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BRITISH COLUMBIA REGIONAL GEOCHEMICAL SURVEY

NELSON (NTS 82F)

STREAM SEDIMENT AND WATER GEOCHEMICAL DATA

P.F. Matysek, W. Jackaman, J.L. Gravel, S.J. Sibbick, S. Feulgen

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INTRODUCTION

Open File package BC RGS 30 / GSC 2355, a joint federal-provincial initiative, contains new data for gold and 25 other elements obtained by re-analyzing stream sediments collected in 1977 from the Nelson map-sheet area (NTS 82F). Also included are the original analytical data from GSC Open File 514 published in 1979 for 13 elements in sediments, and uranium, fluoride and pH values in concomitant waters.

The original reconnaissance survey was undertaken in 1977 by the Geological Survey of Canada (GSC) in conjunction with the British Columbia Ministry of Energy, Mines and Petroleum Resources (MEMPR) under the Canada-British Columbia Uranium Reconnaissance Program. Funds for the determination of mercury were provided by Fisheries and Environment Canada. In 1990, under the MEMPR RGS Archive Program, the samples collected in 1977 were analysed by instrumental neutron activation (INAA). This initiative was funded in part by the Canada/British Columbia Mineral Development Agreement (1985-1990).

Analytical results and field observations from these regional geochemical surveys are used to build both a provincial and national geochemical database for resource assessment, mineral exploration, geological mapping and environmental studies. Sample collection, preparation and analytical methods are closely monitored to ensure consistency and conformance to national standards.

ACKNOWLEDGEMENTS

1977 STREAM SEDIMENT AND WATER SURVEY

E.H.W. Hornbrook directed GSC activities and *N.C. Carter* directed MEMPR activities.

Contracts were let to the following companies for sample collection, preparation and analysis and were managed by staff of the GSC or MEMPR.

COLLECTION : Stokes Exploration Management Ltd., Vancouver, B.C.
S.B. Ballantyne (GSC) and T.E. Kalnins (MEMPR)

PREPARATION : Golder Associates, Ottawa.
J.J. Lynch (GSC)

ANALYSIS : Chemex Laboratories Ltd., Vancouver. (Sediments / Waters)
Atomic Energy of Canada, Ltd., Ottawa. (U in Sediments)
J.J. Lynch (GSC) and W.M. Johnson (MEMPR)

1990 RGS ARCHIVE PROGRAM

The RGS Archive Program was managed by Geological Survey Branch staff of the British Columbia Ministry of Energy Mines and Petroleum Resources.

P.F. Matysek coordinated the operational activities of contract and MEMPR staff. *W. Jackaman* co-ordinated and prepared the production of the open-file. *S.J. Sibbick* and *J.L. Gravel* provided analysis and interpretation of the data. *S. Feulgen* provided computer processing support.

PREPARATION : Rob Phillips, Ottawa, Ont.

ANALYSIS : Becquerel Laboratories, Mississauga, Ont.

OPEN FILE FORMAT

Open File RGS 30 / GSC 2355 includes a data booklet, map booklet and a floppy diskette.

The data booklet provides details of the sample collection, preparation and analysis programs plus data listings, statistics and interpretations.

The map booklet consists of :

- 4 - 1: 100 000 scale sample location maps.
- 1 - 1: 500 000 scale sample location clear mylar overlay and map.
- 1 - 1: 500 000 scale bedrock geology clear mylar overlay and map.
- 1 - 1: 500 000 scale surficial geology map.
- 42 - 1: 500 000 scale symbol and value maps for individual elements in stream sediments and waters.
- 1 - 1: 500 000 base metal anomaly map.
- 1 - 1: 500 000 precious metal anomaly map.

A 5¼" 1.2 Mb (high density) floppy diskette containing data files in ASCII format.

SURVEY DESCRIPTION

PHYSIOGRAPHY, GEOLOGY AND MINERAL POTENTIAL

The Nelson map sheet covers an area of approximately 16,600 square kilometres. The north-south trending Purcell trench, containing Kootenay Lake, divides the region into two physiographic units: the Purcell Mountains to the east, and the Selkirk Mountains to the west (Holland, 1976).

Surficial materials (Map 3, *after* Fulton *et al.*, 1984) consist of widespread deposits of till and colluvium on slopes and till and glaciofluvial sediments within valleys.

The eastern third of the Nelson map sheet (Figure 1 and Table A-1) is underlain by Proterozoic rocks of the Purcell Supergroup. To the west, merging with the Purcell Supergroup, is the Kootenay Arc, a north-trending arcuate structural zone developed in a succession of Hadrynian to Mesozoic age rocks. The western third of the map sheet is dominated by Mesozoic intrusives and high-grade metamorphic rocks of the Shuswap Complex. The geological base map used for Open File RGS 30 is from Okulitch and Woodsworth (1977).

Examples of mineral occurrences found within the survey area are:

- Vein Ag, Pb, Zn (Ainsworth Camp)
- Vein Au, Cu (Rossland Camp)
- Carbonate-hosted Pb, Zn (Reeves-MacDonald)
- Skarn Mo (Red Mountain)

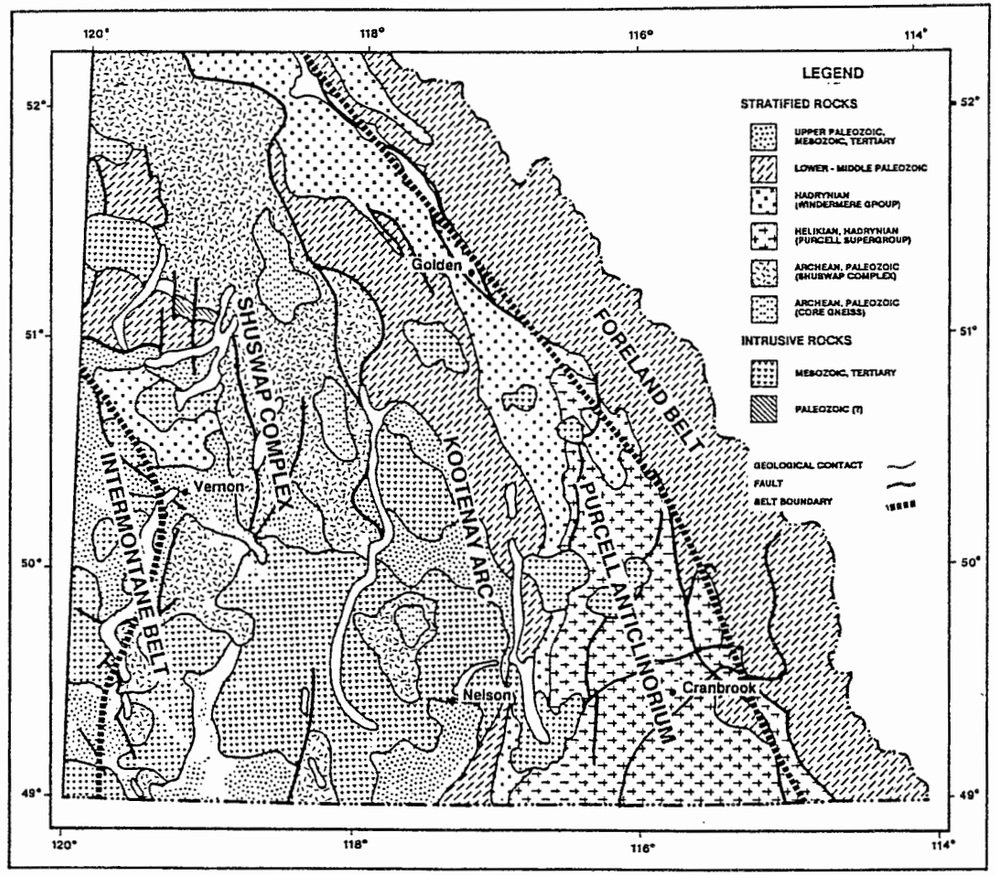


FIGURE 1 Generalized geology map of southeast British Columbia

SAMPLE COLLECTION - 1977

Helicopter and truck-supported sample collection was carried out during the summer of 1977 over the 16,600 square kilometre survey area. Stream sediment and water samples were systematically collected from 1318 sites for an average density of 1 site per 12.6 square kilometres. Field duplicate samples were routinely collected in each analytical block of twenty samples.

Fine grained stream sediments (< 1mm) weighing 1-2 kg were obtained from the active (subject to annual flooding) stream channel and placed in kraft bags. Unfiltered water samples were collected in 250 ml bottles, precautions were taken to exclude suspended solids when possible. Field observations regarding sample media, sample site and local terrain (Table A-2) were recorded.

SAMPLE PREPARATION - 1977

Field dried sediment samples were shipped to Golder Associates, in Ottawa, Ontario for final processing. The samples were air-dried and the -80 mesh (<177 microns) fraction was obtained and ball-milled for subsequent analyses. Quality control reference standards and blind duplicates were inserted into each analytical block of twenty sediment samples. Any -80 mesh sediment remaining after analyses was archived for future studies.

SAMPLE PREPARATION - 1990

The archived -80 mesh stream sediment pulps were retrieved for instrumental neutron activation analysis from the Geological Survey of Canada warehouse in Ottawa. New quality control reference standards were inserted into each analytical block of twenty samples. Existing analytical and field site duplicates contained within the samples sequences were checked and verified.

SAMPLE ANALYSIS - 1977

Chemex Laboratories (North Vancouver) analysed sediment samples for: copper, cobalt, iron, lead, manganese, mercury, molybdenum, nickel, silver, tin, tungsten and zinc. Uranium in stream sediments was determined by Atomic Energy of Canada (Ottawa), Water samples were analyzed for fluorine, uranium, and pH by Chemex Laboratories. Table A-3 summarizes analytical methods, specifications and reported detection limits for the various determinations. Concentrations below the reported detection limit were assigned a value equivalent to one-half of the detection limit.

SAMPLE ANALYSIS - 1990

Becquerel Laboratories (Mississauga), carried out instrumental neutron activation analysis (INAA) of archived stream sediment samples. Samples weighing 20 grams on average were epithermally irradiated for twenty minutes in a neutron flux of 10^{11} neutrons/cm^2/sec. After a decay period of approximately one week, gamma-ray emissions for the elements of interest were measured using a gamma-ray spectrometer with a high resolution, coaxial germanium detector. Counting time was approximately fifteen minutes per sample. Counting data was compiled on a computer and later converted to concentrations. Numerous international reference samples were irradiated within each analytical batch. Sediments were analysed for antimony, arsenic, barium, bromine, cerium, cesium, chromium, cobalt, gold, hafnium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zirconium. Concentrations below the reported detection limit were assigned a value equivalent to one-half of the detection limit.

