

U.S. Department of the Interior

U.S. Geological Survey

Digital Release of Stream-Sediment, Heavy-Mineral-Concentrate, Soil, Water, and Rock Geochemical Data
Collected in the Howard Pass 1ø x 3ø Quadrangle, Alaska

By

Karen D. Kelley, E.A. Bailey, P.H. Briggs, J.M. Motooka, and A.L. Meier

Open-File Report OF 96-711

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

U.S. Geological Survey, DFC, Box 25046, MS 973, Denver, CO 80225

1996

DISCLAIMER

This diskette publication was prepared by an agency of the United States Government. Neither the United States Government nor any agency thereof nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed in this report or represents that its use would not infringe privately owned rights. Reference therein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. Any views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Although all data and software published on this diskette have been used by the U.S. Geological Survey, no warranty, expressed or implied, is made by the U.S. Geological Survey as to the accuracy of the data and related materials and/or the functioning of the software.

INTRODUCTION

Reconnaissance geochemical sampling and analysis was conducted by the U.S. Geological Survey in the Howard Pass quadrangle in the 1970's as part of the assessment of the National Petroleum Reserve in Alaska (NPRA) and in the 1990's as part of the Alaska Mineral Resource Assessment Program (AMRAP). Stream-sediment, soil, heavy-mineral-concentrate, water, and rock samples were collected as part of the reconnaissance studies. The purpose of this report is to release these data in a modern, easy-to-use format. Approximately 25 percent of the chemical data for stream-sediment, soils, and waters included in this report were previously published in hard-copy format (Churkin and others, 1978; Theobald and Barton, 1978; Kelley and others, 1990; Kelley and Taylor, 1996), and hard-copy reports that list rock data for selected areas include Churkin and others (1978), Nokleberg and Winkler (1982), and Kelley and others (1992; 1997). This digital release, which includes data and sample coding information not included in the hard copy reports, supersedes these previous hard-copy reports.

The Howard Pass quadrangle is bounded by latitude 68° N to 69° N and longitude 156° W to 159° W. The analytical results for 1337 stream-sediment, 1093 heavy-mineral-concentrate, 60 soil samples, 92 water, and 561 rock samples are given in this report. The data files included on this diskette are separated by sample media type. All data files are in dBase IV .dbf format. The first two letters of the filename (HP) refer to the quadrangle. Letters following the underscore refer to sample media: CONC, heavy-mineral concentrates; SEDS, stream sediments; SOILS, soils; WAT, water samples; and ROCK, rock samples.

PHYSIOGRAPHIC AND GEOLOGIC SETTING

The Howard Pass quadrangle is located in the central part of the Brooks Range and Arctic Foothills physiographic provinces (Wahrhaftig, 1965), along the northern flank and foothills of the Endicott Mountains. Topography varies from moderately steep in the southern part of the quadrangle to nearly flat with some low rolling hills and broad open valleys in the northern part of the quadrangle.

The quadrangle lies within the Brooks Range fold and thrust belt which spans northern Alaska from west to east. Deformation in the western and central parts of the orogen was north directed and apparently occurred in Late Jurassic to Late Cretaceous time (Mayfield and others, 1983). The metamorphic core of the Brooks Range is composed of Proterozoic and Paleozoic continental-margin sedimentary and igneous rocks that were metamorphosed to blueschist facies during the orogenic episode (Mull, 1982; Till, 1992). North of the metamorphic core is a belt of intensively thrust-faulted middle Paleozoic to Lower Cretaceous sedimentary rocks; allochthons

of Late Jurassic ultramafic and middle Paleozoic to Triassic mafic rocks sit above these thrust sheets (Mayfield and others, 1983). Rocks of the foreland basin are exposed in the foothills north of the mountains. These rocks are predominantly siliciclastic rocks of Lower Cretaceous to Tertiary age that were derived from the Brooks Range and prograded northward and eastward (Mull, 1982).

Only Devonian through Cretaceous sedimentary rocks and lesser mafic and ultramafic igneous rocks of Mississippian(?) through Jurassic age are exposed in the Howard Pass quadrangle. These rocks have been involved in large-scale thrust faulting which have obscured their original stratigraphic relations. They are overlain by late Tertiary and Quaternary glacial and alluvial sedimentary deposits.

