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Rapid Hydrogeochemistry: A summary of two field studies from central and southern interior British Columbia, Canada using a photometer and voltammeter to measure trace elements in water

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Introduction

In this paper we informally define 'rapid hydrogeochemistry' as the field analysis of water for trace elements within 48 hours of sample collection using portable devices and producing data that approach the reliability and detection limits available from commercial laboratories. Portable and bench-top photometers and voltammeters for the analysis of trace elements in water are commercially available, but until recently these devices have not been applied to mineral exploration. Historically they have been used for testing swimming pool water, single analyte environmental testing, and for geothermal exploration (Yehia *et al.* 2013).

Taufen (1997) and Leybourne & Cameron (2010) previously demonstrated the value of hydrogeochemistry as a mineral exploration technique. Encouraged by these examples, two Geoscience BC funded field studies were carried out in 2014 and 2016 to test the practicality and capability of photometers and voltammeters for detecting hydrogeochemical anomalies associated with mineral occurrences in the central and southern interior of British Columbia (BC), Canada. Results of these studies are reported in Yehia & Heberlein (2015), and Yehia *et al.* (2017), and are summarized in this article. In 2014, water samples were collected in August and October from streams and springs draining a porphyry Cu-Mo deposit exposed on the eastern flank of Poison Mountain. In June 2016, a regional-scale hydrogeochemical survey covering 900 km^2 was carried out in the glaciated and mostly till-covered area near Nazko in central BC (Fig. 1). Sampling was repeated in August and October of the same year to study seasonal variations. The Nazko survey area includes two known Cu-Au mineral occurrences: Fishpot and Bob (BC Mineral Inventory – MINFILE # – 093B 066 and 093B 054).

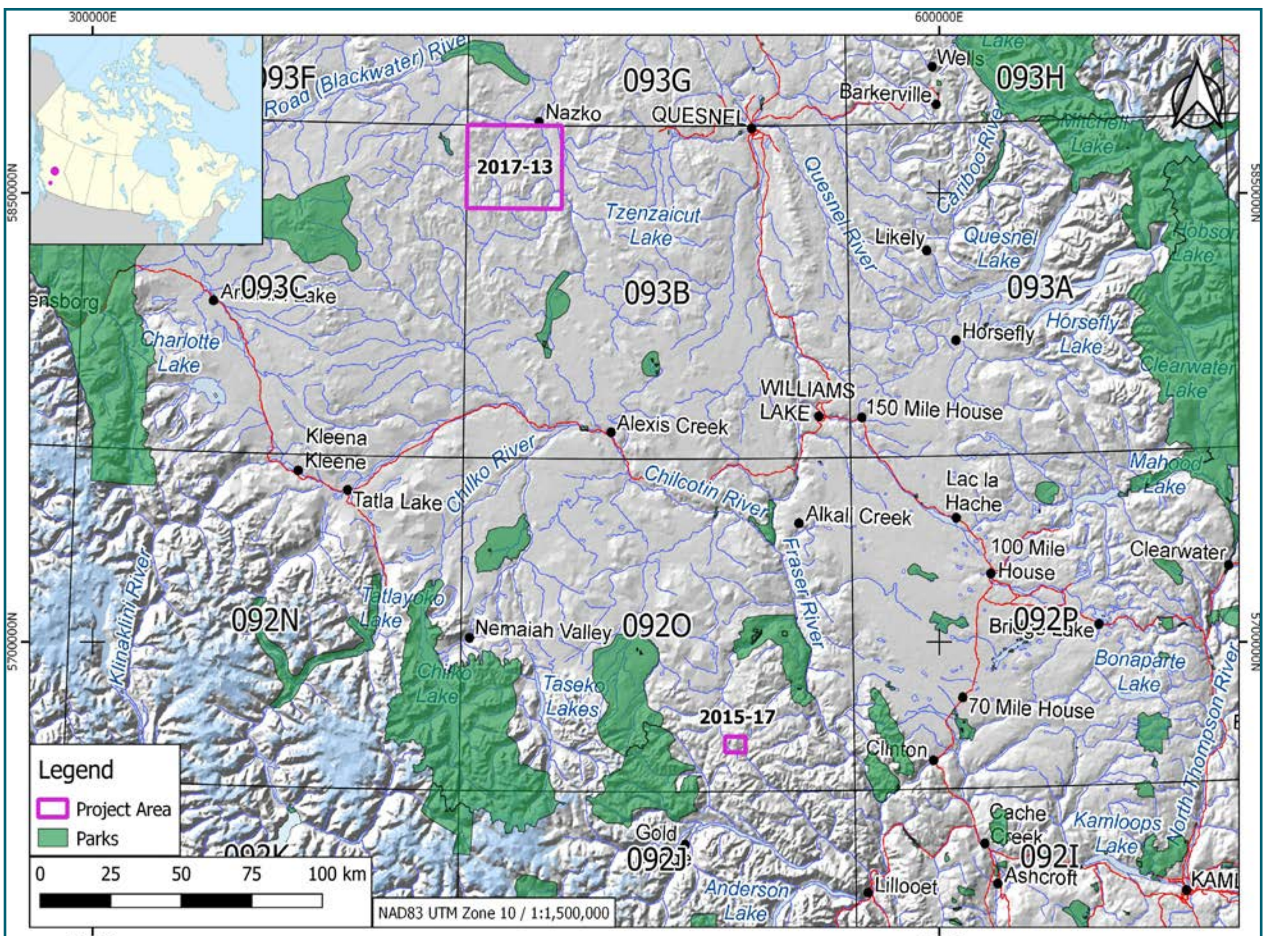

Figure 1. The location of two rapid hydrogeochemistry projects in British Columbia, Canada.