RGS DATA EVALUATION

The ability to discriminate real trends related to geological and geochemical causes from those that result from spurious factors such as sampling and analytical errors is of considerable importance in the success of geochemical data interpretation. An estimate of the reproducibility (precision) allows the quantification of variation due to sampling and analysis, and is an integral part of the evaluation of geochemical data. Estimates of analytical precision and trace element variability within and between sample sites can be determined by utilizing analytical duplicate and field duplicate data.

In order to make these assessments, control reference standard materials and analytical duplicates are routinely inserted to monitor and assess precision and accuracy of analytical results. Each analytical batch of twenty sediment and water samples consists of :

- 17 - Routine samples
- 1 - Field duplicate sample collected adjacent to one of the 17 routine samples (Listed in Appendix A - Field observations and analytical data).
- 1 - Quality control reference standard sample containing sediment of certified element concentrations and known reproducibility.
- 1 - Analytical duplicate sample; a subsample from one of the 17 routine samples (Listed in Appendix B).

SUMMARY STATISTICS

Univariate statistics are presented in Appendix C for element concentrations within stream sediments and waters in order to establish some measure of the range of background levels and thresholds. Statistics were calculated for the total data set and on subsets (N>10) based on lithological units underlying the sample site.

Statistics determined include: minimum and maximum values; range; mode; median; arithmetic and logarithmic means, standard deviations and coefficients of variation; as well as percentile values. Depending upon the element the distribution of element values are also graphically displayed as logarithmic or arithmetic histograms. Please note, these calculations do not include the second values from analytical and field duplicate pairs.

PRECISION ESTIMATES OF SELECTED ELEMENTS

Precision estimates for selected elements were calculated using 211 analytical duplicate pairs from RGS 30, 31 and 33 (NTS 82F, 82K and 82M) using the Thompson and Howarth (1973, 1976, 1978) method. Analytical duplicate INAA data for 82F are listed in Appendix B.

Briefly, their method involves dividing 50 or more analytical duplicate pairs (x_1, x_2) into groups with narrow concentration ranges. For each group, the median value of absolute differences between duplicate pairs ($|x_1-x_2|$) is used as an estimation of the standard deviation (s), whereas the mean value of all the duplicate pair means $(x_1+x_2)/2$ is used as an estimation of the average concentration. Repetition of this procedure for a successive group of concentration ranges obtains a set of corresponding mean concentration and standard deviation estimates for the entire range of data. Linear regression of the estimates provides slope and intercept values from which precision of the dataset can be calculated using the equation:

$$Pc = 200(K/c + S_o)$$

where S_o (coefficient of slope) is the standard deviation at zero concentration and K (intercept) is a constant. This linear function has been determined in many practical cases (Matysek and Sinclair, 1984) to be a satisfactory model for the expression of variation.

Precision estimates for INAA elements were calculated as follows:

Step 1. A list of duplicate means and corresponding absolute differences were calculated.

Step 2. The list was sorted in increasing order of concentration means.

Step 3. The mean concentration and the median difference between pairs for the first group of 11* stream sediments were determined, respectively.

Step 4. Step 3 was repeated for each successive group of 11 stream sediment analytical pairs ignoring any remainder less than 11*.

Step 5. The linear regression of the median differences on the means was calculated. The resultant intercept and coefficient of the calculated line are multiplied by 1.048 and were used to estimate precision.

**Note: Groups of 9 and 13 pairs were used on occasion to improve the regression line fit.*

Precision estimates were determined for Ba, Ce, Fe, La, Rb, Sm, Sc, Th and U only. This particular suite of elements was selected on the following basis:

- Their distributions approximated a Gaussian (normal) curve
- The majority of their concentrations were well above their detection limits.

Precision estimates were not determined for elements characterized by non-Gaussian distributions. These distributions are recognized when the following conditions arise:

- Element abundances are dependent on rare grains
- Concentration levels are near or at the detection limit
- Data contains outliers

RESULTS

Precision estimates obtained from the Thompson and Howarth method are presented in Table 1. Only elements whose correlation coefficients (R-values) were significantly different from zero are listed. Precision estimates calculated by the Thompson and Howarth method for 9 different elements at different concentration levels averaged 16.8% at the 50th percentile, 16.1% at the 80th percentile and 15.6% at the 95th percentile (Table 1).

Studies tailored to the evaluation of error in stream sediment surveys such as Plant (1971), Chork (1977) and Fletcher (1981) generally concluded:

- The combined variability due to local variation and analytical error ranged from 10-25% of the total error.
- Precision ranges of 10-15% at the 95% confidence level are generally encountered and considered acceptable for laboratory variability in most exploration programmes.

Precision estimates determined for these elements are of similar magnitude to those observed from other regional geochemical surveys.

TABLE 1 Thompson and Howarth precision estimates

ELEMENT	MIN	MAX	INTER	SLOPE	R-VALUE	50TH	PREC	80TH	PREC	95TH	PREC
Barium	100	6120	15.833	0.0442	0.6058	660	14.29%	1000	12.58%	1500	11.48%
Cerium	10	1250	3.207	0.05811	0.7412	100	18.90%	170	16.13%	310	14.35%
Iron	0.2	18	0.053	0.071	0.7063	3.4	18.15%	4.6	17.30%	6.2	16.67%
Lanthanum	5	1160	1.244	0.0545	0.8309	60	15.77%	99	14.06%	180	12.87%
Rubidium	5	270	1.153	0.0668	0.6776	88	16.75%	120	16.02%	150	15.61%
Samarium	0.5	150	-0.12	0.0969	0.8973	8.7	17.42%	13.3	18.42%	22.5	19.19%
Scandium	0.6	63.1	0	0.0916	0.8229	11	19.20%	15	19.20%	21.3	19.20%
Thorium	0.5	488	0.252	0.0546	0.9113	15	14.97%	27.3	13.38%	60.4	12.32%
Uranium	0.5	452	-0.121	0.0943	0.9725	6.1	15.61%	14	17.95%	38.3	19.10%

ESTIMATION OF REGIONAL AND SAMPLE SITE ELEMENTAL CONCENTRATION VARIABILITY

INTRODUCTION

Variations in element concentrations of stream sediments are due to regional variation (ie. diverse lithologies, mineralization and influences of the surficial environment) and sample site variation (ie. sampling and analytical variability). Regional and sample site variance components were determined for 15 elements from 76 field duplicate pairs. Selected elements include Ag, Cu, Zn, Pb, Co, Ni, Fe, Mn (1976 data) and Au, As, Sb, Cr, Mo, W, U (1990 data).

METHOD

The estimate of variance components was based on field duplicate data. Since the RGS samples are derived from a variety of lithologies and drainages containing mineral occurrences, log transformation of the data was necessary to approximate normal distributions.

1) Calculate VC_{site} by taking the sum of the squared differences between samples in field duplicate pairs and average the sum over the number of pairs (Mean Sum of Squares).

$$(1)\quad VC_{site} = MSQ_{site} = \Sigma(x_i - \mu_i)^2 / n$$

where x_i = 1st and 2nd samples of each field duplicate pair
μ_i = mean for each duplicate pair
n = number of duplicate pairs

2) Calculate the total variance (VC_{total}) by taking the sum of squared differences for all samples in field duplicate pairs and dividing by the number of samples less 1.

$$(2)\quad VC_{total} = MSQ_{total} = \Sigma(x_j - \mu_j)^2 / N\text{-}1$$

where x_j = all samples in field duplicate pairs
μ_j = mean of all samples in field duplicate pairs
N-1 = number of samples in field duplicate pairs less 1

3) Calculate $VC_{regional}$ by subtracting VC_{site} from VC_{total}.

$$(3)\quad VC_{regional} = VC_{total} - VC_{site}$$

4) Equate variance components to percentages by dividing each component (regional and site) by the total and multiply by 100.

$$(4)\quad VC_{regional} = \frac{VC_{regional}}{VC_{total}} * 100$$

To determine if geochemical trends reflect actual regional variation or are an artifact of sample site variation, F ratios can be calculated between $MSQ_{regional}$ and MSQ_{site};

$$\text{F Ratio}(v1,v3) = \frac{MSQ_{regional}}{MSQ_{site}}$$

where $$MSQ_{regional} = \sum\{(x_i - \mu_i)^2 - (x_j - \mu_j)^2\} / n - 1$$

$v1 = n - 1$ = degrees of freedom for $MSQ_{regional}$
$v3 = n$ = degrees of freedom for MSQ_{site}

Calculated F ratios greater than the critical F ratio (obtained from F tables at the 95% confidence level) indicate that regional variation exceeds sample site variation. Under these circumstances observed regional geochemical trends are not considered to be artefacts of sampling or analytical methods.

RESULTS

Figure 2a presents site and regional variation components. Some general similarities are noted:

- In general, most of the selected elements show low sample site variability (<10%). As a result a high measure of confidence is given to observed elemental regional trends.
- Elements displaying high sample site variance components (>50%) suffer from either nugget effect (Au) or characterized by numerous near detection limit values (Ag). Observed geochemical trends for these elements should be treated with less confidence.

Figure 2b presents F ratios for the selected elements, F_{crit} at the 95% confidence limit for given degrees of freedom is 1.50. All elements surpass this value.

