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Trace, Minor and Major Element Data for Ground Water Near Fairbanks, Alaska, 1999-2000

by

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INTRODUCTION

A groundwater geochemical study was carried out from August 1999 to August 2000 near Fairbanks, Alaska. Groundwater samples were collected at two-month-intervals from 17 domestic water supply wells located throughout the Fairbanks (Fig 1) area to (1) comprehensively define the baseline geochemical signature of the groundwater, (2) examine the spatial variability, (3) examine any seasonal variability, and (4) determine the concentration of arsenic species in the groundwater. This report presents the methodology and analytical results for the groundwater samples taken during this study.

GEOLOGIC BACKGROUND, HYDROLOGY, AND MINERALIZATION

Fairbanks is located in east-central Alaska within what is known as the Yukon-Tanana terrane (YTT), which is described as a pericratonic block of late Paleozoic and older rocks that have experienced multiple episodes of metamorphism and deformation (Foster and others, 1994.) The dominant rocks exposed in the Fairbanks area are those of the Fairbanks Schist, a heterogeneous unit composed of quartzite and muscovite-quartz±garnet±biotite±chlorite schist that is intruded in places by Mississippian orthogneiss (Foster and others, 1994). Less common lithologies of the Fairbanks Schist include amphibolites, magnetite-rich biotite schist, and marble (Newberry and others, 1996). Other important units include: (1) metamorphosed andesite, rhyolite, and basalt of the Devonian Muskox Sequence; (2) slate, phyllite, quartzite, calcareous schist, impure marble and minor metarhyolite tuff of the Birch Hill Sequence; (3) Devonian-Mississippian eclogite-bearing schist, amphibolite and quartzite of the Chatanika assemblage; and (4) Tertiary basalt (Newberry and others, 1996) (Fig 2.) The bedrock units in this area of Fairbanks are poorly exposed and covered by as much as 100 m of Quaternary Fairbanks loess (Pewe, 1975). In addition, there are numerous widely scattered Cretaceous granitic rocks (110 Ma and 90 Ma) that intrude the various metamorphosed Paleozoic rocks.

The younger of the two mid-Cretaceous intrusive events is spatially and temporally associated with the formation of lode gold deposits in the Fairbanks area. The auriferous quartz vein deposits are hosted by either granitic rocks (e.g. Ft. Knox), along the granitoid-schist boundary (e.g. Ryan Lode), solely in the schist itself (e.g. Hi-Yu deposit), or in eclogites (e.g. True North) (Metz, 1991; Newberry and others, 1996). Where the mineralization is hosted in the granitic rocks, the ores show a Bi-Te-W signature and have very low (<< 1 volume percent) sulfide mineral contents. Where hosted in the other rocks, the ores have an As-Sb-Fe signature and have higher sulfide mineral abundances (~2-3 volume percent). The metasedimentary rocks surrounding the mineralized veins also may be sulfidized for tens to hundreds of meters. Much of the mineralization in the Fairbanks area is associated with multiple, northeast-trending faults and shear zones. In addition to the known lode gold deposits, there are extensive placer deposits located near Gilmore Dome and Pedro Dome to the northeast, and near the town of Ester to the southwest of Fairbanks (Metz, 1991; Newberry and others, 1996; McCoy and others, 1997).

The hydrology of the Fairbanks area includes lowland alluvial aquifers consisting of gravel and loess deposits. Fracture controlled bedrock aquifers dominate the flow network in the upper valleys and higher elevations outside of the city proper. Groundwater flow in the alluvial aquifer is controlled by melt water from the Alaska Range and Tanana Valley uplands, with a predominately westward flow direction. The flow in upland fractured bedrock aquifers is controlled by changes in gradient. The upland aquifers are believed to enter the alluvial aquifers in the valley bottoms (Nelson, 1978).

METHODS OF STUDY

Water samples were taken from seventeen domestic wells. The samples were collected at the well intake to the pressure tank, prior to any filtration. Samples were taken during seven sampling runs, at two-month-intervals, beginning in August, 1999 and ending in August, 2000.

