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B.C. REGIONAL GEOCHEMICAL SURVEY ANOMALY RECOGNITION, AN EXAMPLE USING CATCHMENT BASIN ANALYSIS (103I, 103J)

By Paul Matysek and Wayne Jackaman

KEYWORDS: Regional Geochemical Survey, geographic information system, catchment basins, stream sediment, stream water, Nass River.

INTRODUCTION

Since 1976, the Regional Geochemical Survey Program (RGS) has presented stream sediment and water geochemistry data by grouping the data values into distinct percentile ranges and plotting symbols that represent the range. These symbol maps have been useful for the quick appraisal of regional trends and clustering of data. However, they do not account for the considerable variability in trace element concentration encountered with different lithologies. Beginning in 1990, a number of methodologies for integrating bedrock geology with stream sediment geochemistry using a geographic information system (GIS) were examined (Bartier and Keller, 1991; Sibbick, 1994; Jackaman *et al.*, 1995). They concluded that using the catchment basins of each sample site to define its zone of influence (Bonham-Carter and Goodfellow, 1986; Bonham-Carter *et al.*, 1987) provided a logical means for integrating bedrock geology and stream sediment geochemistry. As a result, this method can be used to:

- Reclassify the geological influence on each sample based on its source area.
- Redefine the thresholds which separate anomalous from background populations.
- Define metal concentrations in basins hosting known mineral occurrences.
- Define the actual coverage of a survey.

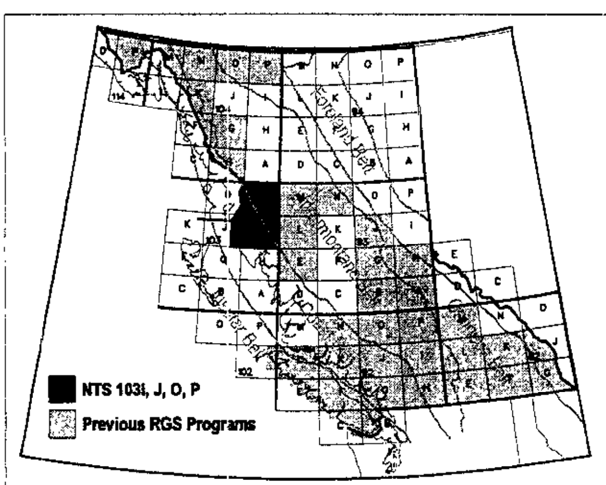

Figure 1. Location map of RGS programs.

RGS open file data packages B.C. RGS 42 (NTS map sheets 103I and 103J) and B.C. RGS 43 (NTS map sheets 103O and 103P) released on June 2, 1995 incorporated catchment basins to improve data integration with other polygonal and point geoscience databases, as well as enhance geochemical patterns and trends on hard-copy maps (Matysek and Jackaman, 1995, Jackaman and Matysek, 1995). Using data from open file B.C. RGS 42 and existing GIS technologies, this paper will present an example of how stream sediment geochemistry can be integrated with digital catchment basins, MINFILE data and bedrock geology to identify and interpret RGS anomalies.

BACKGROUND

SURVEY SUMMARY

Open file B.C. RGS 42 presents field and analytical data from a 1978 joint federal-provincial stream sediment and water survey conducted in the Terrace (103I) and Prince Rupert (103J) map areas (Figure 1). Stream sediment and water samples were systematically collected from 2128 sites at an average density of one site per 8 square kilometres. The original open file, published in 1979, included analytical determinations for 13 metals in stream sediments and uranium, fluoride and pH in stream waters. In the early 1990s the archived sediment pulps were analyzed using instrumental neutron activation for gold and 25 other metals. This new, previously unreleased information, together with original field and analytical data was released as part of open file B.C. RGS 42 on June 2, 1995. This was the first time that digital catchment basins were included with the release packages.

CATCHMENT BASIN DELINEATION

Catchment basins are defined by the topographic height of land that separates a stream from surrounding streams. The resulting polygons are assumed to represent the metal determination of a single stream sediment or water sample collected at the outlet of the catchment basin. For map sheets 103I and 103J, a total of 2128 catchment basins were delineated from NTS 1:50 000 maps by hand tracing basin polygons onto mylar overlays.