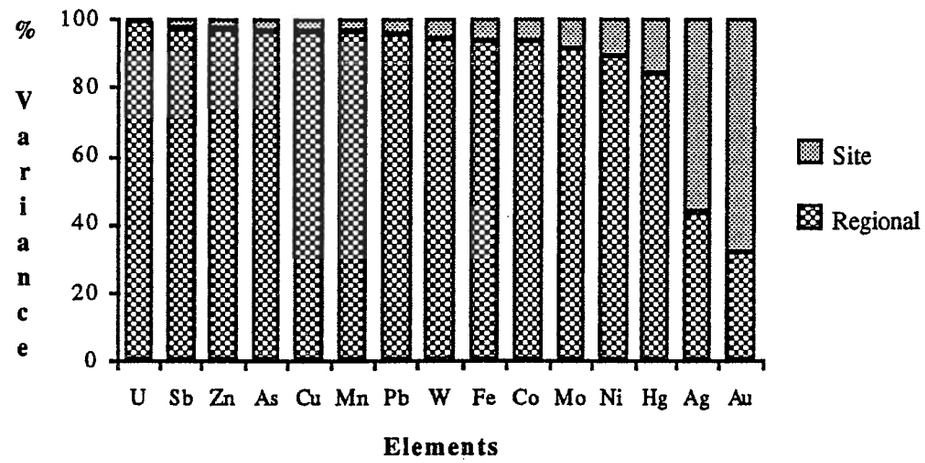


Figure 2a Variance Components for selected elements

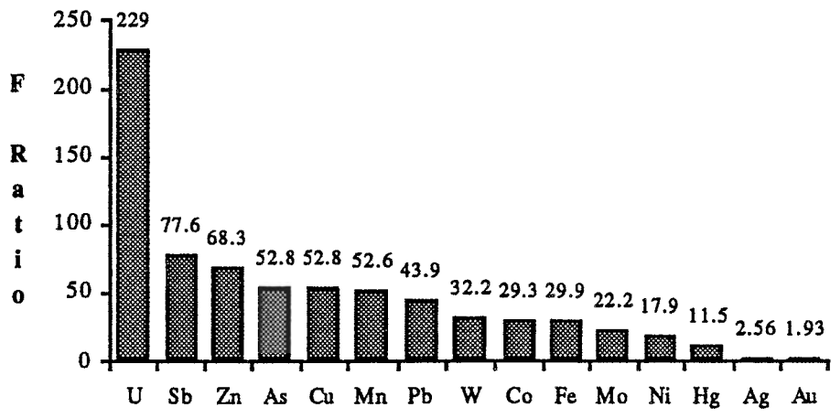


Figure 2b F ratios for selected elements

COMPARISON OF INAA VERSUS AAS TECHNIQUES

Several elements (Co, Fe, Mo and Ni) were determined by both atomic absorption spectroscopy (AAS) and by instrumental neutron activation analysis (INAA). Concentration variations observed between original (AAS) and subsequent (INAA) results are due largely to the analytical methods. AAS requires dissolution of the sample with acids prior to analysis. Aqua regia, a combination of hydrochloric and nitric acids, was primarily used to dissolve RGS sediment samples. Gold and sulphide minerals are dissolved, whereas silicates and some oxides (*ie.* magnetite) are only partially digested. Conversely, INAA does not require sample digestion prior to analysis. Concentrations determined by INAA generally represent the *total* content of that element in the sample. Due to this difference between methods, INAA generally reports slightly higher concentrations than *aqua regia* - AAS.

Figures 3a and 3b represent a comparison of the two techniques for iron and nickel, using data from RGS 30 (NTS 82F). In both cases, INAA gives higher results. A strong correlation is noted for nickel (r = .958); slightly higher INAA results are due to the presence of minute quantities of nickel within the lattices of silicates (ie. feldspars). Iron, however, demonstrates substantial concentration differences between analytical methods and a weaker correlation (r = .646), likely due to the presence of variable amounts of magnetite and hematite commonly found in stream sediment samples.

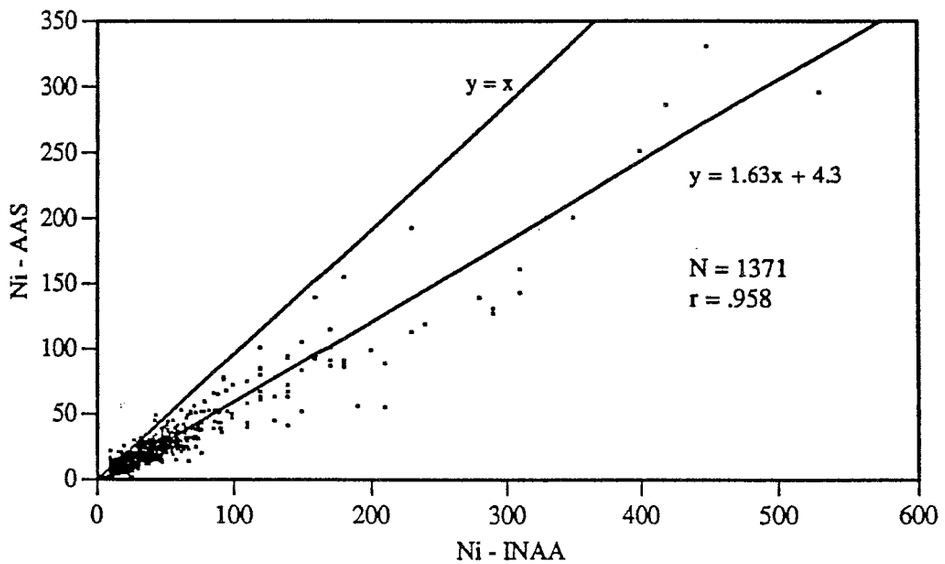


Figure 3a Scatterplot comparing INAA versus AAS results for Ni

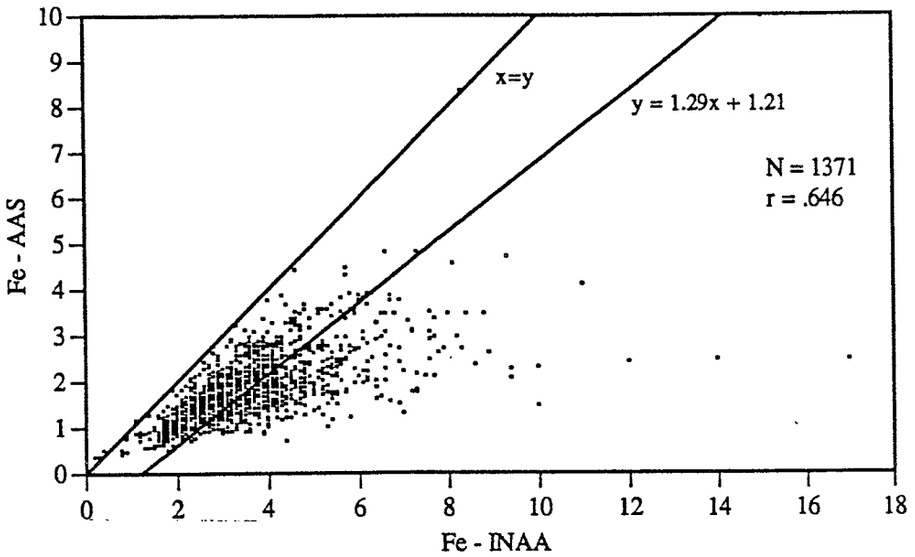


Figure 3b Scatterplot comparing INAA versus AAS results for Fe

* * *

BASE AND PRECIOUS METAL ANOMALY RATING PROCEDURE

INTRODUCTION

Stream sediments collected downstream from mineralized sources commonly exhibit enhanced concentrations for a particular suite of elements. An interpretive technique has been developed that reduces the data set and highlights stream sediment sites characterized by anomalous, multi-element signatures associated with particular mineral deposits. As an example of this methodology, sample evaluation charts and 1:500 000 scale anomaly maps have been produced which outline areas considered to have high base metal and precious metal potential.

METHODOLOGY

Data Subsetting on underlying geological formation

Analytical results for stream sediment samples typically reflect the underlying geology found within the drainage basins. Considerable variability in element concentrations exist between different lithologies. This variability must be considered in order to distinguish anomalous samples from background concentrations. Consequently, analytical data was initially subset on the basis of underlying lithology of the sample site. To better estimate element variability within lithologies, data from adjoining survey areas (RGS 27, 28, 29, 30, 31, 32, 33) were also included.

Threshold Calculations - Sample Evaluation Charts - Anomaly Maps

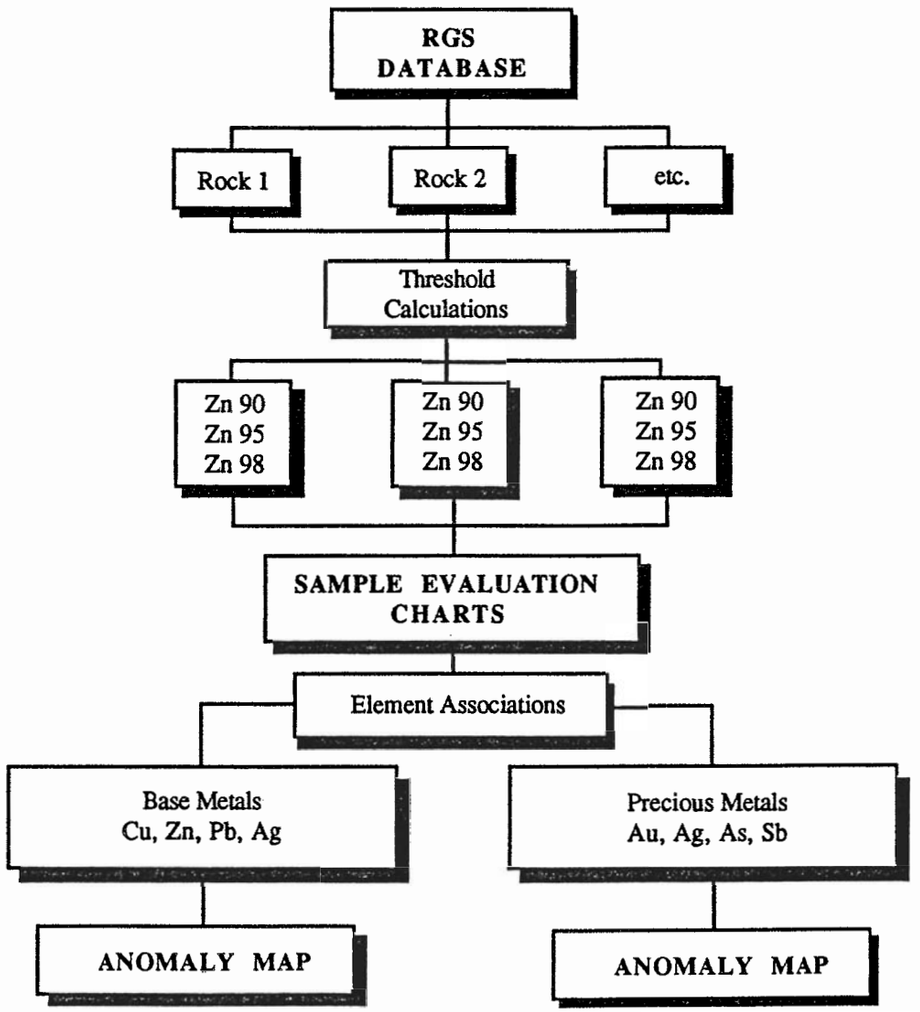
In order to assess the anomalous nature of individual samples, the 90th, 95th and 98th percentiles were calculated for lithologies having 10 or more sample sites and are provided in a threshold table (Appendix D).

