08	11	0.8	0.3	0.2	22		<3	1.7	319	313	6	72	69	<0.05	0.009	<0.02	0.06
		0.61	--	--	10	--	--	--	--		<3	21	307	--	--	59	59	<0.05	< 0.005	<0.02	0.07
LEWIS	DC01	0.022	0.011	0.011	5.1	0.5	0.1	2.4	20		<3	4.4	6.5	<1	6.5	<5	21	<0.05	< 0.005	<0.02	0.03
		18	--	--	30	--	--	--	--		<3	15300	274	--	--	<5	218	0.5	0.11	0.22	9.3
	DC02	0.004	0.002	0.002	7.3	0.7	0.09	4	23		<3	8.7	7.7	--	--	<5	18	<0.05	0.005	<0.02	0.03
		0.029	--	--	6.6	--	--	--	--		<3	31	8.2	--	--	<5	18	<0.05	< 0.005	<0.02	0.04
	DC27	0.032	0.029	0.003	7.7	0.7	0.1	1.2	42		<3	7.1	5.4	--	--	<5	26	<0.05	0.05	<0.02	0.04
		0.3	--	--	7.7	--	--	--	--		<3	136	9.2	--	--	<5	25	<0.05	0.03	<0.02	0.14
OPHIR	DC12	0.003	0.002	0.001	6.2	0.5	0.08	3.8	9.7		<3	4.5	<1	--	--	6.3	101	<0.05	0.03	<0.02	0.03
		0.23	--	--	5.9	--	--	--	--		<3	217	<1	--	--	<5	94	<0.05	0.007	<0.02	0.13
	DC13	0.037	0.034	0.003	6.8	0.5	0.09	1.4	8.2		<3	19	<1	--	--	<5	72	<0.05	0.08	<0.02	0.05
		0.18	--	--	6.6	--	--	--	--		<3	104	<1	--	--	<5	65	<0.05	0.03	<0.02	0.11
QUARTZ	DC15	0.019	0.017	0.002	8.5	0.7	0.1	0.7	20		<3	14	6.6	--	--	<5	25	<0.05	< 0.005	<0.02	0.08
		1.2	--	--	11	--	--	--	--		<3	1070	22.3	--	--	<5	38	0.07	< 0.005	0.07	0.79
QUEEN	DC03	0.005	0.004	0.001	3.6	0.5	0.1	2.8	5.7		<3	15	3.5	--	--	<5	22	<0.05	0.08	<0.02	0.03
		0.14	--	--	3.9	--	--	--	--		<3	127	6.3	--	--	<5	24	<0.05	< 0.005	<0.02	0.12
	DC26	0.024	0.022	0.002	7.3	0.7	0.1	1.1	41		<3	9	5.9	--	--	<5	28	<0.05	< 0.005	<0.02	0.09
		1.9	--	--	12	--	--	--	--		<3	1620	25.4	--	--	<5	53	0.08	< 0.005	0.06	1.38
SNOW	DC07	0.005	0.003	0.002	4.9	0.5	0.1	3.5	87		<3	2.6	<1	--	--	<5	78	<0.05	< 0.005	<0.02	0.04
		0.23	--	--	5.1	--	--	--	--		<3	190	<1	--	--	<5	80	<0.05	< 0.005	<0.02	0.12
	DC04	0.003	0.001	0.002	5.1	0.5	0.09	4.4	39		<3	3	2	--	--	<5	85	<0.05	0.009	<0.02	0.03
		0.17	--	--	5.1	--	--	--	--		<3	143	2	--	--	<5	76	<0.05	< 0.005	<0.02	0.1
	DC05	<0.002	<0.002	<0.002	5.4	0.4	0.09	2.5	46		<3	6.6	<1	--	--	<5	56	<0.05	0.007	<0.02	0.02
		0.068	--	--	5.4	--	--	--	--		<3	52	<1	--	--	<5	50	<0.05	< 0.005	<0.02	0.05
	DC06	0.010	0.008	0.002	5.9	0.5	0.09	2.8	13		<3	3.6	3	--	--	<5	57	<0.05	< 0.005	<0.02	0.04