METHODS OF STUDY

Sample Collection

Stream-sediment samples consist of active alluvium collected from first-order (unbranched) and second-order (below the junction of two first-order) streams as shown on USGS topographic maps (scale = 1:63,360). Each sample was composited from several localities within a 100-ft radius of the sample site. The sediment was sieved at each site through a 10 mesh (2.0 mm) screen and the sediment was collected from the minus-10 mesh fraction. Heavy-mineral concentrates were collected in conjunction with stream sediment sampling by panning minus-10 mesh sediment at the sample site. Soil samples were collected from the streambank beneath the tundra mat that generally blanketed the floodplane of the stream being sampled (Churkin and others, 1978; Theobald and Barton, 1978). Most of these samples were collected at or near the water level and were therefore, saturated with water (Theobald and Barton, 1978). Water samples collected for trace element analyses included an unfiltered and a filtered (0.45- μ m membrane filter) sample which were acidified using 1 ml of concentrated nitric acid. These samples were stored in acid-rinsed polyethylene bottles and kept cool until analyses. Samples collected for anion analysis were also filtered (0.45- μ m membrane filter) and kept cool until analysis. At each collection site, the water temperature, pH, specific conductivity, alkalinity, and dissolved oxygen measurements were recorded.

Sample Preparation

All soil samples and most stream-sediment samples were air-dried, then sieved through a 30-mesh (0.50 mm) stainless-steel sieve. The minus-30-mesh fraction was saved for analysis. As part of orientation studies in selected areas, other size fractions of stream-sediment samples were also collected. These included the minus-30 plus-80 mesh (0.50 to 0.17 mm), minus-80 plus-230-mesh (0.17 to 0.062 mm), and minus-230-mesh fractions (0.062 mm). Data from all sieve sizes are included in this report; sieve size fraction information is recorded in the data tables (in the column Ms for mesh/sieve code and in Cm for submitter comments). The suffix on the field number for sediment samples also indicates mesh size: The suffix 'S' indicates minus-30 mesh; 'SB' indicates minus-30, plus-80 mesh; 'SC' indicates minus-80, plus-230 mesh; and 'SE' indicates minus-230 mesh. 'SG' was a suffix used in the 1977 survey to indicate sediments that were ground; however, because all sediment samples were ground prior to analysis in the later surveys, the suffix designation was dropped.

The heavy-mineral concentrates generally were sieved to minus-20 or minus-30 mesh. The sample was further separated with the heavy liquid bromoform into two fractions: a light-mineral fraction (specific gravity 2.86 or less) and a heavy-mineral fraction (specific gravity greater than 2.86). Following heavy-liquid separation, magnetite and other strongly magnetic minerals were removed from the heavy-mineral fraction by use of a hand magnet and a Frantz isodynamic magnetic separator set at 0.2 ampere and saved for analysis. The remaining fraction was again

sent through the Frantz separator at a setting of 0.6 amperes and the non-magnetic fraction was retained for analysis. Water samples were prepared in the field at the stream site (see Sample collection).

Sample Analysis

The soil, stream-sediment, and heavy-mineral-concentrate samples were analyzed using a semiquantitative, direct-current arc emission spectrographic method (Adrian and others, 1996). Spectrographic results were determined by visually comparing spectra derived from the sample against spectra obtained from laboratory reference standards. Standard concentrations are geometrically spaced over any given order of magnitude of concentration such that values reported for each sample are reported in the geometric sequence 10, 15, 20, 30, 50, 70, 100 etc. The precision of the method is plus or minus one reporting interval at 83 percent, or two intervals at 96 percent confidence (Adrian and others, 1996). The elements analyzed and their nominal limits of determination are listed in table 1.

Selected stream-sediment samples were analyzed for 40 elements using inductively coupled plasma-atomic emission spectrometry (ICP-AES). Each sample was dissolved using a low temperature multi-acid digestion with concentrated hydrochloric, hydrofluoric, nitric, and perchloric acids (Briggs, 1996). Lower limits are shown in table 2. The relative standard deviation for replicate determinations of most elements is about 5 percent.

An organometallic halide extraction method (Motooka, 1996) was used to determine 10 pathfinder elements in stream-sediment samples by ICP-AES. A hydrochloric acid-hydrogen peroxide digestion followed by extraction with diisobutylketone produces the organometallic halide solution. The relative limits of determination are shown in table 3. The relative standard deviation for most elements is about 5 percent.