Using the calculated thresholds, individual samples where assigned the following anomaly ratings :

- an anomaly rating of 1 for concentrations >= 90th but < 95th percentile,
- an anomaly rating of 2 for concentrations >= 95th but < 98th percentile,
- an anomaly rating of 3 for concentrations >= 98th percentile.

Sample evaluation charts (Appendix D) graphically display the anomaly rating for individual elements. In addition, the summed element ratings provide a measure of the anomalous muti-element nature of each sample. Samples must have a minimum rating of 3 to be included in the chart. Anomaly maps produced from the sample evaluation charts highlight the spatial relationships between anomalous samples.

Utilizing the above technique, sample evaluation charts and anomaly maps have been generated to aid the user in identifying potential base metal and precious metal targets. The element suite used for the identification of base and precious metal multi-element anomalies include **Cu - Zn - Pb - Ag** and **Au - Ag - As - Sb**, respectively.



COMMENTS ON THE INTERPRETATION OF GOLD DATA

Understanding gold geochemical data from regional stream sediment surveys requires an understanding of the chemical and physical characteristics of gold in the surficial environment.

Gold is a soft, malleable element of high density (19.3 g/cm^3). Under normal conditions it is chemically inert, most commonly occurring in native form (pure Au) or as electrum (alloyed with silver). Sub-micron sized gold is often bound to clays, adsorbed onto Fe-Mn oxides or contained within organic colloids. At normal surface temperatures, gold will dissolve under rare conditions of high oxidation potential and high acidity where ions such as chloride (Cl^-), thiosulphate ($S_2O_3^{-2}$) or cyanide (CN^-) are present. Normal background concentrations for gold in bedrock vary, but are generally less than 5 ppb. Background levels encountered for stream sediments seldom exceed 10 ppb and commonly are near the detection limit of 1 ppb.

Under normal conditions, gold occurs as rare, discrete particles. In many instances a geochemical subsample may or may not contain a gold grain. This is known as the 'nugget effect'. Generally, larger geochemical sample sizes are required to minimize the nugget effect and more accurately represent gold concentrations. (Clifton *et al.*, 1969; Harris, 1982). Neutron activation analyses for the 1990 RGS Archive program utilized samples weighing on average 20 grams.

Follow-up investigations of gold anomalies should be based on careful consideration of related geological and geochemical information and an understanding of the variability of gold geochemical data. Once an anomalous area has been identified, field investigations should be designed to include detailed geochemical follow-up surveys and collection of large, representative samples. Analysis of field duplicates and blind (subsample) duplicates will increase the reliability of gold results, allowing for improved data interpretation.

Presentation of gold data within the map booklet differs from other elements as follows:

- Analytical duplicate pairs are listed in brackets following the initial determination.
- Results for field duplicate pairs are listed separated by a slash "/".
- Symbol size represents the highest value in field duplicate and blind duplicate analytical pairs.

- Possible variations in map format presentation:

+	Data < 50th percentile
+ 77.....	Single analysis > 95th percentile
+ 103(42)...	Analytical duplicate pair
+ 103/42....	Field duplicate pair

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1991 Regional Geochemical Survey

RGS 30

NELSON - NTS 82F

APPENDIX A

Field Observations and Analytical Data

Notes : Values less than detection limit recorded as 1/2 detection limit value.

Table A-1 Reference Guide for Geological Formations (after Okulitch and Woodsworth, 1977)

Formation	Description
STRATIFIED ROCKS	
CENOZOIC	
QUATERNARY AND RECENT	
Q	glacial deposits, recent alluvium
TERTIARY	
EOCENE - OLIGOCENE	
eoTv	basalt, andesite, volcaniclastic and flow rocks, minor sediments KAMLOOPS and PHOENIX Groups; SANPOIL Volcanics, KLONDIKE Mtn. and O'BRIEN Ck. Fms.
MESOZOIC	
JURASSIC	
JF	shale, siltstone, sandstone, limestone FERNIE Group (includes HALL Fm. - Nelson map area)
TRIASSIC - JURASSIC	
TJv	greenstone, tuff, sediments NICOLA and ROSSLAND Groups; ELISE and ARCHIBALD Fms.
TJs	shale, argillite, limestone, conglomerate, schist, sandstone NICOLA, SLOCAN, ROSSLAND and YMIR Groups; SICAMOUS and ARCHIBALD Fms.
PALEOZOIC - MESOZOIC	
PERMIAN - TRIASSIC	
PTv	greenstone, basalt, andesite, lava, tuff, breccia, serpentinite KASLO Group; TSALKOM Fm.
PALEOZOIC	
CARBONIFEROUS - PERMIAN	
PPT	argillite, quartzite, greenstone, limestone, conglomerate THOMPSON Assemblage (including CACHE CK. -eastern facies), CHAPPERON, KOBAU and ANARCHIST Groups; MT. ROBERTS Fm.
Ms	slate, argillite, chert, schist, conglomerate, limestone MILFORD Group; FLAGSTAFF MTN. Sequence

Formation	Description
STRATIFIED ROCKS	
PALEOZOIC	
LOWER PALEOZOIC	
lPs	argillite, limestone, schist, phyllite, greenstone LARDEAU Group; BROADVIEW, EAGLE BAY, NELWAY, ACTIVE and METALINE Fms.; LEDBETTER SLATE, GRASS Mtn. Sequence
LOWER CAMBRIAN	
lEs	quartzite, limestone, phyllite, argillite HAMILL and GOG Group; EAGER, BADSHOT, MOHICAN, DONALD, RENO, LAIB & QUARTZITE RANGE Fms.; Maitlen Phyllite, Emerald & Reeves Limestone Members
PALEOZOIC (AND OLDER?)	
Pns	orthogneiss, foliated and massive granitic rocks, schist, paragneiss, minor amphibolite and marble OKANAGAN Metamorphic and Plutonic Complex
Pgn	orthogneiss OKANAGAN Metamorphic & Plutonic Complex
PROTEROZOIC	
HADRYNIAN (WINDERMERE)	
Hs	sandstone, conglomerate, limestone, grit, minor volcanic rocks MIETTE and HORSETHIEF Ck. Groups; TOBY, SHEDROOF and MONK Fms.; IRENE and LEOLA Volcanics; SILVER Ck. and CHASE Fms. near Shuswap Lake
HELIKIAN (BELT-PURCELL)	
HSU	quartzite, argillite, dolomite, limestone, siltstone MISSOULA Grp.; MT. NELSON, DUTCH Ck., GATEWAY, PHILLIPS & ROOSVILLE Fms.
HSM	limestone, argillite, quartzite, andesite, breccia, tuff SIYEH, KITCHENER, WALLACE, HELENA, and SHEPPARD Fms.; Purcell Lava
HSL	quartzite, argillite, siltstone RAVALLI Group; CRESTON, ALDRIDGE, FORT STEELE, PRITCHARD, WATERTON, APPEKUNY, ALTYN, GRINNELL AND WERNER PK. Fms.

Formation	Description
INTRUSIVE ROCKS	
MESOZOIC - CENOZOIC	
CRETACEOUS AND/OR TERTIARY	
LATE CRETACEOUS AND/OR EARLY TERTIARY	
KTm	CORYELL INTRUSIONS: monzonite, monzodiorite; lesser syenite, diorite, granodiorite, quartz monzonite
KTgd	predominantly granodiorite, quartz diorite; lesser diorite, monzonite, quartz monzonite, gneiss, migmatite
KTqm	quartz monzonite, granite, alaskite; lesser granodiorite, quartz diorite, gneiss, migmatite
MESOZOIC	
CRETACEOUS	
EARLY AND/OR MID-CRETACEOUS	
EKqm	quartz monzonite, granite; lesser granodiorite, quartz diorite
EKgd	granodiorite, quartz diorite; lesser quartz monzonite
JURASSIC	
MIDDLE AND/OR LATE JURASSIC	
Jg	granodiorite, quartz diorite, lesser quartz monzonite
PALEOZOIC	
LATE PALEOZOIC (MAINLY)	
Pub	ultramafic rocks; peridotite, serpentinite
PROTEROZOIC	
Pg	HELLROARING STOCK: granodiorite

Table A-2 Reference Guide for Field Observations

Column	Definition and Descriptions
MAP	1:50 000 NTS map sheet number
SAMPLE ID	Sample number
UTM ZONE	UTM Zone Number
UTM EAST	UTM East Coordinate
UTM NORTH	UTM North Coordinate
STA	Replicate Sample Status: **0** = Routine Sample **1** = 1st Field Duplicate **2** = 2nd Field Duplicate **8** = Blind Duplicate **9** = Control Reference
MED	Sample Media Collected: **1** = Stream Sediment only **6** = Stream Sediment & Water **7** = Moss-Mat Sediment only **8** = Moss-Mat Sediment & Water
FORMATION **ROCK TYPE** **AGE**	(see Table A-1)
WAT COL	Water Colour: **0** = Colourless **2** = White Cloudy **1** = Brown Clear **3** = Brown Cloudy
FLW	Water Flow Rate: **0** = Stagnant **3** = Fast **1** = Slow **4** = Torrent **2** = Moderate