		0.086	--	--	5.9	--	--	--	--		<3	61	2	--	--	<5	54	<0.05	< 0.005	<0.02	0.06
	DC08	0.074	0.061	0.013	6.6	0.6	0.09	2	22		<3	13	2	--	--	<5	45	<0.05	0.02	<0.02	0.1
		0.75	--	--	7.5	--	--	--	--		<3	482	4.3	--	--	<5	48	<0.05	0.009	0.02	0.41
	DC25A	0.028	0.025	0.003	6.6	0.6	0.1	1.1	26		<3	9.7	3.8	--	--	<5	51	<0.05	0.02	<0.02	0.06
		0.12	--	--	6.4	--	--	--	--		<3	60	2	--	--	<5	46	<0.05	0.01	<0.02	0.1
	DC25B	0.030	0.016	0.005	6.6	0.5	0.1	1.1	25		<3	8	2	--	--	<5	50	<0.05	0.03	<0.02	0.05
		0.14	--	--	6.4	--	--	--	--		<3	64	3	--	--	<5	47	<0.05	0.02	0.02	0.11

Table 6. Cont

Drainage	Field_No	Cr	Cu	Li	Mn	Mo	Ni	P	Pb	Rb	Sb	Se	Sr	Ti	U	V	W	Zn	Zr
AMER	DC21	6	<0.5	2.5	0.6	2.1	0.3	0.02	<0.05	0.21	0.3	< 1	121	0.8	0.31	1.5	0.53	<0.5	< 0.05
		3.6	<0.5	1.3	1.1	2.4	0.6	< 0.01	<0.05	0.2	0.35	1.6	108	< 0.1	0.22	1.2	0.43	0.6	< 0.05
	DC20	6.2	<0.5	1.8	0.2	0.32	0.4	0.02	<0.05	0.25	0.1	< 1	115	0.6	0.26	1.8	0.38	<0.5	< 0.05
		3.5	<0.5	1.1	1.2	< 0.2	1	0.01	<0.05	0.31	<0.1	1.7	102	2.8	0.26	1.1	0.2	0.6	< 0.05
ANAC	DC18	4.3	<0.5	1.2	0.6	1.6	0.3	0.02	<0.05	0.14	0.22	< 1	159	0.6	0.01	1.3	1.4	<0.5	0.06
		2	0.81	1.2	16.5	1.9	1.2	0.01	0.4	0.47	0.3	< 1	147	11	< 0.005	1.7	0.1	2.3	0.1
	DC19	5.6	<0.5	1.7	35	0.3	0.4	0.02	<0.05	0.15	<0.1	< 1	383	0.5	0.08	1.6	0.1	2.4	0.07
		3	<0.5	2	36	0.75	0.7	< 0.01	0.08	0.22	0.2	< 1	366	2	0.04	1.2	0.08	2	0.07
BELL	DC16	5.7	0.72	2.2	0.1	0.32	0.3	0.02	<0.05	0.27	<0.1	1	113	0.6	0.29	1.4	0.37	<0.5	< 0.05
		4	<0.5	2.2	2.6	0.95	0.7	< 0.01	<0.05	0.32	0.1	1.1	107	2.4	0.24	1.5	0.30	1	< 0.05
	DC17	1	<0.5	<1	0.04	0.29	0.7	< 0.01	<0.05	0.27	<0.1	4.2	181	0.5	1.3	0.5	0.1	0.9	< 0.05
		2.8	<0.5	<1	0.4	0.23	1.1	< 0.01	<0.05	0.3	<0.1	4.4	161	1.2	1.3	0.8	0.03	<0.5	< 0.05
DOME	DC09	6.4	<0.5	1.9	0.3	0.2	0.3	0.02	<0.05	0.22	<0.1	< 1	134	0.7	0.22	1.7	0.2	<0.5	< 0.05
		3.4	0.61	2.2	7.2	0.77	0.9	0.02	0.2	0.4	0.1	1	133	10	0.19	1.5	0.2	1	0.1
	DC10	3.9	<0.5	3.2	0.1	< 0.2	0.3	0.02	<0.05	0.2	0.1	1.5	100	0.5	0.17	1	1.6	<0.5	< 0.05
		14	5	18	493	0.44	18	0.2	5.4	2.6	0.21	1.9	99	57	0.5	21	1.4	29	0.4
	DC11	6	<0.5	2.3	4.1	< 0.2	0.3	0.1	<0.05	0.26	<0.1	< 1	111	0.6	0.15	1.5	1.0	2.1	< 0.05