Well-rinsed five-gallon plastic buckets were used for sample collection. A PVC hose was attached to the hose bib and water was turned on. Specific conductance, temperature, and pH were measured at 5-10 minute intervals for as long as 45 minutes, or until the temperature stabilized between 3-4° C and the pH and specific conductance stabilized. After these readings stabilized, samples for chemical analyses were then taken. The samples consisted of (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. All samples were kept cool on ice in the field and refrigerated in the laboratory until analysis. Samples were filtered with 0.45-micron disposable 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, or wrapped in plastic and aluminum foil, to avoid exposure to sunlight.

ANALYTICAL TECHNIQUES

A large number of chemical elements were analyzed using a variety of quantitative and semi-quantitative analytical techniques. Table 1 shows the various elements determined and the analytical methods used for each. What follows 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 Aborgast (1996). U.S. Geological Survey laboratories analyzed all samples.

Inductively Coupled Plasma-Atomic Emission Spectrometry

In this multi-element technique, concentrations of major (Al, Ca, Fe, K, Mg, Na, and Si) and selected minor and trace elements were determined using a Leeman Labs-DRE ICP-AES™. Major cations were analyzed using the radial view whereas the axial view was used for minor and trace metals. The limits of determination are shown in Table 2.

Inductively Coupled Plasma-Mass Spectrometry

Acidified filtered and unfiltered water samples were analyzed for 44 elements by ICP-MS using a method developed by the U.S. Geological Survey (Meier et al., 1994). This method is used to determine the elements directly on the water samples without need for any pre-concentration or dilution. Elemental detection limits are in the sub-part per billion range, and the working linear range is six or more orders of magnitude. This method is most useful for trace and minor elements in the parts per billion range, whereas analyses for major elements in the parts per million range are less accurate and better determined by ICP-AES analysis.

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 (written communication, 2002). Lower determination limits are shown in Table 3.

Alkalinity as CaCO3

Alkalinity was measured both in the field and in the laboratory. In the field, a 100 ml sample was titrated using 0.01630 N or 1.60N sulfuric acid to a final pH of 4.5 using a digital titrator. The alkalinity in the lab was measured using the Preset Endpoint method described by Theodorakos (written communication, 2002), where the sample is titrated with a specified concentration of H2SO4 until a pH of 4.5 is reached.

Atomic Absorption Spectrometry

The concentrations 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+}+As^{5+} totals 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 a with 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 ppb for each species.

Ferrous Iron by Colorimetry

Ferrous iron was determined by colorimetric methods using a Hach 2010ä photo spectrometer. Samples were introduced into an AccuVac Ampulä and mixed rapidly. The phenanthroline reagent reacts with the ferrous iron in the sample to form an orange color in proportion to the ferrous iron concentration. The ampule was then placed into the spectrophotometer and the concentration was measured (Theodorakos, written communication, 2002). For concentrations higher than 3 ppm, samples were diluted and re-analyzed.

DESCRIPTION OF TABLES

Below are brief descriptions of the various tables and fields within those tables. First are tables containing sample and site descriptive information, followed by tables containing chemical analyses. These data tables can be found in the two files associated with this report.

***Tables containing descriptive information*:**

TblSampleSiteInfo	Contents	
	Fields:	
	Site_ID	site identifier
	Field_No	corresponding field number
	Latitude	latitude in decimal degrees
	Longitude	longitude in decimal degrees
	Coordinate Source	how coordinates were obtained
	Descrip	brief description of site
TblFieldData	Contents	
	Fields:	
	Field_No	field number
	Date_Coll	date collected
	Time_Coll	time collected
	Temp_C	water temperature at site, degrees Celsius
	pH	water pH at site
	Cond_mS/cm	water conductivity, microsiemens/centimeter
	DO_ppm	dissolved oxygen in water at site, parts per million
	Alk_lab_ppm	water alkalinity in lab, as parts per million CaCO3
	Alk_Field ppm	water alkalinity at site, as parts per million CaCO3

Tables containing geochemical analyses:

The following fields are common to all geochemical analyses:

Field_No	field number
Lab_No	sample laboratory assigned number
Job_No	job number for job in which sample was analyzed
Sample_Desc	description of how sample was prepared for analysis

These fields listed above apply to the tables listed below:

TblAnions	anion analyses, filtered/unacidified water samples
TblCatFA	ICP-MS cation analyses, filtered/acidified water samples
TblCatRaw	ICP-MS cation analyses, unfiltered/acidified water samples
TblCat-AES	ICP-AES select major, minor and trace elements, filtered/acidified samples
TblFe^{2+}	Fe^{2+} analyses, water filtered/acidified
TblAs^{3+}	As^{3+} analyses, water filtered/acidified

The Field number consists of the following information:
The first two numbers indicate the year (ie. 99=1999 and 00= 2000)
The next number indicates the sampling run, sampling runs corresponding to the following months:

1=August, 1999
2=October, 1999
3=December, 1999
4=February, 2000
5=April, 2000

6=June, 2000
7=August, 2000

The final numbers after the dash refer to the sampling site (site numbers 06 through 22.) Therefore, a sample taken at site number 22, in February of 2000, would have the following Site_ID= 004-22

Abbreviations in tables

N.S.	No sample taken
N.A.	No analyses done
B.D.L	Below detection limit for method used
-	No Data

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Table 1. Symbol and name of elements and ions determined and method of analysis. Method abbreviations are ICP-MS=Inductively Coupled Plasma-Mass Spectrometry, ICP-AES=Inductively Coupled Plasma-Atomic Emission Spectrometry, GFAAS=Graphite Furnace Atomic Adsorption Spectrometry, IC=Ion Chromatography, CaCO3=Alkalinity, COLOR=Ferrous iron by colorimetric techniques.

Element	ICP-MS	ICP-AES	GFAAS	IC	$CaCO_3$	COLOR
Ag, silver	X					
Al, Aluminum	X					
As, Arsenic	X	X				
As^{3+}, trivalent arsenic			X			
Ba, Barium	X					
Be, Beryllium	X					
Bi, Bismuth	X					
Ca, Calcium	X	X				
Cd, Cadmium	X	X				
Ce, Cerium	X					
Co, Cobalt	X					
Cr, Chromium	X					
Cs, Cesium	X					
Cu, Copper	X	X				
Fe, Iron	X	X				
Fe^{2+}, Divalent Iron						X
K, Potassium	X	X				
La, Lanthanum	X					
Li, Lithium	X					
Mg, Magnesium	X	X				
Mn, Manganese	X	X				
Mo, Molybdenum	X					
Na, Sodium	X	X				
Ni, Nickel	X					
P, Phosphorus	X					
Pb, Lead	X					
Rb, Rubidium	X					
Sb, Antimony	X					
Se, Selenium	X					
Si, Silica	X	X				
Sr, Strontium	X	X				
U, Uranium	X					
V, Vanadium	X					
W, Tungsten	X					
Zn, Zinc	X	X				
Cl^-, Chloride				X		
F^-, Fluoride				X		
NO_3^-, Nitrate				X		
SO_4^{2-}, Sulfate				X		
Alkalinity as Calcium Carbonate					X	

Table 2. Lower limits of determination for ICP-MS and ICP-AES.

	Lower Determination Limit	
ELEMENT	ICP-MS	ICP-AES
	Parts per Million	
Ca	0.05	1
Mg	0.01	1
Na	0.01	1
K	0.01	1
SiO_2	0.25	1
	Parts per billion	
Ag	0.01	
Al	0.01	
As	0.2	30
Ba	0.02	50
Be	0.05	
Bi	0.01	
Cd	0.02	10
Ce	0.01	
Co	0.02	
Cr	1	
Cs	0.01	
Cu	0.5	10
Fe	10	10
Fe2+	N.A.	
La	0.01	
Li	0.1	10
Mn	0.01	10
Mo	0.02	
Ni	0.1	
P	0.01	
Pb	0.05	
Rb	0.01	
Sb	0.02	
Se	0.2	
Sr	0.02	1
U	0.01	
V	0.1	
W	0.02	
Y	0.01	
Zn	0.5	10

Table 3. Lower determination limit for IC in parts per million.

ELEMENT	IC Lower Determination Limit
Cl^-	0.1
F^-	0.05
NO_3^-	0.5
SO_4^-	0.5