Column	Definition and Descriptions
SED COL	Sediment Colour: **B** = Black **R** = Red **G** = Grey-Blue **T** = Tan-Brown **O** = Olive-Green **W** = White-Buff **P** = Pink **Y** = Yellow
SED PPT	Sediment Precipitate: **N** = None (otherwise same as SED COL)
CON	Contamination: **N** = None **D** = Domestic **P** = Possible **F** = Forestry **A** = Agricultural **M** = Mining
SED COMP	Sediment Composition: estimate of Sand-Fines-Organic content **0** = Absent **1** = Minor (<1/3 of total) **2** = Moderate (>1/3 but <2/3) **3** = Major (>2/3 of total)
STRM WDTH	Stream Width: in metres
STRM DPTH	Stream Depth: in centimetres
BNK	Bank Composition: **A** = Alluvium **R** = Rock **C** = Colluvium **S** = Talus **G** = Outwash **T** = Till **O** = Organic **U** = Unknown
BNK PPT	Bank Precipitate: **N** = None (otherwise same as SED COL)
CHL BED	Channel Bed: **B** = Boulders **S** = Gravel-Sand **F** = Silt-Clay **O** = Organics

Column	Definition and Descriptions
CHL PTN	Channel Pattern: **S**=Shoots-Pools **M**=Meandering **B**=Braided **D**=Disturbed
ELEV	Elevation: in metres
PHY	Physiography: **H**=Hilly **P**=Plateau **L**=Lowland **S**=Swamp **M**=Mature mountains **Y**=Youthful
DRN	Drainage Pattern: **D**=Dendritic **H**=Herringbone **G**=Glacially deranged **I**=Interrupted **R**=Rectangular
TYP	Stream Type: **P**=Permanent **S**=Seasonal
ODR	Stream Order: **1**=Primary **3**=Tertiary **2**=Secondary **4**=Quaternary
SRC	Stream Source: **G**=Groundwater **S**=Spring runoff **M**=Melt water **U**=Unknown

METHODS OF SAMPLE ANALYSIS

1977 Program

Co, Cu, Fe, Pb, Mn, Ni, Ag and **Zn** were determined as follows: a one gram sample was reacted with 3 ml of concentrated HNO_3 for 30 minutes at 90°C. 1 ml concentrated HCl was added and the digestion was continued at 90°C for an additional 90 minutes. The sample solution was then diluted to 20 ml with metal free water and mixed. Concentrations were determined by AAS using an air-acetylene flame. Background corrections were made for **Pb, Ni, Co** and **Ag**.

For **Hg**, a 0.5 gram sample was reacted with 20 ml concentrated HNO_3 and 1 ml concentrated HCl for 10 minutes at room temperature and for 2 hours at 90°C in a hot water bath. After digestion, the sample solutions was cooled and diluted to 100 ml with metal free water. Mercury present in the solution was reduced to the elemental state by the addition of 10 ml of 10% W/V $SnSO_4$ in H_2SO_4. Resultant mercury vapour was then flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrometer. Absorption measurements were made at 253.7 NM.

Mo was determined by AAS using a nitrous oxide - acetylene flame. A 0.5 gram sample was reacted with 1.5 ml concentrated $HN0_3$ at 90°C for 30 minutes. At this point 0.5 ml concentrated HCl was added and the digestion continued for an additional 90 minutes. After cooling, 8 ml of 1250 ppm Al solution was added and the sample solution diluted to 10 ml before aspiration into the AAS.

For **Sn**, a 1 gram sample is heated with NH_4I in a modified pyropot furnace for 15 minutes at 500oC. This reaction converts the Sn in the sample to $SnSI_4$. After cooling, the residue is leached with 20 ml of a solution which contains 5% V/V HCl and 6% W/V ascorbic acid. After leaching, the sample was cooled to room temperature and 5 ml of 4% W/V trioctylphosphine oxide in methyl isobutyl ketone (MIBK) were added. The test tube was capped and shaken for 60 seconds. The solvent layer was then transfered to a small tube and centrifuged. Sn in the solvent layer was then determined by AAS using a nitrous-oxide acetylene flame at 2863 angstrom units.

W was determined as follows: a 0.2 gram sample was fused with 1 gram $KHSO_4$ in a rimless test tube at 575°C for 15 minutes. The cooled melt was then leached with 10 ml concentrated HCl in a water bath heated to 85°C. After the soluble material had completely dissolved, the insoluble material was allowed to settle and an aliquot of 5 ml was transferred to another test tube. 5 ml of 20% $SnCl_2$ solution was then added to the sample aliquot, mixed and heated for 10 minutes at 80°C in a hot water bath. A 1 ml aliquot of dithiol solution (1% dithiol in iso-amyl-acetate) was added to the solution and heated for 4-6 hours at 80-85°C in a hot water bath. The solution was then removed from the hot water bath and cooled; 2.5 ml of kerosene was added to dissolve the globule containing the tungsten-dithiol complex. W was measured by determining the absorbance of the kerosene solution at 630 nm using a spectrophotometer.

U in sediments was determined using instrumental neutron activation analysis (INAA) with delayed neutron counting. A 1 gram sample was sealed into a 7-dram polyethylene vial. Irradiation was provided by a Slowpoke Reactor with an operating flux of 10^{12} neutrons/cm^2/sec. Each sample was irradiated for 60 seconds. Following a 20-second delay, the sample was counted with 6 BF_3 detector tubes embedded in paraffin for 60 seconds.

U in water was determined by a fluorometric method. Uranium was initially preconcentrated by evaporation. The residue was fused with a mixture of Na_2CO_3, K_2CO_3 and NaF in a platinum dish. After cooling, the fluorescence of the fused pellet was measured using a Turner Fluorometer.

F in water was determined using a specific ion electrode. An aliquot of the sample was mixed with an equal volume of TISAB II solution (total ionic strength adjustment buffer). Fluoride content was measured using a Corning 101 Electrometer with an Orion Fluoride Electrode.

For the determination of **pH** an aliquot of water was transferred to a clean dry beaker. **pH** was measured using a Fisher Accumet pH Meter.

1990 Archive Program

Becquerel Laboratories (Mississauga), Ltd. carried out instrumental neutron activation analysis (INAA) of archived stream sediment sample splits. Samples weighing 20 grams on average were irradiated epithermally for twenty minutes in a neutron flux of 10^{11} neutrons/cm^2/sec. After a decay period of approximately one week, gamma-ray emissions for the elements of interest were measured using a gamma-ray spectrometer with a high resolution, coaxial germanium detector. Counting time was approximately fifteen minutes per sample. Counting data was compiled on a computer and later converted to concentrations. Numerous international reference samples were irradiated within each analytical batch.

Sediments were analyzed for antimony, arsenic, barium, bromine, cerium, cesium, chromium, cobalt, gold, hafnium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zirconium. Concentrations below the reported detection limit were assigned a value equivalent to one-half of the detection limit. Detection limits for these elements are listed in Table A-4.

Element	Detection Limits	Sample Weight	Determination Method	
Cobalt	2 ppm			
Copper	2 ppm			
Iron	0.02 pct			
Lead	2 ppm	1 g	AAS	Atomic Absorption Spectrophotometry
Manganese	5 ppm			
Nickel	1 ppm			
Silver	0.2 ppm			
Zinc	2 ppm			
Molybdenum	2 ppm	0.5 g		
Tin	2 ppm	1 g		
Mercury	10 ppb	0.5 g		
Tungsten	4 ppm	0.2 g	COLOR	Colorimetric
Uranium	0.2 ppm	1 g	NA DNC	Neutron Activation
pH - water	0.1 pH unit	25 ml	GCE	Fisher Accumet pH meter
U - water	0.05 ppb	5 ml	LIF	Fluorometric Method
F - water	20 ppb	25 ml	ION	Fluorine Ion Specific Electrode

Table A-3 1977 Routine RGS Analytical Methods

Element	Detection Limits	Element	Detection Limits
Gold	2 ppb	Molybdenum	1 ppm
Antimony	0.1 ppm	Nickel	10 ppm
Arsenic	0.5 ppm	Rubidium	5 ppm
Barium	100 ppm	Samarium	0.5 ppm
Bromine	0.5 ppm	Scandium	0.5 ppm
Cerium	10 ppm	Sodium	0.1 pct
Cesium	0.5 ppm	Tantalum	0.5 ppm
Chromium	5 ppm	Terbium	0.5 ppm
Cobalt	5 ppm	Thorium	0.5 ppm
Hafnium	1 ppm	Tungsten	2 ppm
Iron	0.2 pct	Uranium	0.2 ppm
Lanthanum	5 ppm	Ytterbium	2 ppm
Lutetium	0.2 ppm	Zirconium	200 ppm