The resulting polygons were digitized, with each polygon labeled to correspond to its unique RGS sample number. On occasion, nested polygons were produced where two samples were taken from successive sites on the same stream; in these cases the downstream polygon was defined to end at the upstream sample site. The corresponding RGS data were joined to each digital polygon record for interpretation. Areas of each polygon, polygon perimeter and percentage coverage of underlying basin formations were calculated using simple GIS subroutines and are included in the data listings of the open file.

This technique is a discrete polygon method and therefore assumes within-polygon uniformity of the geochemistry. However, within a basin, various other physical factors may influence the composition of the stream sediment sample or contribute to within-basin variation. These include variations in bedrock geology, slope, aspect, curvature, vegetation, differential weathering of bedrock, rainfall and wildlife. There are also factors that transcend drainage basin boundaries. Geological material from beyond the catchment boundary may be present due to glacial transport or anthropogenic pollution. These factors should be considered when interpreting catchment basin data.

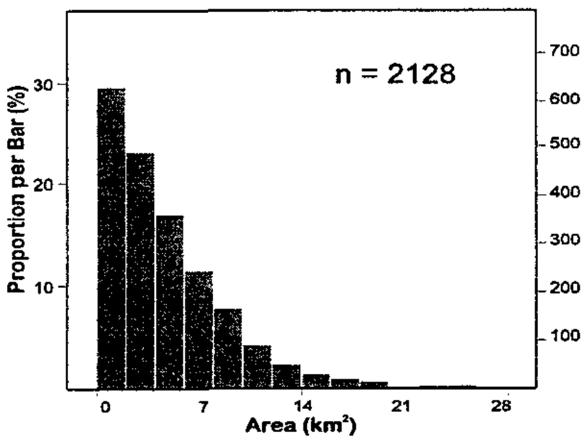

Figure 2. Histogram showing catchment basin areas for map sheets 103I and J.

CATCHMENT BASINS AND RGS DATA INTEGRATION

CATCHMENT BASIN AREAS

A histogram of catchment basin areas for map sheets 103I and 103J is shown in Figure 2. Catchment basin areas range from less than 1 square kilometre to 40 square kilometres, with a mean area on the order of 5 square kilometres. The modal area of the catchments falls within 1 to 2 square kilometres. Of the 2128 RGS sites, 1327 have drainage basins that cover an area of 5 square kilometres or less. Area coverage of the RGS catchments totals 10 254 square kilometres or 62% of the land area. The remaining unsurveyed 38% represents glaciers, coastal areas lacking well-defined drainage basins, broad valleys or, more importantly, drainages bounded by surveyed catchments that were intentionally excluded from the sampling program. Exclusion of a catchment basin from the survey is a reflection of the intended sampling density of the RGS program. Designed to provide cost efficient regional geochemical data, the RGS program does not define the geochemistry of every first or second order stream within a map area. As a result, mineral occurrences in unsurveyed catchments may be missed. Examination of regional anomalies or subtle geochemical patterns in drainages that bound these unsurveyed areas may help to identify mineralized catchments.

GEOCHEMICAL PATTERNS AND CATCHMENT BASINS

Figures 3 and 4 depict the gold and copper concentrations and associated mineral occurrences recorded in the MINFILE database within sampled catchment areas. These maps illustrate the power of using catchment basins for portraying regional geochemical trends and, in this particular case, identifying and discriminating prospective catchment basins which have high percentile concentrations of gold and copper and contain no recorded mineral occurrences.

GEOLOGICAL INFLUENCE

In previous RGS open files, every RGS sample site was coded on the basis of underlying geology at the sample site. This coding was used to calculate univariate statistics for each element and for the determination of thresholds. Unfortunately, classification of the sample site by its underlying geology may not accurately represent the site and may result in the misidentification of anomalies. This is especially significant where there are two or more geochemically different formations within a catchment basin. As a result, the number and the area of formations within each RGS catchment basin was determined using a geological basemap compiled by MacIntyre *et al.* (1994). Of the 2128 RGS catchments in map sheets 103I and 103J, 51% are underlain entirely by a single formation (*e.g.*, Paleocene granodiorites, N = 142; Paleozoic leucogneiss and migmatites, N = 139; and dacitic pyroclastic rocks of the Telkwa Formation, N = 124), 38% are underlain by two formations and 11% by three or more formations.