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Quarterly newsletters are published in March, June, September, December

Deadlines for submission of articles or advertisements:
March newsletter: January 15
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Manuscripts should be double-spaced and submitted in digital format using Microsoft® WORD. Articles should be between 2000 and 3000 words. Do not embed figures or tables in the text file.

Figures and/or photos (colour or black and white) should be submitted as separate .eps files. Alternate file formats include high resolution (2400 dpi or higher) tiff, jpeg or PDF files.

Tables should be submitted as separate digital files in Microsoft® EXCEL format.

All scientific/technical articles will be reviewed. All contributions may be edited for clarity or brevity.

Formats for headings, abbreviations, scientific notations, references and figures must follow the *Guide to Authors for Geochemistry: Exploration, Environment, Analysis* (GEEA) that are posted on the GEEA website at: https://www.geolsoc.org.uk/geea-authorinfo

An abstract of about 250 words must also be submitted that summarizes the content of their article. This abstract will be published in the journal ELEMENTS on the 'AAG News' page.

Submissions should be sent to the Editor of **EXPLORE**:
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ADVERTISERS

Notes from the Editor

Welcome to the third **EXPLORE** issue of 2019. This issue features two articles. The first describes the use of rapid geochemical techniques for water analysis in the field, tested in British Columbia, Canada and was written by Ron Yehia, Dave Heberlein, and Ray Lett. The second article explains why geochemists use -80 mesh as a size fraction for geochemical analysis and was written by Bob Garrett. This issue also features a report on the Mexican Geological Survey by our new AAG Regional Councillor for Mexico, Tomás Grijalva.

EXPLORE thanks all those who contributed to the writing and/or editing of this issue, listed in alphabetical order: Steve Amor, Dennis Arne, Al Arsenault, John Carranza, Steve Cook, Travis Ferbey, Bob Garrett, Tomás Grijalva, Stew Hamilton, Dave Heberlein, David Leng, Ray Lett, Mike Parkhill, Steve Smith, Brian Townley, and Ron Yehia.

Beth McClenaghan
Editor

President's Message

By the time you are reading this, my penultimate message as President of the AAG, you will have received my recent letter soliciting nominations for election to AAG Council for the upcoming 2020-2021 term. The approaching Council term is a particularly significant one given that it will coincide with the 50th anniversary of the founding of the Association in 1970 as the Association of Exploration Geochemists (AEG). Note, the AEG became the AAG in 2003. The Council term also coincides, more generally, with a figurative 'passing of the torch' from that founding generation of exploration geochemists and their successors, to a new generation of applied geochemists who will steer our discipline into the next half-century.

This brings me to the main point of my message, which is to highlight the importance of service to our geochemical community in achieving the above. The AAG is a volunteer organization, relying on geochemists to volunteer their time and energy to staff the Executive, the Council, and the slate of Regional Councilors around the world. The planning and running of Symposia, the funding and teaching of educational workshops and the peer review of scientific papers are just a few of the many collaborative activities of the global geochemical community which would not be possible in the absence of our dedicated volunteers - past, present and future. Of course many individual benefits also accrue from such service, as the opportunity to meet and work with our many talented colleagues around the world helps us to grow and develop as scientists.

So what is required to serve on AAG Council? Simply, you must be a Fellow in good standing with the Association. If you are an AAG Member with at least six years of post-Bachelors degree experience, I urge you to submit your application for Fellowship at the first opportunity. Full details of the requirements are available at the AAG website. Becoming a Fellow is a relatively simple procedure and will put you in a position to help influence the activities of the AAG over the coming years and decades. A broad slate of candidates for election to Council each year ensures that the membership has the opportunity to select a capable and diverse group of men and women to guide AAG activities. It is also a sign of a healthy organization, where individuals are prepared to work together for the common good of geochemistry, wherever we may call our home in the world.

To sum up, I urge all Fellows to consider putting their names forward for election to AAG Council for the upcoming 2020-2021 term. Councilors serve a term of two years, and may then stand for election to a second two-year term. Half of the Council seats come up for re-election every year, providing continuity on Council from one year to the next. Serving on Council also provides the experience to potentially serving on the Executive, as President or in one of the other Executive positions, where one can play a guiding role in the Association. Many notable geochemists from industry, government and academia have served terms as President and Vice-President of the Association over the past half-century. Many of these have been giants of our discipline who have made significant contributions to applied geochemistry in all its forms. Bill Coker and Stan Hoffman, who have since died, are examples of two distinguished former AAG Presidents who played significant roles in my own education as a geochemist over the years.

As a final note, it is with considerable sadness that I must pass along news of the tragic death of Peter Winterburn in Chile in June. Peter was an accomplished scientist in mineral exploration and academia, and a good friend to many. He had recently returned to Santiago to rejoin Vale after several years as Professor of Exploration Geochemistry at the Mineral Deposit Research Unit (MDRU) at The University of British Columbia in western Canada. The AAG extends its most sincere condolences to Peter's family. We will provide further details on his life and accomplishments in the next issue of **EXPLORE**.