Table A-4 1990 INAA Detection Limits

1977 Field Observations and Analytical Results

																								Water			Stream Sediment												
MAP	SAMPLE ID	UTM ZONE	UTM EAST	UTM NORTH	STA	MED	FM	WAT COL	FLW	SED COL	SED PPT	CON	SED COMP	STRM WDTH	STRM DPTH	BNK	BNK PPT	PHY	DRN	TYP	ODR	SRC	DATE	FW 20 ppb ION	UW 0.05 ppb LIF	pH 0.1 GCE	Co 2 ppm AAS	Cu 2 ppm AAS	Fe 0.02 pct AAS	Pb 2 ppm AAS	Mn 5 ppm AAS	Hg 10 ppb AAS-F	Mo 2 ppm AAS	Ni 2 ppm AAS	Ag 0.2 ppm AAS	Sn 2 ppm AAS	W 4 ppm COLOR	U 0.2 ppm NADNC	Zn 2 ppm AAS :DL :Uni :Mth
82F04	771009	11	442552	5454493		6	EKgd	0	2	R	N	F	220	3.0	46	C	N	M	I	P	2	G	0606	62	0.44	6.2	3	8	1.05	16	270	20	2	4	0.1	1	5	12.5	38
82F04	771015	11	451777	5433540		6	Jg	0	1	R	N	P	121	1.2	30	A	N	H	I	P	3	G	0706	52	0.26	6.3	4	10	1.20	57	185	40	1	6	0.1	1	2	12.3	78
82F04	771016	11	454778	5429070		6	TJv	0	2	R	N	N	120	2.4	30	T	N	M	I	P	2	G	0706	74	0.22	6.5	6	18	1.40	100	230	60	1	8	0.2	1	4	11.7	168
82F04	771017	11	454606	5433036		1	Jg			W	N	N	310	0.6		T	N	M	I	S	2	U	0706				5	16	1.30	165	255	60	1	8	0.1	1	3	7.2	315
82F04	771018	11	454088	5435042		6	Jg	0	2	W	N	N	220	1.8	30	T	N	M	I	P	2	G	0706	100	0.16	5.7	6	16	1.30	100	280	40	1	10	0.1	1	2	5.0	180
82F04	771019	11	450435	5436638		6	Jg	0	2	R	N	P	220	2.7	46	A	N	M	I	P	2	G	0706	98	0.12	6.3	10	34	2.35	245	545	120	1	20	0.5	1	2	8.0	515
82F04	771020	11	448168	5435905		6	TJv	0	2	R	N	P	021	1.5	30	C	N	M	I	P	2	G	0706	80	0.08	7.2	6	22	1.40	105	235	90	1	8	0.2	1	2	4.3	220
82F04	771022	11	447397	5432403		6	TJv	0	2	R	N	N	022	1.2	15	C	N	M	I	P	3	G	0706	90	1.40	7.4	6	18	1.40	30	635	50	4	8	0.3	1	3	30.7	82
82F04	771023	11	444320	5434586		6	Jg	0	1	R	N	N	022	0.6	15	C	N	M	I	P	3	G	0706	58	0.02	7.1	10	18	2.50	38	1900	30	2	8	0.1	1	2	5.4	104
82F04	771024	11	444820	5436806		6	Jg	0	2	R	N	P	210	4.0	30	C	N	M	D	P	2	G	0706	110	0.08	7.6	15	220	2.10	59	510	650	3	16	0.8	2	4	4.0	205
82F04	771026	11	445143	5436651		6	Jg	0	1	R	N	P	310	3.0	30	C	N	H	I	P	3	G	0706	96	0.32	7.5	6	12	1.80	17	390	40	1	8	0.1	1	3	5.1	76
82F04	771027	11	443533	5437978		6	Jg	0	1	R	N	P	022	1.5	15	U	N	H	I	P	3	G	0706	68	0.08	7.4	8	30	2.15	47	420	70	2	12	0.1	1	6	8.6	116
82F04	771028	11	458503	5429316	1	6	TJv	0	2	G	N	P	210	0.9	15	C	N	H	I	P	3	G	0806	110	0.02	8.0	2	26	0.70	51	255	40	3	4	0.1	1	2	1.0	80
82F04	771029	11	458503	5429316	2	6	TJv	0	2	G	N	P	210	0.9	15	C	N	H	I	P	3	G	0806	110	0.02	8.0	3	26	0.75	46	250	30	3	6	0.1	1	2	0.9	74
82F04	771030	11	461560	5431085		6	TJv	0	2	R	N	P	220	1.2	30	C	N	M	I	P	2	G	0806	66	0.02	8.2	13	42	2.45	13	595	20	2	16	0.1	1	2	2.1	78
82F03	771031	11	470189	5436054		6	TJv	0	3	R	N	N	210	3.0	46	C	N	M	I	P	3	G	0806	34	0.02	7.8	17	46	3.55	11	660	30	1	30	0.1	3	2	2.6	84
82F03	771032	11	469542	5436116		6	TJv	0	2	R	N	N	220	4.0	30	C	N	M	I	P	4	G	0806	34	0.02	8.0	18	64	3.80	17	725	50	2	26	0.1	1	2	1.9	114
82F03	771033	11	470722	5434335		6	TJv	0	2	R	N	N	220	2.4	30	C	N	H	I	P	3	G	0806	58	0.10	7.3	20	48	3.25	18	545	70	2	74	0.1	1	4	7.5	92
82F03	771034	11	470837	5432860		6	Ms	0	2	R	N	N	022	1.2	30	C	N	H	I	P	4	G	0806	92	0.14	8.1	13	42	2.85	42	915	60	1	52	0.2	1	2	5.2	154
82F03	771035	11	469866	5432092		6	Ms	0	3	R	N	P	120	3.7	46	C	N	M	I	P	2	G	0806	42	0.02	8.0	19	50	3.55	10	760	30	1	32	0.1	1	2	2.5	90
82F03	771036	11	466180	5432773		6	Ms	0	2	R	N	N	121	1.8	30	C	N	M	I	P	3	G	0806	50	0.02	8.3	12	38	2.75	2	470	10	1	16	0.1	1	2	1.7	60
82F04	771037	11	463012	5432326		6	TJv	0	2	R	N	P	120	1.5	30	C	N	M	I	P	2	G	0806	72	0.02	8.1	5	34	1.35	30	875	40	2	6	0.1	1	2	1.3	92
82F04	771038	11	458725	5441304		6	TJv	0	1	R	N	P	111	1.2	15	C	N	M	I	P	3	G	0806	66	0.02	8.0	8	24	2.00	27	290	20	1	18	0.1	1	2	4.4	136
82F04	771039	11	457927	5437555		6	TJv	0	2	W	N	P	111	0.9	15	C	N	M	I	P	3	G	0806	72	0.02	8.2	1	20	0.75	59	200	50	2	8	0.1	1	2	1.0	220
82F04	771040	11	457426	5433740		6	TJv	0	1	R	N	P	022	0.9	15	C	N	H	I	P	2	G	0906	80	0.02	8.0	5	46	1.25	275	205	100	1	14	0.4	2	2	2.6	270
82F04	771042	11	460108	5437062		6	JF	0	1	R	N	P	021	0.9	15	C	N	M	I	P	3	G	0906	58	0.02	8.2	9	30	1.95	44	350	40	1	14	0.1	1	2	1.9	106
82F04	771043	11	458926	5436162		6	JF	0	1	R	N	P	120	0.6	15	C	N	M	I	P	3	G	0906	68	0.02	7.8	3	50	1.00	265	405	120	2	8	0.2	1	2	1.4	345
82F04	771044	11	461955	5437640		6	JF	0	1	R	N	P	012	0.9	15	C	N	M	I	P	3	G	0906	50	0.02	8.0	8	58	1.85	100	1200	70	1	20	0.2	1	2	1.6	136
82F03	771045	11	464231	5437795		6	TJv	0	2	R	N	P	120	1.2	30	C	N	M	I	P	3	G	0906	34	0.02	8.0	14	36	2.70	12	620	30	1	20	0.1	1	2	2.1	106
82F04	771047	11	462409	5438856	1	6	JF	0	1	R	N	P	120	1.2	30	C	N	M	I	P	3	G	0906	38	0.02	8.1	12	34	2.60	15	545	30	1	18	0.1	1	2	2.3	102
82F04	771048	11	462409	5438856	2	6	JF	0	1	R	N	P	120	1.2	30	C	N	M	I	P	3	G	0906	34	0.02	8.1	12	32	2.50	14	510	30	1	18	0.1	1	2	1.8	96
82F04	771049	11	462693	5439312		6	JF	0	3	R	N	P	021	4.6	46	C	N	M	I	P	3	G	0906	34	0.02	7.9	15	56	3.35	16	465	50	1	24	0.2	1	2	2.2	215
82F03	771050	11	465121	5440292		6	JF	0	3	R	N	P	220	3.7	30	C	N	M	I	P	3	G	0906	26	0.02	7.8	19	56	3.90	8	745	30	2	28	0.1	1	2	2.1	235
82F03	771051	11	471393	5445329		6	TJs	0	3	R	N	P	210	2.4	30	C	N	M	I	P	3	G	0906	10	0.02	7.7	19	62	3.75	7	710	40	1	24	0.1	1	2	2.2	98
82F03	771052	11	471222	5442140		6	TJs	0	2	R	N	P	021	2.1	30	C	N	M	I	P	3	G	0906	10	0.02	7.2	17	42	3.20	21	595	70	1	66	0.1	1	2	2.5	124
82F03	771053	11	471786	5442816		6	TJs	0	3	R	N	N	121	3.7	30	C	N	M	D	P	3	G	0906	10	0.02	7.5	15	48	3.30	14	730	40	1	16	0.1	1	2	2.8	98
82F03	771054	11	471387	5446955		6	TJs	0	3	R	N	P	310	4.6	46	C	N	M	D	P	2	G	0906	10	0.02	7.8	17	46	3.65	8	635	20	1	40	0.1	1	2	1.9	94
82F03	771055	11	468268	5446197		6	TJv	0	3	R	N	N	121	2.4	46	C	N	M	D	P	3	G	0906	38	0.02	7.5	16	54	3.45	15	600	30	1	18	0.1	1	2	2.1	82
82F04	771056	11	457917	5445949		6	TJs	0	2	R	N	P	220	3.0	30	C	N	M	D	P	3	G	1106	52	0.02	7.6	12	44	2.80	12	545	20	1	30	0.2	1	2	4.6	136
82F04	771057	11	460810	5446258		6	TJs	0	2	R	N	P	210	1.2	30	C	N	M	I	P	3	G	1106	38	0.02	8.0	8	28	2.15	34	520	40	1	14	0.1	1	2	2.4	96