REFINED THRESHOLD VALUES

Univariate statistics were calculated on the total dataset and subsets of ten or more catchment basins underlain by a single formation. Percentiles, means, medians and standard deviations have been provided to assist in determining threshold concentrations. For example, mean copper concentration in the 103I and 103J RGS catchment basins is 27 ppm. Possible thresholds using the

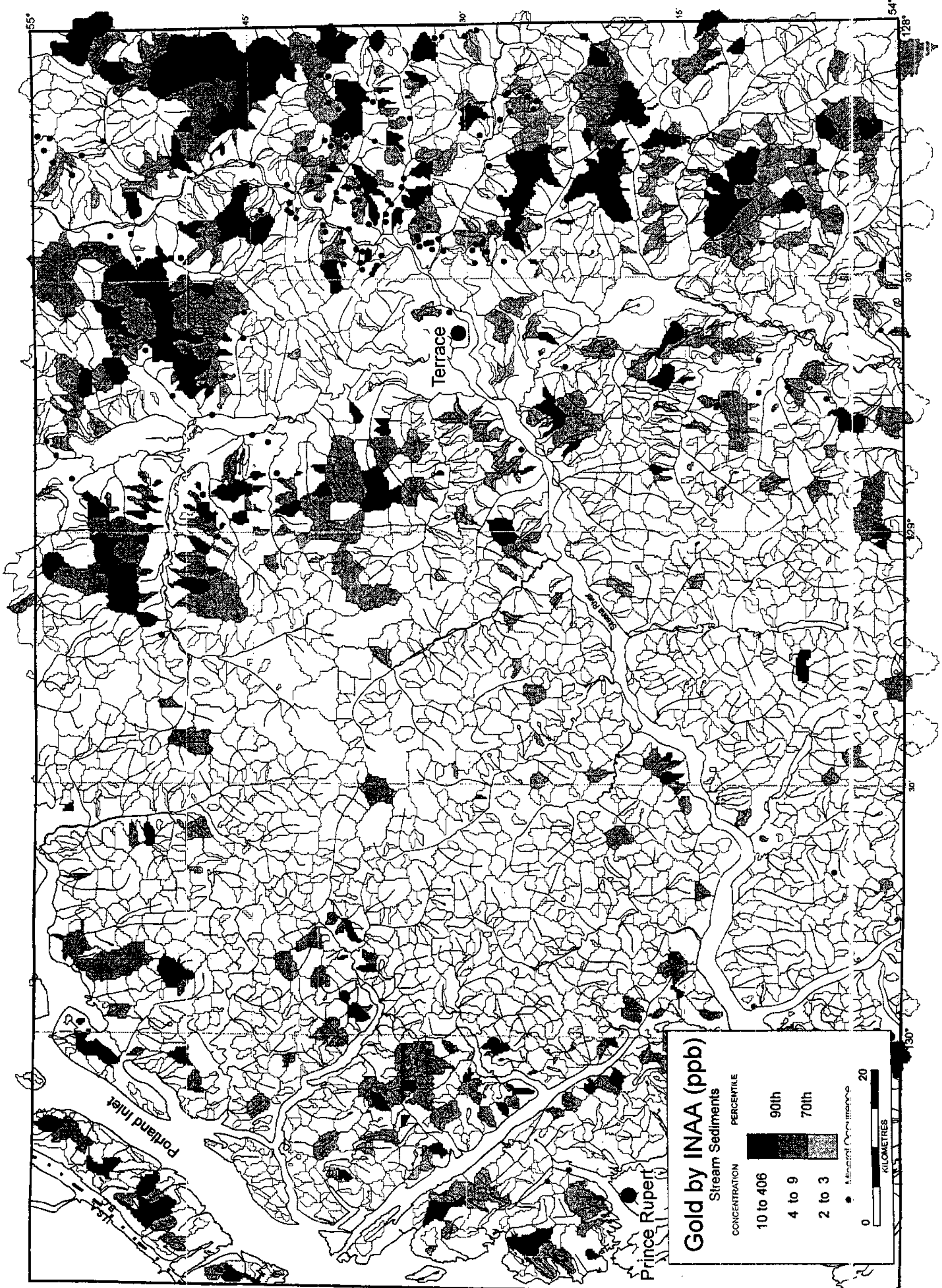

Figure 3. Distribution of gold in stream sediments and the location of known gold occurrences.