Stephen Cook, *President*

Rapid Hydrogeochemistry: A summary of two field studies… *continued from page 1*

Table 1. Summary of field and quality control samples.

Report	Field samples	Field duplicates	Analytical duplicates	Deionized water blanks	SLRS-6 standard	ALS Environmental Laboratory checks
2015-17	79	8	NA	2	NA	40
2017-13	171	9	9	10	10	23
Total	250	17	9	12	10	63

Methods

Table 1 lists the number of water and quality control samples collected during each campaign as well as samples analysed by a commercial laboratory. Samples were collected from mid-stream into #2 high-density polyethylene (HDPE) bottles and tested within 48 hours. Manufacturer's requirements state that no filtration is necessary as both devices test for dissolved constituents. As well, acidification is not required if tests are performed immediately or as soon as possible after sampling. For longer wait times needed for voltammeter tests, acidification is recommended. Samples were stored in plastic bottles in coolers. Refrigeration was not required. The primary portable analytical instrument used in both studies was the Palintest® Photometer 8000 (Fig. 2). The instrument measures the absorbance and transmittance of light through metal-colour complexes at different light wave lengths (e.g., 500 nm) to determine element concentration.

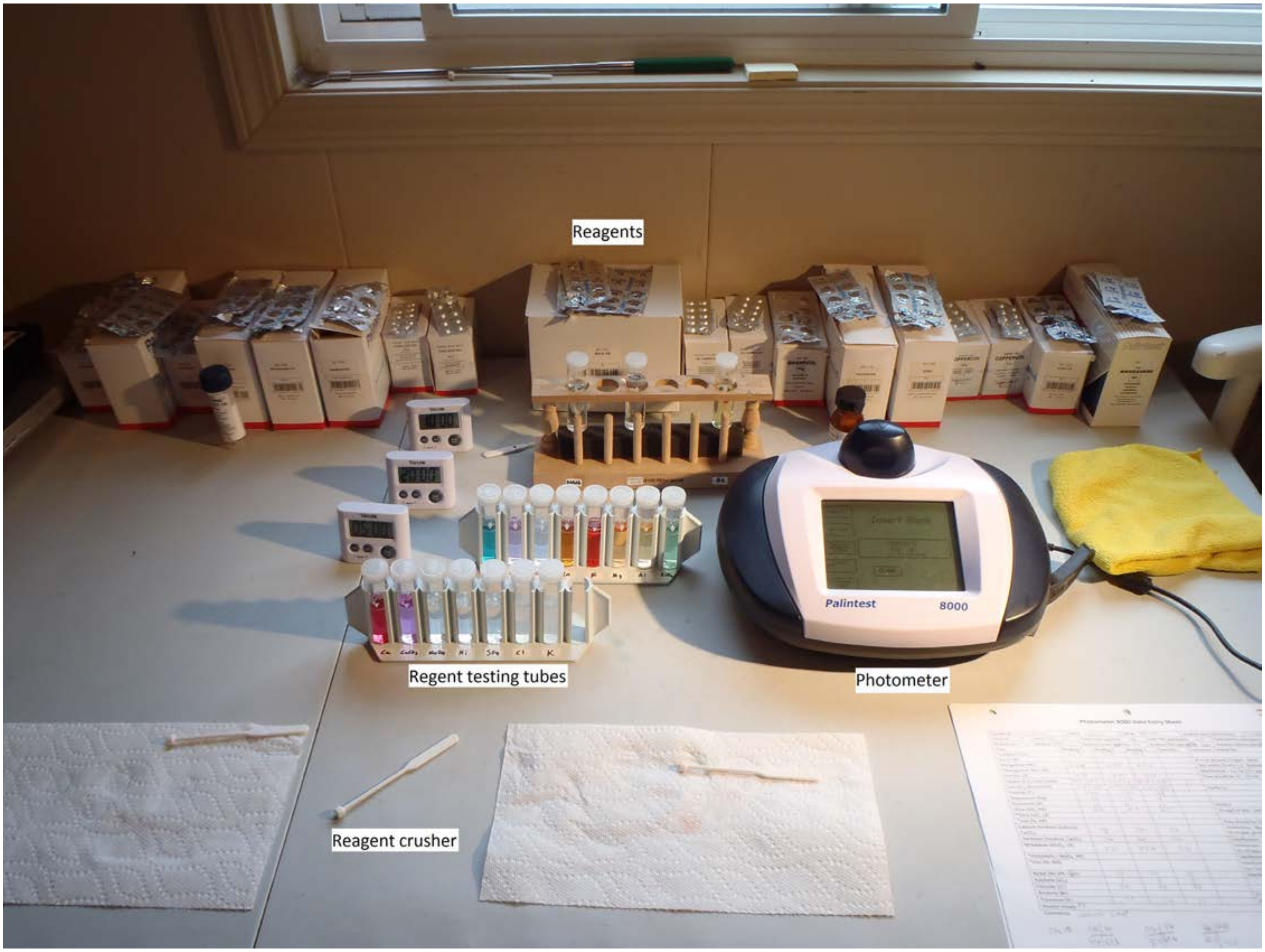

Figure 2. Photograph showing a typical set-up for 2016 photometer analysis of water samples for trace elements in a field laboratory. The reagents are in silver packages at the top of the photograph. Water samples with reagents added ready for analysis are in the 10 ml tubes held in the racks. The photometer is in the centre right.