Water samples were analyzed for 28 elements by ICP-AES. The lower limits are listed in table 2. The relative standard deviation for the method is 10 percent (Briggs and Fey, 1996). The water samples were also analyzed by inductively coupled plasma-mass spectrometry (ICP-MS). The ICP-MS method is semiquantitative but allows for determination of more than 60 elements directly from the water sample without the need for preconcentration or dilution and with detection limits in the sub-part-per-billion range (Meier and others, 1994). Standard deviation for the method may be as high as 25 percent for some elements (A.L. Meier, oral commun., 1995). Anions were determined on the filtered unacidified stream water samples using ion chromatography (d'Angelo and Ficklin, 1996). The relative standard deviation for this method is approximately 10 percent.

DESCRIPTION OF DATA

Sample description, geologic, and analytical data are presented in each of the sample media files. Sample site locations are given as latitude and longitude both in decimal degree and degree-minute-second formats in the tables. The following list summarizes table structure and sample description column headings. For table structures, "A8" refers to an alphanumeric format eight characters wide, while "N" indicates a numeric column format. Sample description code explanations are listed in Appendix A.

Table Structure	Column Identifier	Description
A6	Jobnum	assigned laboratory job number
A7	Labnum	assigned sample laboratory number
A8	Fieldnum	sample field identification number
A8	Date_sub	date sample submitted to laboratory
A8	Date_col	date sample was collected
A20	Submitter	submitter name
A9	Lat_dms	latitude in degree-minute-second
A11	Lon_dms	longitude in degree-minute-second
N	D_lat	latitude in decimal degrees
N	D_lon	longitude in decimal degrees
A2	LL_precis	latitude/longitude precision
A1	St	type of sample media
A1	Mc	method sample collected
A1	Sc	sample source
A1	Rt	rock type
A1	Ga	geologic age
A2	Ms	mesh/sieve code
A2	Sd	additional sample description information
A2	Sd3	additional sample description information
A2	Sd4	additional sample description information
A2	Sd5	additional sample description information
A2	Sp1	sample lab preparation information
A2	Sp2	sample lab preparation information
A2	Sp3	sample lab preparation information
A2	Cm	lab/submitter comments

Chemical data follows the above sample description information in the data files. The chemical data are accurate to two significant digits. Trailing zeros are non-significant. Columns in which the element headings contain the prefix "S" represent emission-spectrographic data. The prefix "ICPA" indicates inductively coupled plasma-atomic emission spectrometry; "ICPM" indicates inductively coupled plasma-mass spectrometry; "AA" indicates atomic absorption analyses; "IC" indicates ion chromatography; "CDT" indicates conductivity. The suffix "P" indicates a partial digestion, and "T" indicates a total digestion. The results for the elements are reported either in parts per billion (PPB), parts per million (PPM), or percent (PCT). The results for conductivity are reported in $\mu\text{S}/\text{cm}$. For rock descriptions, the following codes apply: oc, outcrop; fl, float; qtz, quartz; cc, calcite; ss, sandstone; and ls, limestone.

Definitions of the qualifier codes used in the tables are as follows: B, sample not analyzed for this element; N, not detected at the specified level of detection; "<", detected, but below the specified limit of determination; and ">", greater than the specified upper limit of determination.