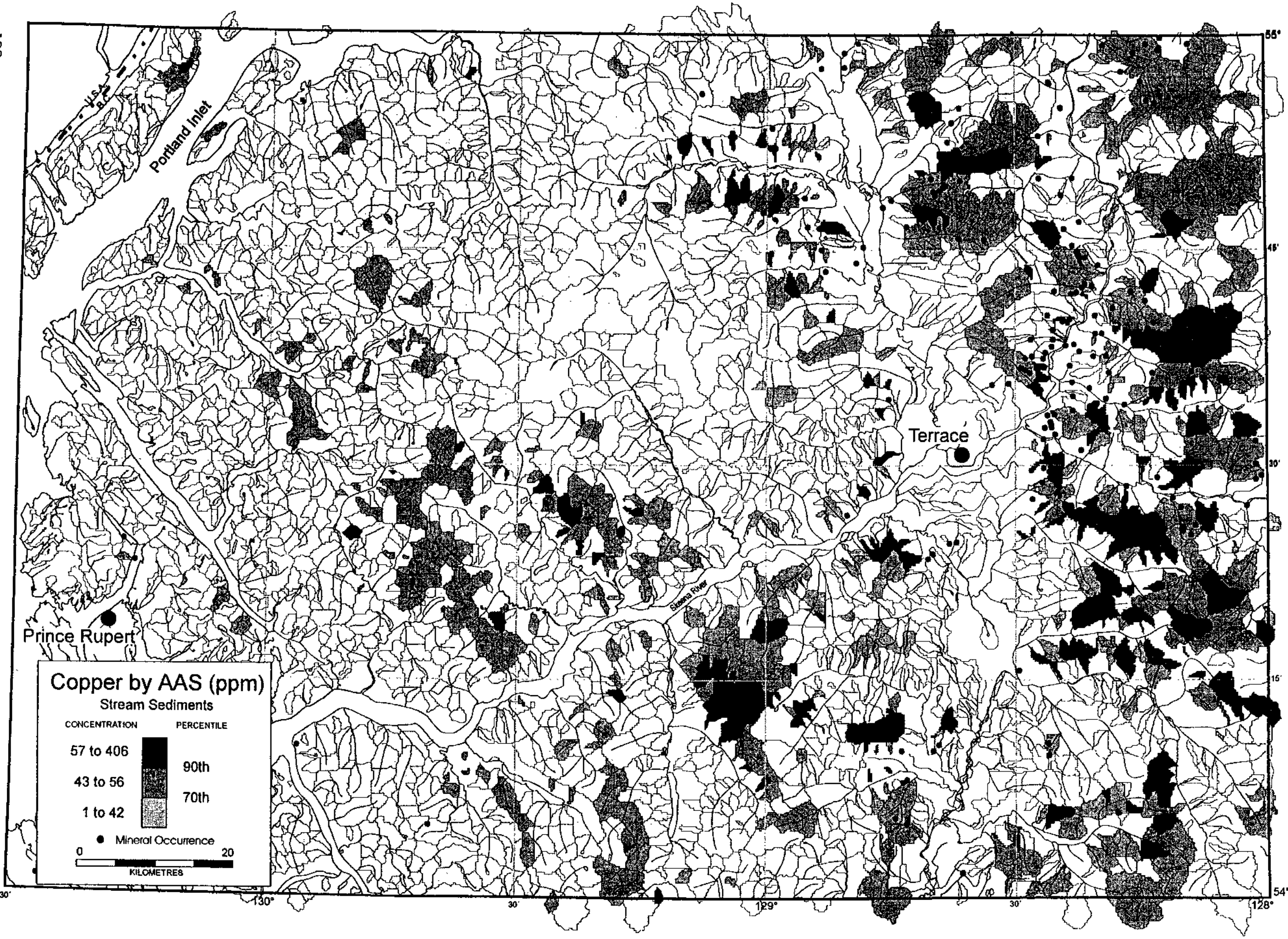

Figure 4. Distribution of copper in stream sediments and the location of known copper occurrences.

mean plus two standard deviations are 81 ppm, or 72 ppm using the 95th percentile concentration. More reliable estimates of background and threshold values can be obtained for basins underlain by a single formation. For example, copper concentrations in homogeneous Paleocene granodiorite catchment basins average 13 ppm while the mean plus two standard deviations concentration is 26 ppm, and 36 ppm at the 95th percentile. In contrast, copper in homogenous Telkwa Formation basins averages 56 ppm with a mean plus two standard deviations concentration of 123 ppm and a concentration of 148 ppm at the 95th percentile concentrations. The presence of multiple formations within a catchment basin presents another challenge for establishing thresholds. Multiple linear regression methods have been used by Bonham-Carter and Goodfellow (1986) and Bonham-Carter *et al.* (1987) to correct for the areal proportions of geologic units within a catchment area.