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Rapid Hydrogeochemistry: A summary of two field studies... *continued from page 5*

In addition to the photometer, the 2016 study also included the use of the Modern Water PDV6000*Ultra* voltammeter (Fig. 3). The voltammeter uses anodic stripping voltammetry (ASV) to measure the ionic concentration of metals such as Cu, As, Pb and Cd in water by applying a negative (reducing) potential for 60 seconds to the electrodes to deposit (i.e., reduce) the metal onto the electrode surface. When metal has been deposited, the metal is then stripped (oxidized) off the electrodes by increasing the potential at a constant rate. As the metal ions are released, a current is generated, which is plotted on a "voltammogram" where the analyte concentration is displayed as a function of current (voltammogram peak height on a y axis) and voltage at a specific metal oxidation potential (along the x axis). The use of field portable anode stripping voltammeters for water analysis has been described previously by Hall & Vaive (1992). Tables 2 and 3 compare the portable instrument detection limits with those of the chosen commercial laboratory.

Figure 3. Photograph from 2016 study showing the portable voltammeter set-up. The instrument is resting on top of the yellow case, and the cell containing the test electrodes and the water sample rest on a holder just above the case handle. Laptop is not required for voltammeter operation.

Table 2. Photometer reagent detection limits.

Photometer	Palintest instrument numerical detection limit (mg/l)	ALS Environmental Laboratory detection limit (mg/l)
Aluminum (Al)	0.01	0.001
Calcium hardness (Calcicol[1])	1	1
Chloride (Cl^-, Chloridol[1])	0.1	0.5
Copper (Cu, Coppercol[2], free and total[2])	0.01	0.0002
Hardness (Hardicol[2], total)	1	1
Iron (Fe)	0.01	0.01
Magnesium (Mg)	1	0.1
Manganese (Mn)	0.001	0.0001
Molybdate (MoO_4)	0.01	0.000050 (Mo)
Nickel (Ni)	0.01	0.0005
Potassium (K)	0.1	0.05
Silica (High Range, SiO_2)	0.1	0.5
Sulphate (SO_4)	1	0.3
Zinc (Zn)	0.01	0.001

[1] Calcicol, Chloridol, Coppercol and Hardicol are Palintest terminology for proprietary reagents.
[2] Free copper – Palintest terminology for dissolved Cu.

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Table 3. Voltammeter reagent detection limit.

Voltammeter	Modern Water published typical DL in clean water (mg/l)	ALS Environmental Laboratory detection limit (mg/l)
Arsenic (As)	0.0005	0.0001
Copper (Cu)	0.0005	0.0002
Cadmium (Cd)	0.0005	0.000005
Lead (Pb)	0.0005	0.00005

Data Quality

An important component of both studies was quality control and assessment of the dependability of the analytical results. Quality control procedures included analysis of manufacturer's standard colour solutions to monitor instrument accuracy and drift and the use of field duplicate and analytical replicate samples to monitor precision and analytical error. Three Palintest certified standard calibration solutions were measured at the beginning of each day before routine sample analysis. Calibration results demonstrated acceptable accuracy; no test fell outside the manufacturer's recommended margin of error of ±2%. For the Modern Water voltammeter, accuracy was monitored using a manufacturer's calibration standard that was analyzed in triplicate before sample testing. Acceptable accuracy is defined as all three determinations falling within ±5% mV range.

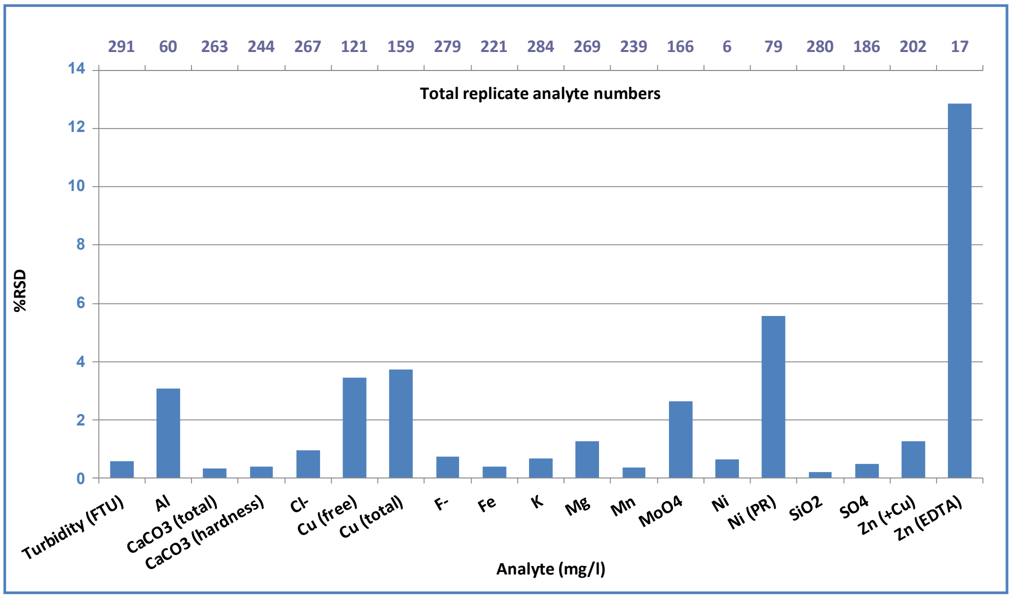

Figure 4. Percent RSD value estimates from triplicate photometer readings for the combined 2015 and 2017 results.