REFERENCES CITED

- Adrian, B.M., Arbogast, B.F., Detra, D.E., and Mays, R.E., 1996, Direct-current arc emission spectrographic method for the semiquantitative analysis of geologic materials, in B. F. Arbogast, ed., Analytical methods manual for the Mineral Resource Surveys Program: U.S. Geological Survey Open-File Report 96-525, p.130-143.
- Briggs, P. H., and Fey, D. L., 1996, Twenty-four elements in natural and acid mine waters by inductively coupled plasma-atomic emission spectrometry, in B. F. Arbogast, ed., Analytical methods manual for the Mineral Resource Surveys Program: U.S. Geological Survey Open-File Report 96-525, p. 95-101.
- Churkin, M., Jr., Mayfield, C.F., Theobald, P.K., Barton, H.N., Nokleberg, W.J., Winkler, G.R., and Huie, Carl, 1978, Geological and geochemical appraisal of metallic mineral resources, southern National Petroleum Reserve in Alaska: U.S. Geological Survey Open File Report 78-70A, 82 p.
- Briggs, P.H., 1996, Forty elements by inductively coupled plasma-atomic emission spectrometry, in B. F. Arbogast, ed., Analytical methods manual for the Mineral Resource Surveys Program: U.S. Geological Survey Open-File Report 96-525, p. 77-94.
- d'Angelo, W.M., and Ficklin, W.H., 1996, Fluoride, chloride, nitrate, and sulfate in aqueous solution by chemically suppressed ion chromatography, in B. F. Arbogast, ed., Analytical methods manual for the Mineral Resource Surveys Program: U.S. Geological Survey Open-File Report 96-525, p. 149-153.
- Kelley, K. D., Borden, J. C., Bailey, E. A., Fey, D. L., Motooka, J. M., and Roushey, B., 1992, Geochemically anomalous areas in the west-central part of the Howard Pass Quadrangle, National Petroleum Reserve, Brooks Range, Alaska--Evidence for sediment-hosted Zn-Pb-Ag-Ba mineralization, in Bradley, D.C., and Dusel-Bacon, C., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1991: U.S. Geological Survey Bulletin 2041, pp. 60-69.
- Kelley, K.D., Slaughter, K.E., and Motooka, J.M., 1990, Results of inductively coupled plasma-atomic emission spectroscopy analyses of minus 30-mesh stream-sediment samples from within and adjacent to the National Petroleum Reserve Alaska: U.S. Geological Survey Open File Report 90-501, 19 p.
- Kelley, K.D., and Taylor, C.D., 1996, Natural environmental effects associated with the Drenchwater zinc-lead-silver massive sulfide deposit with comparisons to the Red Dog and Lik deposits, west-central Brooks Range, Alaska, in Moore, T.E., and Dumoulin, J.A., eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1994: U.S. Geological Survey Bulletin 2152, p. 31-45.
- Kelley, K.D., Taylor, C.D., and Cieutat, B.A., 1997, Silver-lead-zinc mineral occurrences in the Howard Pass Quadrangle, Brooks Range, Alaska, in Dumoulin, J.A., and Gray, J.E., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1995: U.S. Geological Survey Bulletin, in press.
- Mayfield, C.F., Tailleux, I.L., and Ellersieck, Inyo, 1983, Stratigraphy, structure, and palinspastic synthesis of the western Brooks Range, northwestern Alaska: U.S. Geological Survey Open-File Report 83-779, 58 p., scale 1:1,000,000.

Meier, A.L., Grimes, D.J., and Ficklin, W.H., 1994, Inductively coupled plasma mass spectrometry--a powerful analytical tool for mineral resource and environmental studies [abs], in Carter, L.M.H., Toth, M.I., and Day, W.C., eds., USGS research on mineral resources--1994, Part A--Program and Abstracts, Ninth V.E. McKelvey Forum on Mineral and Energy Resources, 9th, Tucson, Ariz., February 22-25, 1993: U.S. Geological Survey Circular 1103-A, p. 67-68.

Motooka, J.M., 1996, Organometallic halide extraction for 10 elements by inductively coupled plasma-atomic emission spectrometry, in B. F. Arbogast, ed., Analytical methods manual for the Mineral Resource Surveys Program: U.S. Geological Survey Open-File Report 96-525, p. 102-108.

Mull, C.G., 1982, The tectonic evolution and structural style of the Brooks Range, Alaska--An illustrated summary, in Powers, R.B., ed., Geological studies of the Cordilleran thrust belt: Denver, Colorado, Rocky Mountain Association of Geologists, v. 1, p. 1-45.

Nokleberg, W. J., and Winkler, G. R., 1982, Stratiform zinc-lead deposits in the Drenchwater Creek area, Howard Pass quadrangle, northwestern Brooks Range, Alaska: U.S. Geological Survey Professional Paper 1209.

Theobald, P.K., and Barton, H.N., 1978, Basic data for the geochemical evaluation of National Petroleum Reserve, Alaska: U.S. Geological Survey Open-File Report 78-70D, 102 p.