1990 Analytical Results

Stream Sediment

MAP	SAMPLE ID	UTM ZONE	UTM EAST	UTM NORTH	STA	MED	FM	Au 2 ppb INAA	Sb 0.1 ppm INAA	As 0.5 ppm INAA	Ba 100 ppm INAA	Br 0.5 ppm INAA	Ce 10 ppm INAA	Cs 0.5 ppm INAA	Cr 5 ppm INAA	Co 5 ppm INAA	Hf 1 ppm INAA	Fe 0.2 % INAA	La 5 ppm INAA	Lu 0.2 ppm INAA	Mo 1 ppm INAA	Ni 10 ppm INAA	Rb 5 ppm INAA	Sm 0.5 ppm INAA	Sc 0.5 ppm INAA	Na 0.1 % INAA	Ta 0.5 ppm INAA	Tb 0.5 ppm INAA	Th 0.5 ppm INAA	W 2 ppm INAA	U 0.2 ppm INAA	Yb 2 ppm INAA	Zr 200 ppm INAA	Wt 0.001 g INAA	:DL :Uni :Mth
82F04	771009	11	442552	5454493		6	EKgd	2	0.4	1.9	1000	3.3	100	2.1	25	5	8	1.8	84	0.2	1	10	150	6.1	5.0	2.7	7.2	0.7	31.9	3	14.0	2	330	29.596	
82F04	771015	11	451777	5433540		6	Jg	2	2.2	5.1	1100	7.0	100	2.4	54	8	10	2.7	76	0.2	1	18	87	8.2	10.0	2.6	2.0	1.2	16.0	2	16.0	2	430	22.674	
82F04	771016	11	454778	5429070		6	TJv	2	4.1	6.4	870	13.0	150	1.5	61	8	13	3.0	110	0.2	1	16	72	8.1	11.0	2.2	2.6	1.0	24.0	3	13.0	2	510	7.696	
82F04	771017	11	454606	5433036		1	Jg	2	6.6	11.0	990	2.3	130	2.0	70	7	10	3.2	90	0.2	1	13	86	8.9	9.0	2.2	2.3	1.2	22.2	2	8.4	2	480	11.813	
82F04	771018	11	454088	5435042		6	Jg	2	5.0	8.5	1100	3.3	83	1.8	63	6	6	2.4	59	0.2	1	18	87	6.5	8.1	2.1	1.7	0.9	14.0	2	5.7	2	300	13.534	
82F04	771019	11	450435	5436638		6	Jg	18	10.0	15.0	1100	8.1	130	2.2	110	14	10	4.0	92	0.2	1	30	80	10.1	12.0	1.9	2.5	1.4	20.0	2	8.3	2	290	10.194	
82F04	771020	11	448168	5435905		6	TJv	34	4.0	12.0	1500	4.1	140	1.8	77	11	13	3.6	96	0.2	1	22	100	10.8	11.0	2.6	2.8	1.4	22.2	2	6.4	2	560	21.121	
82F04	771022	11	447397	5432403		6	TJv	83	1.1	11.0	830	8.1	120	1.8	65	10	12	2.8	83	0.2	5	20	73	7.3	11.0	2.4	3.0	1.0	19.0	2	36.7	2	340	11.319	
82F04	771023	11	444320	5434586		6	Jg	2	1.5	37.0	1200	9.3	110	2.0	75	16	6	4.5	77	0.2	2	15	75	7.9	14.0	2.4	2.2	1.1	12.0	2	6.8	2	260	15.785	
82F04	771024	11	444820	5436806		6	Jg	200	2.2	23.0	1200	10.0	130	2.7	140	24	10	4.9	89	0.2	2	40	68	8.7	18.0	2.3	2.4	1.1	13.0	3	4.9	2	300	16.319	
82F04	771026	11	445143	5436651		6	Jg	2	0.7	7.3	1100	1.8	120	1.8	76	12	7	4.0	83	0.2	1	10	72	8.1	16.0	2.6	2.5	1.3	15.0	2	6.2	2	400	5.696	
82F04	771027	11	443533	5437978		6	Jg	4	1.7	19.0	970	7.0	100	1.9	81	13	8	3.7	72	0.2	1	28	68	7.1	15.0	2.0	2.1	0.9	12.0	4	10.0	2	320	10.411	
82F04	771028	11	458503	5429316	1	6	TJv	2	2.0	5.7	450	14.0	18	0.9	35	5	1	1.2	14	0.2	1	10	27	1.8	4.8	0.8	0.5	0.5	2.8	2	1.1	2	200	4.237	
82F04	771029	11	458503	5429316	2	6	TJv	2	2.1	6.8	550	15.0	26	1.1	42	5	2	1.4	17	0.2	1	10	30	2.4	5.3	0.9	0.5	0.5	3.4	2	1.2	2	200	6.224	
82F04	771030	11	461560	5431085		6	TJv	5	2.3	14.0	1100	4.6	55	2.6	110	19	5	4.2	37	0.2	1	30	69	5.6	16.0	2.0	1.0	0.8	6.8	2	2.6	2	290	19.403	
82F03	771031	11	470189	5436054		6	TJv	5	3.1	18.0	1100	3.4	63	3.3	310	27	4	5.8	39	0.2	1	59	70	6.4	23.7	2.2	0.9	1.0	7.2	2	3.4	2	300	21.996	
82F03	771032	11	469542	5436116		6	TJv	3	2.5	15.0	1200	14.0	57	3.4	210	28	2	6.1	37	0.2	1	54	63	5.5	26.3	2.4	0.9	1.0	5.4	2	2.7	2	200	19.168	
82F03	771033	11	470722	5434335		6	TJv	46	1.9	15.0	910	3.1	61	3.1	390	24	4	4.4	42	0.2	1	110	80	5.9	19.0	1.7	1.0	1.0	10.0	2	7.8	2	210	8.236	
82F03	771034	11	470837	5432860		6	Ms	2	1.5	14.0	560	32.0	67	2.9	150	16	3	3.2	43	0.2	1	62	70	5.4	11.0	1.3	1.2	0.9	12.0	2	5.1	2	200	3.060	
82F03	771035	11	469866	5432092		6	Ms	9	2.4	17.0	1100	3.4	71	3.0	230	27	4	5.3	44	0.2	1	59	71	6.4	22.2	2.2	1.1	0.8	7.4	2	3.0	2	260	21.459	
82F03	771036	11	466180	5432773		6	Ms	2	1.6	11.0	1200	0.6	53	2.0	150	22	4	4.9	33	0.3	1	32	60	5.1	23.2	2.8	0.8	0.9	5.3	2	2.3	2	200	22.565	
82F04	771037	11	463012	5432326		6	TJv	5	1.7	11.0	550	41.0	31	2.3	37	8	3	2.2	20	0.3	1	10	32	3.0	8.4	1.3	0.5	0.5	3.8	2	1.3	2	200	7.684	
82F04	771038	11	458725	5441304		6	TJv	20	1.4	7.9	1200	7.8	91	2.7	140	14	12	4.6	60	0.2	1	30	80	7.7	14.0	2.2	1.7	1.2	14.0	2	4.6	2	490	23.911	
82F04	771039	11	457927	5437555		6	TJv	10	2.0	4.5	420	13.0	21	1.3	47	5	2	1.4	23	0.2	1	10	17	2.1	4.8	0.6	0.7	0.5	4.2	2	1.2	2	200	1.775	
82F04	771040	11	457426	5433740		6	TJv	9	8.3	17.0	760	33.0	68	1.9	98	9	5	2.8	45	0.2	1	27	55	4.9	11.0	2.0	1.0	0.7	10.0	2	2.8	2	240	9.394	
82F04	771042	11	460108	5437062		6	JF	3	2.2	8.8	1100	11.0	67	2.3	110	15	5	4.0	42	0.3	1	31	67	5.3	18.0	2.6	1.0	0.8	6.7	2	2.5	2	230	18.539	
82F04	771043	11	458926	5436162		6	JF	12	9.5	21.0	570	18.0	36	1.7	58	8	3	2.2	23	0.2	1	17	41	2.9	9.1	1.3	0.5	0.5	3.9	2	1.5	2	200	10.127	
82F04	771044	11	461955	5437640		6	JF																												
82F03	771045	11	464231	5437795		6	TJv	2	1.5	8.4	1300	6.7	72	2.8	120	21	4	4.9	46	0.3	1	41	67	5.8	21.6	2.7	1.1	0.9	6.5	2	2.6	2	200	22.748	
82F04	771047	11	462409	5438856	1	6	JF	10	1.3	6.5	1000	6.2	58	2.4	100	17	4	4.1	36	0.3	1	37	53	4.8	18.0	2.3	0.9	0.8	5.7	2	2.2	2	200	13.659	
82F04	771048	11	462409	5438856	2	6	JF	2	1.5	7.9	1300	6.9	70	2.8	120	19	4	4.6	43	0.2	1	38	67	5.5	20.0	2.7	1.1	0.9	6.5	2	2.6	2	200	18.902	
82F04	771049	11	462693	5439312		6	JF	3	2.2	10.0	1100	7.2	43	2.9	120	19	2	4.5	29	0.2	1	47	56	4.7	20.9	2.0	0.7	0.8	5.0	2	2.6	2	200	13.911	
82F03	771050	11	465121	5440292		6	JF	3	2.6	13.0	1200	4.0	46	2.7	180	28	3	6.2	31	0.2	2	59	63	5.3	27.0	2.2	0.8	0.9	4.9	2	2.7	2	200	18.996	
82F03	771051	11	471393	5445329		6	TJs	4	1.9	10.0	1100	6.3	55	3.0	170	32	4	6.7	34	0.3	1	53	60	5.6	30.2	2.5	0.8	0.9	6.4	2	3.0	2	200	27.712	
82F03	771052	11	471222	5442140		6	TJs	3	1.9	20.0	960	14.0	49	4.7	340	24	2	4.7	28	0.2	1	120	75	4.9	20.0	1.9	0.6	0.7	5.2	2	2.8	2	200	17.612	
82F03	771053	11	471786	5442816		6	TJs	4	2.0	15.0	860	11.0	46	2.9	120	19	3	4.6	29	0.2	1	28	61	4.6	19.0	2.2	0.6	0.7	5.1	2	3.1	2	210	11.236	
82F03	771054	11	471387	5446955		6	TJs	3	1.9	12.0	1000	4.1	53	3.1	250	26	3	6.2	32	0.2	1	75	58	5.3	27.7	2.6	0.8	0.8	5.4	2	2.8	2	240	22.842	
82F03	771055	11	468268	5446197		6	TJv	5	2.0	14.0	910	18.0	55	3.5	160	26	5	6.8	33	0.4	1	41	55	5.5	28.0	2.4	0.8	1.0	6.3	2	2.7	2	370	19.075	
82F04	771056	11	457917	5445949		6	TJs	4	1.0	8.8	1100	10.0	79	5.5	120	19	6	4.9	52	0.2	1	54	78	7.3	18.0	2.1	1.1	1.2	10.0	2	5.5	3	200	7.154	
82F04	771057	11	460810	5446258		6	TJs	3	2.1	17.0	890	22.0	54	5.5	93	14	5	3.8	36	0.3	1	32	61	4.7	13.0	1.9	0.8	0.7	7.7	2	2.6	2	270	7.801	