TABLE 1. MEDIAN CONCENTRATION OF SELECTED TRACE ELEMENTS IN RGS CATCHMENT BASINS CONTAINING SHOWINGS OR PROSPECTS WITH GOLD (N=60) AND FOR THE TOTAL 103I/J DATASET (N=2120)

N	Cu ppm	Pb ppm	Zn ppm	Hg ppb	Au ppb	Sb ppm	As ppm
60	44	5	88	20	5	1.2	7.2
2120	20	2	44	20	2	0.2	1.1

Characterization of Trace Element Concentrations Downstream from Mineral Occurrences

Of the 137 reported mineral occurrences containing gold, 73, or 53%, fall within RGS catchment basins (MINFILE 103I, 1989; MINFILE 103J, 1989). Ten of these are past producers, three are developed prospects, six are prospects and 54 are showings. Similarly, of the 150 reported occurrences with copper, 111, or 74%, fall within RGS catchment basins. Ten of these are past producers, four are developed prospects, eleven are prospects and 86 are showings.

In order to characterize the stream sediment trace element distributions downstream from mineral occurrences, statistics for RGS basins containing known occurrences were calculated. Basins that contain past producers or developed prospects were not included because of the high probability of contamination due to development work. For example, mean gold values for RGS catchments with occurrences classified as showings or prospects containing gold are 21 ppb, almost two times higher than the total dataset mean. Seven catchments returned values greater than 20 ppb, with the highest concentration being 406 ppb gold. However, approximately 28% returned detection limit values (2 ppb), probably reflecting the problems associated with the particle scarcity effect. Similarly, mean copper values for RGS catchments containing showings or prospects with copper are 59 ppm, two times higher than the total dataset mean. Eleven catchments returned values greater than 100 ppm copper, with the highest concentration being 420 ppm.

Median values of associated trace elements in RGS basins can be used to characterize multi-element signatures and identify prospective basins. For example, by applying selected trace element median concentrations obtained from RGS basins containing showings or prospects with gold (Table 1) to the entire database for all the metals, 22 RGS catchment basins were identified (Table 2) that exceeded the listed median values and contained no recorded mineral occurrences. As of November 1, 1995, 16 of the 22 prospective basins were open to staking. Table 1 also lists the medium value concentration of the selected trace elements for the total 103I/J dataset.

TABLE 2. PROSPECTIVE RGS BASINS

Map	ID	Cu ppm	Pb ppm	Zn ppm	Hg ppb	Au ppb	Sb ppm	As ppm	Claim Status
103I15	781115	46	7	116	40	308	1.2	13.0	partial
103I15	781133	52	20	114	30	6	1.5	19.0	open
103I15	781142	64	17	130	70	30	1.3	45.0	open
103I10	783118	66	7	138	110	12	1.5	44.0	open
103I14	783126	48	7	98	40	67	1.4	33.0	open
103I15	783142	48	32	154	40	15	2.7	174.0	open
103I15	783143	54	17	102	130	38	1.4	33.0	open
103I16	785036	52	28	194	30	7	2.9	75.5	reserve
103I16	785051	48	10	158	80	6	1.5	15.0	reserve
103I09	785072	56	6	92	70	8	1.9	10.0	open
103I09	785132	142	14	100	50	6	2.6	9.0	open
103I09	785137	200	32	186	60	14	2.8	23.0	staked
103I09	785146	74	26	102	60	14	2.2	8.6	open
103I10	785471	68	16	120	30	9	1.8	95.8	open
103I15	785550	54	10	126	30	24	1.6	26.0	open
103I16	785560	54	46	196	70	37	4.7	65.3	open
103I09	785623	88	16	230	30	6	1.2	44.0	staked
103I16	785710	84	31	108	50	12	2.2	58.6	open
103I15	785715	126	60	118	30	18	2.1	38.0	partial
103I16	785724	54	10	110	40	46	1.5	28.0	open
103I15	787790	114	16	310	60	11	2.8	60.9	open
103I15	787794	58	9	158	40	8	1.4	30.0	open

CONCLUSIONS

Desk-top GIS technologies, combined with an increasing availability of digital geoscience data, have become an extremely powerful mineral exploration tool. The integration of digital catchment basins, MINFILE and bedrock geology with stream sediment geochemistry is a practical example of how this tool can be used to identify and evaluate RGS anomalies which may be worthy of follow-up investigation.

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