Till, A.B., 1992, Detrital blueschist-facies metamorphic mineral assemblages in Early Cretaceous sediments of the foreland basin of the Brooks Range, Alaska, and implications for orogenic evolution: *Tectonics*, v. 11, no. 6, p. 1207-1223.

Wahrhaftig, Clyde, 1965, Physiographic divisions of Alaska: U.S. Geological Survey Professional Paper 482, 52 p.

Table 1.--Limits of determination for Emission Spectrographic Analysis
 Numbers in () were limits before 1988

Elements	Sediments		Concentrates	
	Lower limit	Upper limit	Lower limit	Upper limit
Percent				
Iron (Fe)	.05	20	.1	50
Magnesium (Mg)	.02	10	.05	20
Calcium (Ca)	.05	20	.1	50
Sodium (Na)	.2	5	.5	10
Titanium (Ti)	.002	1	.005 (10)	2
Phosphorus (P)	.2	5	.5	10
Parts per million				
Silver (Ag)	.5	5,000	1.0	10,000
Arsenic (As)	200	10,000	500	20,000
Gold (Au)	10	500	20	1,000
Boron (B)	10	2,000	20	5,000
Barium (Ba)	20	(20,000*) 5,000	50	(50,000) 10,000
Beryllium (Be)	1	1,000	2	2,000
Bismuth (Bi)	10	1,000	20	2,000
Cadmium (Cd)	20	500	50	1,000
Cobalt (Co)	(5) 10	2,000	(10) 20	5,000
Chromium (Cr)	10	5,000	20	10,000
Copper (Cu)	5	20,000	10	50,000
Gallium (Ga)	5	500	10	1,000
Germanium (Ge)	10	100	20	200
Lanthanum (La)	(20) 50	1,000	(50) 100	2,000
Manganese (Mn)	10	5,000	20	10,000
Molybdenum (Mo)	5	2,000	10	5,000
Niobium (Nb)	20	2,000	50	5,000
Nickel (Ni)	5	5,000	10	10,000
Lead (Pb)	10	20,000	20	50,000
Palladium (Pd)	--	--	5	1,000
Platinum (Pt)	--	--	20	1,000
Antimony (Sb)	100	10,000	200	20,000
Scandium (Sc)	5	100	10	200
Tin (Sn)	10	1,000	20	2,000
Strontium (Sr)	100	5,000	200	10,000
Thorium (Th)	100	2,000	200	5,000
Vanadium (V)	10	10,000	20	20,000
Tungsten (W)	(50) 20	10,000	(100) 50	20,000
Yttrium (Y)	10	2,000	20	5,000
Zinc (Zn)	200	10,000	500	20,000
Zirconium (Zr)	10	1,000	20	2,000

* In addition to the pre-1988 samples with this limit, the 1992 samples were re-analyzed with the 20,000 ppm upper limit for Ba

Table 2.--Limits of determination for 40-element inductively coupled plasma-atomic emission spectroscopy (ICP-AES)

Elements	Stream-sediments Lower limit	Water Lower limit
Al	0.005%	0.1 ppm
Ca	0.005%	0.02 ppm
Fe	0.005%	0.005 ppm
K	0.05%	1 ppm
Mg	0.005%	0.01 ppm
Na	0.005%	0.2 ppm
P	0.005%	---
Si	---	0.01 ppm
Ti	0.005%	1 ppb
Ag	2 ppm	2 ppb
As	10 ppm	---
Au	8 ppm	---
B	---	10 ppb
Ba	1 ppm	2 ppb
Be	1 ppm	1 ppb
Bi	10 ppm	10 ppb
Cd	2 ppm	1 ppb
Ce	4 ppm	---
Co	1 ppm	3 ppb
Cr	1 ppm	1 ppb
Cu	1 ppm	10 ppb
Eu	2 ppm	---
Ga	4 ppm	5 ppb
Ho	4 ppm	---
La	2 ppm	---
Li	2 ppm	4 ppb
Mn	4 ppm	1 ppb
Mo	2 ppm	10 ppb
Nb	4 ppm	---
Nd	4 ppm	---
Ni	2 ppm	5 ppb
Pb	4 ppm	10 ppb
Sc	2 ppm	---
Sn	5 ppm	6 ppb
Sr	2 ppm	0.5 ppb
Ta	40 ppm	---
Th	4 ppm	---
U	100 ppm	---
V	2 ppm	6 ppb
Y	2 ppm	---
Yb	1 ppm	---
Zn	2 ppm	3 ppb
Zr	---	1 ppb