1977 Field Observations and Analytical Results

																							Water		Stream Sediment														
MAP	SAMPLE ID	UTM ZONE	UTM EAST	UTM NORTH	STA	MED	FM	WAT COL	FLW	SED COL	SED PPT	CON	SED COMP	STRM WDTH	STRM DPTH	BNK	BNK PPT	PHY	DRN	TYP	ODR	SRC	DATE	FW 20 ppb ION	UW 0.05 ppb LIF	pH 0.1 GCE	Co 2 ppm AAS	Cu 2 ppm AAS	Fe 0.02 pct AAS	Pb 2 ppm AAS	Mn 5 ppm AAS	Hg 10 ppb AAS-F	Mo 2 ppm AAS	Ni 2 ppm AAS	Ag 0.2 ppm AAS	Sn 2 ppm AAS	W 4 ppm COLOR	U 0.2 ppm NADNC	Zn 2 ppm AAS	:DL :Uni :Mth
82F04	771058	11	461989	5445156		6	TJs	0	2	R	N	P	121	3.0	30	C	N	M	D	P	2	G	1106	44	0.02	7.9	9	28	2.20	16	440	20	1	20	0.1	1	2	2.7	102	
82F04	771059	11	461389	5443235		6	TJv	0	2	R	N	N	210	2.1	30	U	N	M	I	P	3	G	1106	58	0.02	8.1	12	32	2.65	11	480	10	1	14	0.1	1	2	3.4	76	
82F04	771060	11	461615	5450052		6	EKgd	0	2	W	N	P	210	1.2	30	C	N	M	I	P	3	G	1106	46	0.46	7.8	12	42	3.05	25	720	30	2	14	0.5	1	12	19.1	96	
82F04	771062	11	461384	5449856		6	EKgd	0	2	R	N	P	220	1.5	30	C	N	M	I	P	2	G	1106	62	0.46	7.6	9	24	2.55	21	520	30	2	16	0.2	1	2	14.9	78	
82F03	771063	11	465255	5445190		6	TJs	0	2	R	N	P	210	1.8	30	C	N	M	I	P	3	G	1106	44	0.02	7.9	16	44	3.55	9	700	10	1	20	0.1	1	2	2.2	86	
82F03	771064	11	466309	5448308		6	TJv	0	2	R	N	P	120	3.7	46	C	N	M	I	P	1	G	1206	36	0.10	7.5	10	30	2.20	7	365	10	1	14	0.1	1	2	3.1	60	
82F03	771065	11	465994	5451062	1	6	EKgd	0	2	R	N	P	220	3.0	46	C	N	M	I	P	3	G	1206	40	0.12	7.4	7	18	1.60	6	270	20	1	10	0.1	2	2	4.3	46	
82F03	771066	11	465994	5451062	2	6	EKgd	0	2	R	N	P	220	3.0	46	C	N	M	I	P	3	G	1206	34	0.02	7.4	8	20	1.75	7	310	20	1	10	0.2	1	2	4.6	52	
82F03	771067	11	465688	5450994		6	EKgd	0	2	R	N	N	121	3.0	30	C	N	M	I	P	4	G	1206	32	0.18	7.7	7	22	1.85	25	610	50	1	10	0.2	1	2	12.8	72	
82F03	771068	11	463907	5454724		6	EKgd	0	1	R	N	F	210	1.5	30	C	N	H	I	P	3	G	1206	32	0.12	7.4	7	26	1.70	21	445	30	1	14	0.3	1	2	6.7	72	
82F05	771069	11	462913	5457553		6	EKgd	0	2	R	N	F	120	1.5	30	C	N	H	I	P	4	G	1206	32	0.10	6.9	12	24	1.90	20	580	40	1	14	0.2	1	2	4.9	72	
82F03	771070	11	469485	5449022		6	TJs	0	2	R	N	P	121	1.8	15	C	N	H	I	P	3	G	1206	40	0.05	7.4	8	16	1.55	5	245	5	1	6	0.1	1	2	3.4	36	
82F03	771071	11	473988	5448932		6	TJs	0	2	R	N	P	121	1.2	15	C	N	H	I	S	4	G	1206	42	0.02	7.4	13	76	3.15	49	670	50	2	22	1.0	1	4	6.2	120	
82F03	771072	11	474067	5447641		6	TJs	0	2	R	N	N	121	1.2	15	C	N	M	I	S	4	G	1206	40	0.02	7.6	9	40	2.50	28	725	50	1	12	0.1	1	2	4.0	106	
82F03	771073	11	473419	5452449		6	TJv	0	2	R	N	P	121	1.2	15	C	N	M	I	P	4	G	1206	40	0.12	7.7	14	68	2.95	34	1000	50	1	14	0.6	1	2	8.1	148	
82F03	771074	11	475827	5447660		6	TJs	0	2	R	N	N	120	1.5	30	C	N	H	I	P	4	G	1206	30	0.02	7.7	10	34	2.60	17	600	30	1	12	0.1	1	2	2.2	86	
82F03	771076	11	476055	5450823		6	TJv	0	2	R	N	N	220	1.5	30	C	N	M	I	P	4	G	1206	52	0.02	7.7	16	58	3.65	45	865	40	3	32	0.4	1	2	3.2	345	
82F03	771077	11	474792	5452528		6	TJs	0	2	R	N	N	120	2.4	30	C	N	M	I	P	4	G	1206	52	0.02	7.6	17	68	3.50	38	850	30	1	28	0.3	1	2	2.9	245	
82F03	771078	11	473151	5454675		6	TJs	0	2	R	N	P	121	1.5	30	C	N	M	I	P	4	G	1306	32	0.02	7.5	16	64	3.35	57	640	40	1	24	0.1	1	5	3.7	150	
82F06	771079	11	471792	5455607		6	TJs	0	2	R	N	N	121	1.8	30	C	N	M	I	P	4	G	1306	30	0.10	7.3	8	48	2.30	53	540	40	1	10	0.2	1	8	6.1	150	
82F06	771080	11	469654	5457541		6	EKgd	0	2	R	N	N	121	3.4	30	C	N	M	I	P	4	G	1306	24	0.10	6.9	8	24	2.15	26	685	30	1	10	0.1	1	2	7.2	68	
82F06	771082	11	466696	5457144		6	EKgd	0	3	R	N	P	120	1.8	30	C	N	M	I	P	3	G	1306	22	0.02	7.0	11	28	1.50	28	555	40	1	10	0.1	1	2	7.3	56	
82F06	771083	11	466382	5456847	1	6	EKgd	0	2	R	N	P	022	1.5	30	C	N	M	I	P	3	G	1306	10	0.08	7.4	8	36	1.85	19	655	40	2	14	0.1	1	3	5.5	64	
82F06	771084	11	466382	5456847	2	6	EKgd	0	2	R	N	P	022	1.5	30	C	N	M	I	P	3	G	1306	10	0.08	7.4	9	42	2.05	16	645	40	2	14	0.1	1	2	5.0	60	
82F06	771085	11	473623	5459831		6	EKgd	0	3	R	N	F	120	2.7	46	T	N	M	D	P	4	G	1306	10	0.02	7.3	17	64	2.65	7	730	30	1	30	0.1	1	2	4.7	54	
82F06	771086	11	473914	5459607		6	EKgd	0	3	R	N	F	121	1.5	30	C	N	M	I	P	4	G	1306	10	0.02	7.5	18	58	3.05	13	640	20	1	22	0.1	1	2	2.8	76	
82F06	771087	11	467581	5462989		6	EKgd	0	3	R	N	N	021	3.0	30	C	N	M	I	P	4	G	1306	10	0.05	7.1	11	22	2.25	28	520	40	1	24	0.1	1	4	7.8	84	
82F06	771088	11	469418	5462353		6	EKgd	0	3	R	N	P	120	3.0	30	C	N	M	I	P	4	G	1306	10	0.10	6.7	6	12	1.60	4	280	10	1	6	0.1	1	3	2.9	38	
82F06	771089	11	469403	5462029		6	EKgd	0	3	R	N	N	121	3.7	46	C	N	M	D	P	4	G	1306	10	0.18	7.1	11	28	2.70	40	520	30	1	22	0.2	1	6	14.9	72	
82F06	771090	11	477765	5464585		6	TJv	0	3	R	N	N	120	3.4	30	T	N	M	I	P	4	G	1406	10	0.05	7.0	13	50	2.80	19	615	30	1	20	0.1	1	10	5.9	70	
82F06	771091	11	479680	5464101		6	JF	0	3	R	N	N	120	3.0	30	C	N	M	I	P	4	G	1406	10	0.02	7.3	15	56	2.95	8	545	20	1	24	0.3	1	2	2.4	132	
82F06	771092	11	479587	5463555		6	JF	0	3	R	N	N	120	4.3	46	T	N	M	D	P	3	G	1406	10	0.02	7.5	16	60	2.70	6	465	60	1	24	0.1	1	2	2.3	80	
82F06	771094	11	482276	5463771		6	JF	0	3	R	N	N	120	4.9	61	C	N	M	D	P	4	G	1406	10	0.02	7.5	14	52	2.70	3	295	30	1	26	0.1	1	2	2.8	186	
82F06	771095	11	483928	5458167		6	TJv	0	2	R	N	N	211	1.8	30	C	N	H	I	P	3	G	1406	140	0.08	7.6	17	74	3.45	72	755	40	17	42	0.1	1	12	7.1	400	
82F03	771096	11	480262	5454960		6	JF	0	2	R	N	N	121	2.1	30	C	N	H	D	P	3	G	1406	74	0.02	7.8	18	66	3.85	37	850	20	6	38	0.2	1	3	2.8	405	
82F06	771097	11	483463	5462879		6	TJv	0	2	R	N	N	022	1.2	15	C	N	M	I	P	4	G	1506	58	0.02	7.9	18	102	2.60	21	890	60	1	104	0.2	1	2	4.7	72	
82F06	771098	11	483084	5465506		6	TJv	0	2	R	N	N	121	1.5	30	C	N	M	I	P	4	G	1506	10	0.02	7.9	16	68	2.45	13	615	40	1	22	0.1	1	2	2.0	62	
82F06	771099	11	484027	5456260		6	TJv	0	2	R	N	N	121	1.2	15	C	N	M	I	P	4	G	1506	120	0.02	7.4	24	166	2.85	41	1000	70	5	330	0.4	1	20	3.8	425	
82F06	771100	11	479646	5455841		6	JF	0	3	R	N	N	121	1.8	30	C	N	M	D	P	3	M	1506	64	0.02	7.4	18	64	3.45	26	715	40	4	30	0.1	1	2	2.2	265	
82F06	771102	11	480436	5459324		6	JF	0	3	R	N	F	121	2.7	30	C	N	M	I	P	4	G	1506	54	0.02	7.4	17	52	3.10	50	680	30	2	26	0.2	1	2	2.2	194	