		2.9	<0.5	2.5	2.7	0.46	0.6	< 0.01	<0.05	0.22	0.1	< 1	100	< 0.1	0.11	1.1	0.75	0.7	< 0.05
	DC14	5.6	<0.5	2.5	12	< 0.2	0.4	0.02	<0.05	0.23	<0.1	< 1	125	0.9	0.27	1.6	0.27	<0.5	< 0.05
		3.8	0.52	1.7	19	0.46	1.5	0.02	0.2	0.42	0.1	1	128	6	0.22	2.2	0.22	2.1	0.06
	DC24	6	1.2	2.6	18	0.27	0.7	0.02	<0.05	0.32	0.22	< 1	134	0.7	0.28	1.8	0.37	0.7	< 0.05
		3.7	<0.5	2.2	17	0.67	0.9	< 0.01	<0.05	0.3	0.27	1	123	0.4	0.22	1.3	0.27	0.7	0.06
GW	DC22	4.9	0.65	192	36	2.8	0.8	0.02	0.1	3.5	25	< 1	458	0.3	5.3	1.5	36.0	2	0.88
		4.8	1.2	155	39	2.6	1.6	0.03	0.4	4.2	24	< 1	431	0.4	5.3	2.4	38.0	2	0.98
	DC23	4.2	<0.5	68	99	0.28	0.5	0.02	<0.05	1.7	<0.1	< 1	717	0.2	0.13	0.8	0.92	3.4	0.09
		3	3.3	50	98	< 0.2	0.9	0.02	0.69	1.7	<0.1	< 1	613	0.6	0.14	0.9	1.0	6	< 0.05
LEWIS	DC01	3.1	<0.5	1.2	1.3	< 0.2	0.3	0.01	<0.05	0.26	0.55	< 1	84	0.5	0.15	0.8	0.24	<0.5	< 0.05
		16	16	11	790	0.34	21	0.5	12	7.9	1.2	1.8	114	191	1.3	28	0.47	59	1.8
	DC02	5.7	<0.5	<1	0.2	0.39	0.5	0.03	<0.05	0.21	1.2	< 1	59	0.6	0.01	1.7	0.2	<0.5	0.06
		2	<0.5	<1	1	0.82	0.6	< 0.01	<0.05	0.2	1.4	< 1	56	0.5	< 0.005	0.6	0.1	<0.5	0.05
	DC27	5.1	<0.5	1.4	9.3	0.24	0.6	0.02	<0.05	0.19	2.6	< 1	101	0.7	0.13	1.2	0.33	<0.5	0.09
		2.7	0.5	1.4	14	< 0.2	1	0.01	0.1	0.27	2.8	< 1	91	4.6	0.12	1.1	0.2	0.7	0.08
OPHIR	DC12	4.6	<0.5	2.8	0.6	2.1	0.4	0.02	0.05	0.22	0.31	< 1	152	0.6	0.31	1.5	0.98	<0.5	< 0.05
		4	0.64	2.6	6.2	1.8	1.1	< 0.01	0.1	0.34	0.26	1	132	4.8	0.29	1.5	0.05	0.9	< 0.05
	DC13	4.7	<0.5	2	6.9	0.41	0.4	< 0.01	<0.05	0.18	<0.1	< 1	147	0.4	0.24	1.9	0.42	0.7	0.06
		3.2	<0.5	1.3	9.2	0.22	1	< 0.01	0.06	0.25	<0.1	< 1	127	2.4	0.24	1.4	0.1	0.9	< 0.05
QUARTZ	DC15	5.6	1.1	1.3	10	< 0.2	0.6	0.02	<0.05	0.53	0.56	< 1	75	1	0.21	1.7	0.87	5.6	0.1
		4.3	5.6	1.5	26	0.31	2.5	0.03	0.64	1.4	0.63	1.2	68	34	0.26	3.7	0.61	6.5	0.2
QUEEN	DC03	5.1	1	<1	2.9	0.72	0.5	0.1	<0.05	0.05	4.1	< 1	36	0.6	0.06	1.5	0.2	1	0.1
		2.2	1	<1	11	1.2	1	< 0.01	0.1	0.19	4.4	< 1	34	2.3	0.03	1	0.1	0.9	0.2
	DC26	4.4	0.5	1.1	7.6	< 0.2	0.6	0.02	<0.05	0.16	3.9	< 1	107	0.8	0.13	1.6	0.32	<0.5	0.07
		4.5	3.4	1.5	39	0.41	3.9	0.07	1.6	1.3	4.1	< 1	104	38	0.21	4.4	0.30	12	0.2