During initial photometer testing prior to the 2014 study, it was observed that on occasion repeated photometer readings displayed small variations. Therefore, triplicate analysis of each sample was instituted as part of the standard operational procedure to quantify analytical precision (expressed as percent relative standard deviation or %RSD). Analytical precision for the two sampling campaigns are presented in Figure 4. The results show that %RSD values for most analytes are below 6%, confirming the precision of the analytical method. Zn (EDTA) has a slightly higher but still acceptable value of 13%.

Overall precision calculated from photometer field duplicate results is presented in Figure 5. The %RSD values are well within acceptable precision levels for exploration samples. The best results are for SiO_2, (5.42%), $CaCO_3$ (~8.0%), and Mn (6.15%) while the poorest precision was for Cl^- (32.03%). The photometer has larger %RSD values than the commercial laboratory because of its higher detection limits and lower display resolution.

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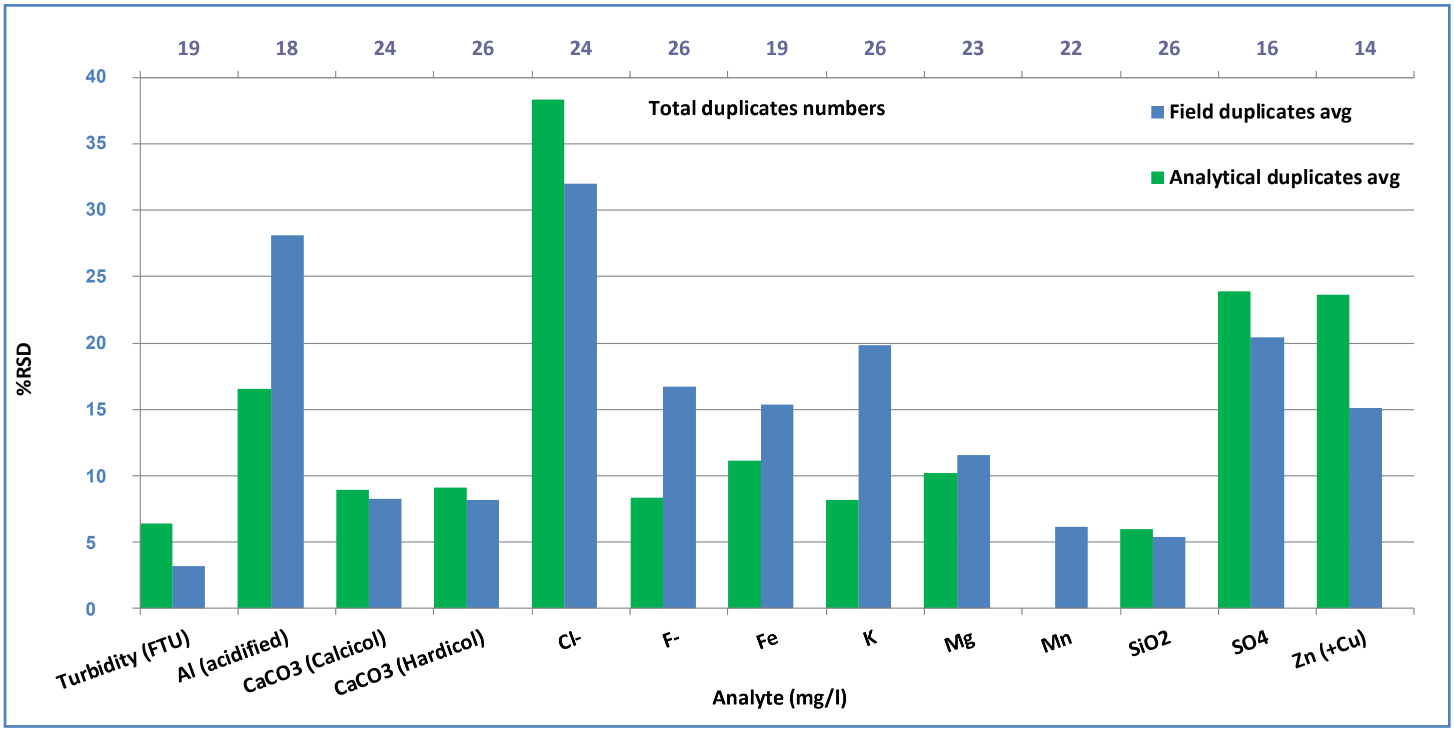

Figure 5. A summary of Photometer field and analytical precisions for the combined studies.