Table 3.--Limits of determination for 10-element inductively coupled plasma-atomic emission spectroscopy (ICP-AES)

Numbers in () were limits before 1991

Elements	Stream-sediments Lower limit
Ag	(0.045 ppm) 0.067 ppm
As	0.67 ppm
Au	(0.15 ppm) 0.10 ppm
Bi	0.60 ppm
Cd	0.05 ppm
Cu	0.05 ppm
Mo	0.06 ppm
Pb	0.67 ppm
Sb	0.60 ppm
Zn	0.05 ppm

APPENDIX A

Explanation of sample description codes

Lat/lon precision (LL_precis)

- A apparently accurate to nearest second
- B apparently accurate to nearest minute
- C apparently accurate to nearest degree
- D digitized; accurate to nearest second

Sample Type (St)

- A rock
- B unconsolidated sediment
- C organic material
- D soil
- E water
- F other
- G gas

Method collected (Mc)

- A single (grab)
- B composite
- C channel
- D other

Sample source (Sc)

- A outcrop
- B mine
- C dump or prospect pit
- D float
- E drill hole, well
- F marine
- G other
- H stream
- I spring
- J lake
- K aquaduct, canal, irr. ditch
- L atmosphere

Rock type (Rt)

- A unidentified rock
- B sedimentary rock
- C metamorphic rock
- D igneous rock

E unconsolidated sediment
F conglomerate
G sandstone
H siltstone
I claystone
J shale
K limestone or dolomite
L carbonate
M gneiss
N schist
O quartzite
P marble
Q skarn
R phyllite or slate
S felsic igneous
T intermediate igneous
U mafic igneous
V ultramafic igneous
W feldspathoidal
X chert or jasperoid
Y other

Geologic age of sample (Ga)

A Precambrian undifferentiated
B Early Precambrian
C Middle Precambrian
D Late Precambrian
E Paleozoic undifferentiated
F Cambrian
G Ordovician
H Silurian
I Devonian
J Mississippian
K Pennsylvanian
L Permian
M Mesozoic undifferentiated
N Triassic
P Jurassic
Q Cretaceous
R Tertiary undifferentiated
S Paleocene
T Eocene
U Oligocene
V Miocene
W Pliocene
X Quaternary undifferentiated
Y Pleistocene
Z Holocene

Mesh/sieve fraction (Ms)

- A unknown, assumed to be -80 mesh
- B identified as -80 mesh
- C identified as -100 mesh
- D identified as -120 mesh
- E identified as -150 mesh
- F identified as -200 mesh
- G identified as -60 mesh
- H identified as -40 mesh
- I identified as -35 mesh
- J identified as -30 mesh
- K identified as -24 mesh
- L identified as -20 mesh
- M identified as -30+80 mesh
- N Other--see Lab/submitter comments (Cm)

Sample description (Sd)

- AL alluvium
- AS ash
- CL clay
- CV colluvium
- C pan or artificial concentrate
- C1 concentrate, high magnetic fraction
- C2 concentrate, moderately magnetic fraction
- C3 concentrate, low or non-magnetic fraction
- GV gravel
- GT grit
- HS heavy sand
- LO loess
- MD mud
- OZ ooze
- SN sand
- SD stream sediment
- SI silt
- TI till

Sample description (Sd3)

- AN animal parts
- CS combined splits of heavy-mineral-concentrate
- DM detrital magnetites
- MS splits of magnetites
- NS non-magnetic splits from heavy-mineral-concentrate
- OA oxalic acid leachate
- VG vegetation

Sample description (Sd4)

- GD glacial debris

MT moss-trap-sediment sample

PT peat material

SP spruce

Sample description (Sd5)

MI mill tailings

MT moose pellets

WL willow leaves

Sample preparation (Sp1)

AD ashed

BR bromoform

GR ground

Sample preparation (Sp2)

FR Frantz isodynamic separator

PV pulverized

Sample preparation (Sp3)

FS fire assay PGE

HG hand ground

HM separated by hand magnet

RT split into red tops

Lab/submitter comments (Cm)