SNOW	DC07	3.9	<0.5	1.5	0.7	< 0.2	0.5	< 0.01	<0.05	0.45	<0.1	2.5	163	0.4	0.63	1.1	0.2	0.5	< 0.05
		3.1	0.6	1.1	13	< 0.2	1.6	0.01	0.2	0.61	<0.1	3.1	154	4.4	0.64	1.2	< 0.02	2	< 0.05
	DC04	4.4	<0.5	2.7	0.08	0.2	0.4	< 0.01	<0.05	0.3	<0.1	1.4	172	0.3	0.44	1.2	0.22	<0.5	< 0.05
		3.2	<0.5	1.1	5.4	< 0.2	1	0.01	0.09	0.42	<0.1	1.9	159	4	0.47	1.2	0.1	0.7	< 0.05
	DC05	1.2	<0.5	1.6	0.09	< 0.2	0.4	< 0.01	<0.05	0.25	<0.1	1.3	161	0.3	0.45	0.7	0.1	<0.5	< 0.05
		1.7	<0.5	<1	1	< 0.2	0.9	< 0.01	<0.05	0.29	<0.1	1.5	148	1.9	0.44	0.7	0.04	<0.5	< 0.05
	DC06	6.1	<0.5	1.3	2.7	< 0.2	0.4	0.02	<0.05	0.25	0.27	< 1	100	0.6	0.08	1.6	3.8	<0.5	< 0.05
		2.6	<0.5	<1	3.2	0.4	0.6	< 0.01	<0.05	0.26	0.29	< 1	92	1.2	0.04	0.9	3.2	<0.5	0.06
	DC08	4.5	<0.5	2.3	27	0.8	0.5	0.02	<0.05	0.26	0.42	< 1	150	0.7	0.25	1.4	0.2	0.6	0.06
		3.9	0.99	<1	40	0.63	1.6	0.02	0.3	0.53	0.42	1.2	135	15	0.28	2.2	0.05	6.7	0.1
	DC25A	5.1	0.67	3.4	17	0.55	0.6	0.01	<0.05	0.28	0.53	< 1	155	0.4	0.32	1.4	0.2	0.7	0.06
		3.6	0.6	2.4	22	0.36	1	< 0.01	0.05	0.33	0.5	< 1	135	1.4	0.29	1.4	< 0.02	0.8	< 0.05
	DC25B	5.2	0.58	2.9	18	0.41	0.6	0.01	<0.05	0.28	0.54	< 1	151	0.5	0.32	1.8	0.2	0.5	0.06
		3.8	0.7	2.4	24	0.28	1	0.01	0.06	0.36	0.51	1.1	140	1.5	0.3	1.4	0.06	0.9	0.06

Table 6. Cont

Drainage	Field_No	Sum Cation	Sum Anions	Charge Imbalance (%)
AMER	DC21	2.391	2.333	2.457
	DC20	2.741	2.694	1.731
ANAC	DC18	0.877	0.815	7.268
	DC19	1.86	1.819	2.265
BELL	DC16	2.475	2.319	6.501
	DC17	4.144	4.413	-6.298
DOME	DC09	2.341	2.283	2.498
	DC10	2.071	2.015	2.774
	DC11	2.223	2.176	2.109
	DC14	2.617	2.482	5.298
	DC24	2.642	2.493	5.827
GW	DC22	7.553	7.299	3.416
	DC23	3.515	3.416	2.865
LEWIS	DC01	2.582	2.615	-1.279
	DC02	1.735	1.69	2.672
	DC27	2.761	2.751	0.353
OPHIR	DC12	3.001	3.014	-0.418
	DC13	2.942	2.747	6.874
QUARTZ	DC15	2.252	2.175	3.492
QUEEN	DC03	1.568	1.512	3.636
	DC26	2.509	2.475	1.394
SNOW	DC07	4.379	4.198	4.241
	DC04	3.363	3.372	-0.258
	DC05	3.642	3.659	-0.47
	DC06	2.059	1.991	3.341
	DC08	3.089	3.027	2.014
	DC25A	3.219	3.279	-1.867
	DC25B	3.231	3.258	-0.817

Table 7. Statistical summary of water analyses for filtered-acidified and unfiltered-acidified surface water samples.