Only one field and analytical duplicate was measured by the voltammeter, which was insufficient to determine the %RSD. Voltammeter precision estimated from replicate analysis produced %RSD values of 9.00% for As (6 repeat analyses), 9.94% for Cu (15 repeat analyses), and 3.82% for Pb (2 repeat analyses), which are reasonable for duplicates. As part of the 2016 quality control procedures, Natural Research Council (NRC) Canada river water certified reference material (SLRS-6) was used to monitor accuracy (bias) and drift. Results are shown in Table 4 below.

Table 4. Nazko study National Research Council Canada Natural Water Standard Concentration (SLRS-6) comparison results.

	Photometer	Photometer	Voltammeter
Sample ID	Al (Acidified, mg/l)	Mg (mg/l)	Cu (µg/l)
L160600000022	0.02	1.6	NA
L160600000054	0.03	1	23.62
L160600000079	0.03	1	19.73
L160800000083	0.03	1.3	28.01
L160800000104	0.02	3	26.47
L160800000136	0.02	4	30.51
L161000000145	0.03	3	30.05
L161000000163	0.03	2	25.72
L161000000198	0.02	4	30.59
Mean	0.026	2.322	26.838
SD	0.005	1.21	3.808
%RSD	20.62%	52.11%	14.19%
%Bias	-23.08%	8.86%	12.30%
NRC SLRS-6	0.0338	2.133	23.9

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Results produced by both instruments were compared with ALS Environmental Laboratory's ICP-OES analyses. Correlations between the photometer and laboratory data are shown for $CaCO_3$ Hardicol (total hardness), Mg and SiO_2 results (Fig. 6a-c). Results for these analytes in the 2014 samples display the best overall correlation. Despite showing a slight high bias in the photometer results, SiO_2 results for the 2016 samples appear to show a reasonable correlation between the laboratory and field methods. Extreme differences are apparent for Al and Fe shown in Figure 6 (d-e). These differences are attributed to the type of test the reagents perform. Whereas laboratory ICP-MS analysis provides concentrations of the cations regardless of their speciation, the photometer reagent will only interact with a specific dissolved ionic species in the test solution (Palintest personal communication). These differences are small enough for the results to still be meaningful.