	Surface Water Samples									
	Filtered-acidified					**Unfiltered-acidified**				
Parameter	**MAX**	**MIN**	**MEDIAN**	**MEAN**	**n**	**MAX**	**MIN**	**MEDIAN**	**MEAN**	**n**
T	7.6	2	3.5	3.9	25	7.6	2	3.5	3.9	25
pH	8	7	7.5	7.5	25	8	7	7.5	7.50	25
Cond (µS/cm)	535	90	289	304	25	535	90	289	304	25
(mg/L)										
D.O.	13	7	12	11	25	13	7	12	11.00	25
AlkCaCO3	140	35	100	104	25	140	35	100	104	25
AlkHCO3	170	43	122	126	25	170	43	122	126	25
Cl	0.7	0.4	0.5	0.6	26	0.7	0.4	0.5	0.6	26
F	0.10	0.08	0.10	0.09	24	0.1	0.08	0.10	0.09	24
NO3	4.4	0.7	2.5	2.5	26	4.4	0.7	2.45	2.51	26
SO4	130	3	19	26	26	130	3	19	26	26
Ca	64	11	31	32.0	26	61	11	34	34	26
Mg	25	1.8	12	13.0	26	23	1.8	11	12.0	26
Na	5	0.7	1.6	1.8	26	5.1	0.78	1.5	1.7	26
K	0.66	0.26	0.4	0.4	26	1	0.18	0.38	0.40	26
Fe	0.074	0.002	0.016	0.020	23	18	0.02	0.18	1.6	25
(µg/L)										
Ag	<3					<3				
Al	19	0.95	7.6	8.1	26	15300	17	132	1056	26
As	7.7	1	3.7	4.0	14	274	1	4	25	15
B	7.4	6.3	6.3	6.7	3	5.5	5.3	5.4	5.4	2
Ba	101	18	56	53	26	218	18	54	64	26
Be	<0.05					0.5	0.07	0.14	0.21	4
Bi	0.08	0.005	0.03	0.038	12	0.11	0.007	0.02	0.030	8
Cd	<0.02					0.22	0.02	0.06	0.07	7
Co	0.10	0.02	0.04	0.04	26	9.3	0.04	0.12	0.82	26
Cr	6.4	1	5.1	4.8	26	16	1.7	3.5	4.1	26
Cu	1.2	0.5	0.7	0.8	7	16	0.5	0.8	2.7	14
Li	3.4	1.1	2.0	2.1	23	18	1.1	1.9	3.0	20
Mn	35	0.04	2.0	6.8	26	790	0.4	12	62	26
Mo	2.1	0.20	0.39	0.66	17	2.4	0.22	0.46	0.76	21
Ni	0.7	0.3	0.4	0.5	26	21	0.6	1	2.6	26
P	0.1	0.01	0.02	0.03	21	0.5	0.01	0.02	0.07	13
Pb	0.05	0.05	0.05	0.05	1	12	0.05	0.2	1.3	17
Rb	0.53	0.05	0.25	0.25	26	7.9	0.19	0.33	0.78	26
Sb	4.1	0.1	0.5	1.0	16	4.5	0.1	0.33	0.91	20
Se	4.2	1	1.5	2.0	6	4.4	1	1.4	1.7	16
Si	4.1	1.7	3	3	26	14	1.8	3.1	3.9	26
Sr	383	36	130	134	26	366	34	125	126	26
Ti	1	0.3	0.6	0.6	26	191	0.4	3.4	17	24
U	1.3	0.01	0.25	0.27	26	1.3	0.03	0.25	0.34	24
V	1.9	0.5	1.5	1.4	26	28	0.6	1.35	3.3	26
W	3.8	0.1	0.3	0.6	26	13	0.03	0.2	0.39	24
Zn	5.6	0.5	0.7	1.4	11	59	0.6	0.95	6.0	22
Zr	0.1	0.06	0.06	0.07	11	1.8	0.05	0.1	0.24	15