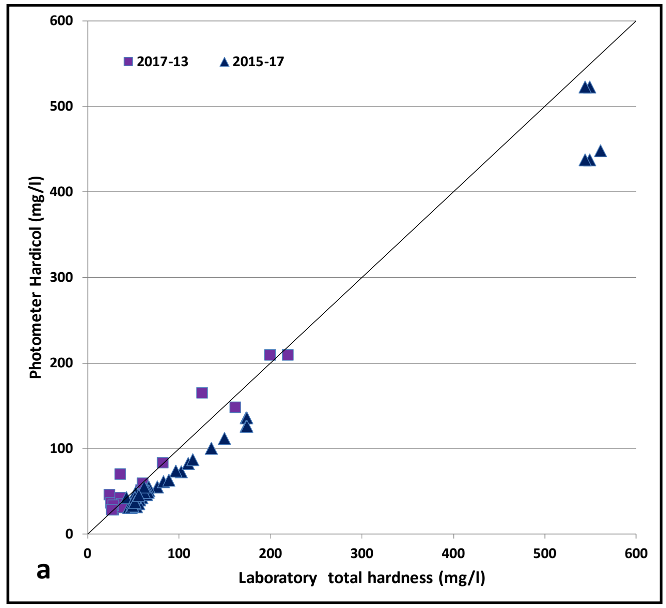
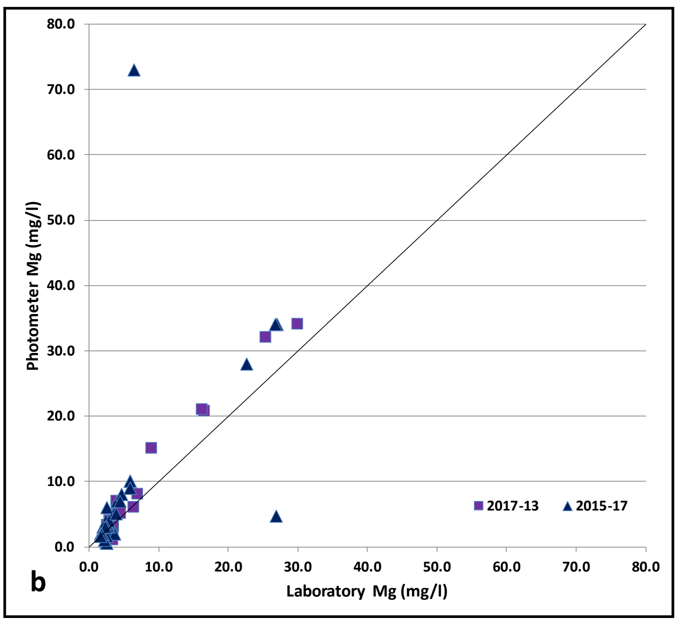
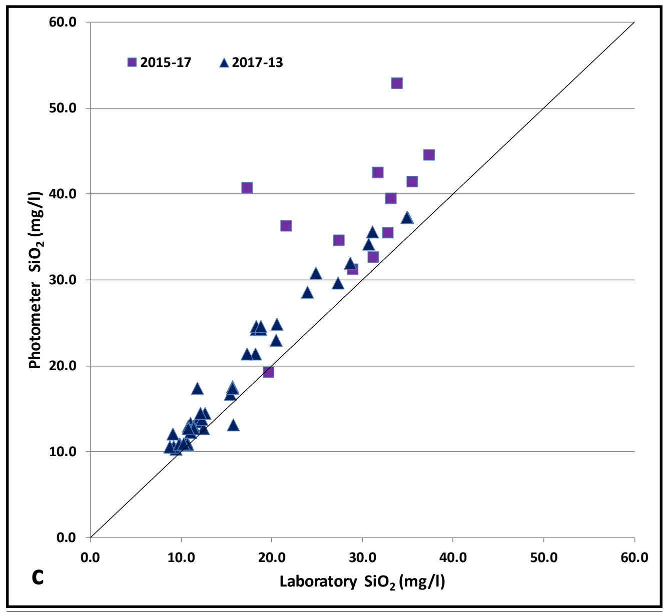
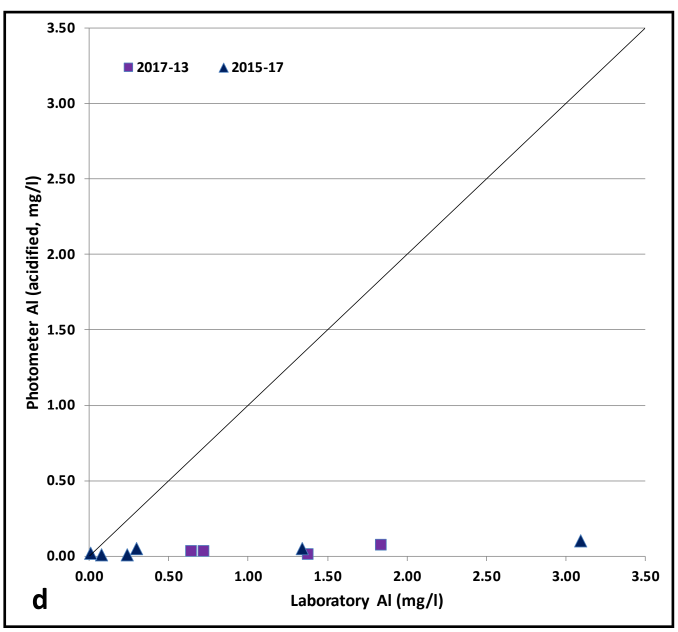
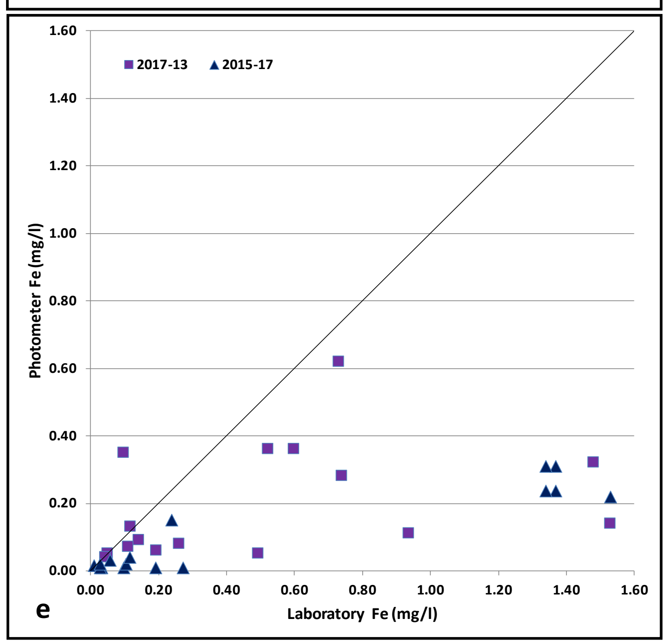


Figure 6. A comparison of photometer and laboratory results for (a) Hardicol (Palintest reagent terminology for total hardness), (b) Mg, (c) SiO_2, (d) Al, and (e) Fe.









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Results

This article discusses the Poison Mountain (2014) and Nazko (2016) water sampling results for As, Cu and SO_4 for the month of October. A more comprehensive description and discussion of the results is reported by Yehia & Heberlein (2015) and Yehia et al. (2017). For the Poison Mountain study, total Cu results (Fig. 7) show elevated Cu values up to 1.60 mg/l over the mineralized zone. The highest concentrations occur in two springs (red dots; Fig. 7) in the upper reaches of 'Copper Creek' with concentrations diminishing downstream. Sulphate concentrations up to 290 mg/l (Fig. 8) in both spring and stream waters reflect drainage from the sulphide mineralized zone. Elevated concentrations persist downstream for about four kilometres as a strong dispersion trend along Poisonmount Creek.

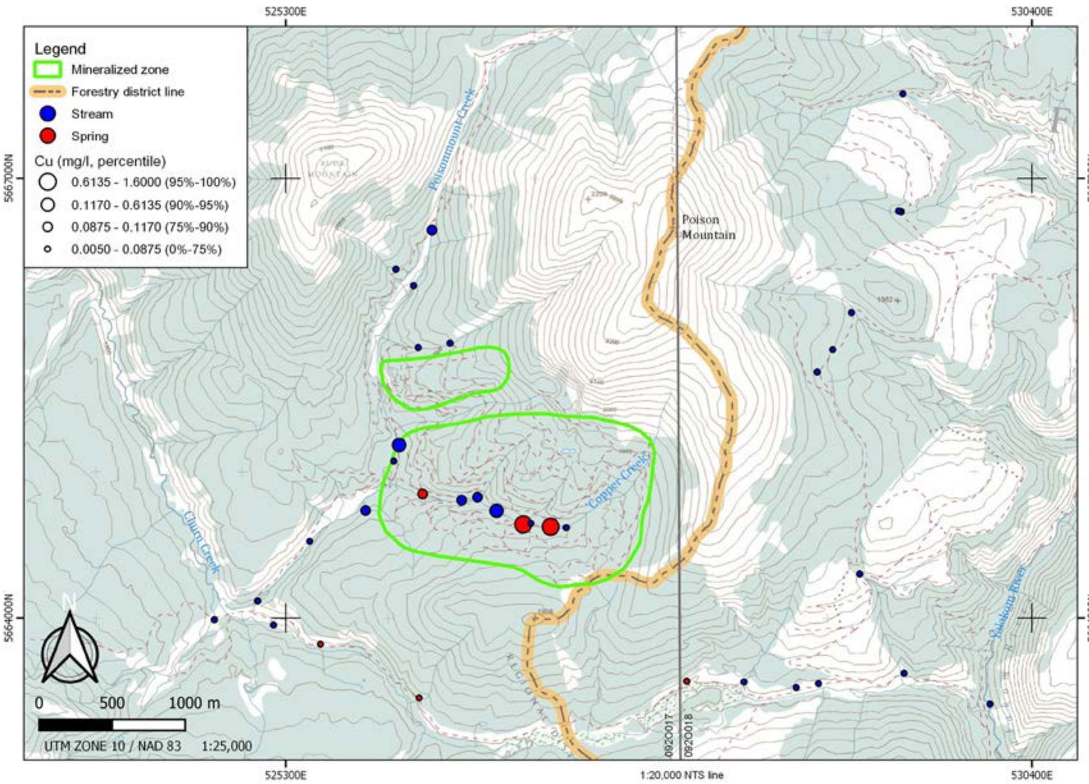

Figure 7. Report 2015-17 October photometer Cu (total) results for water samples from the Poison Mountain study.

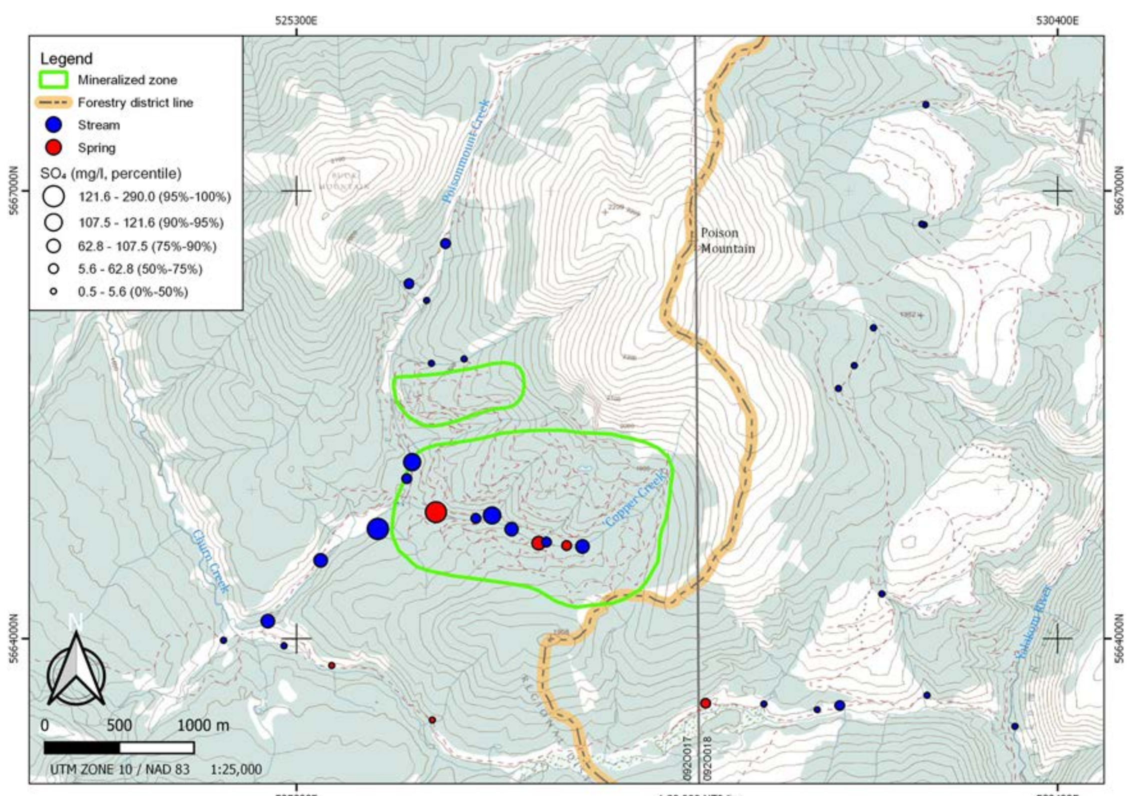

Figure 8. Report 2015-17 October photometer SO_4 results for water samples from the Poison Mountain study.

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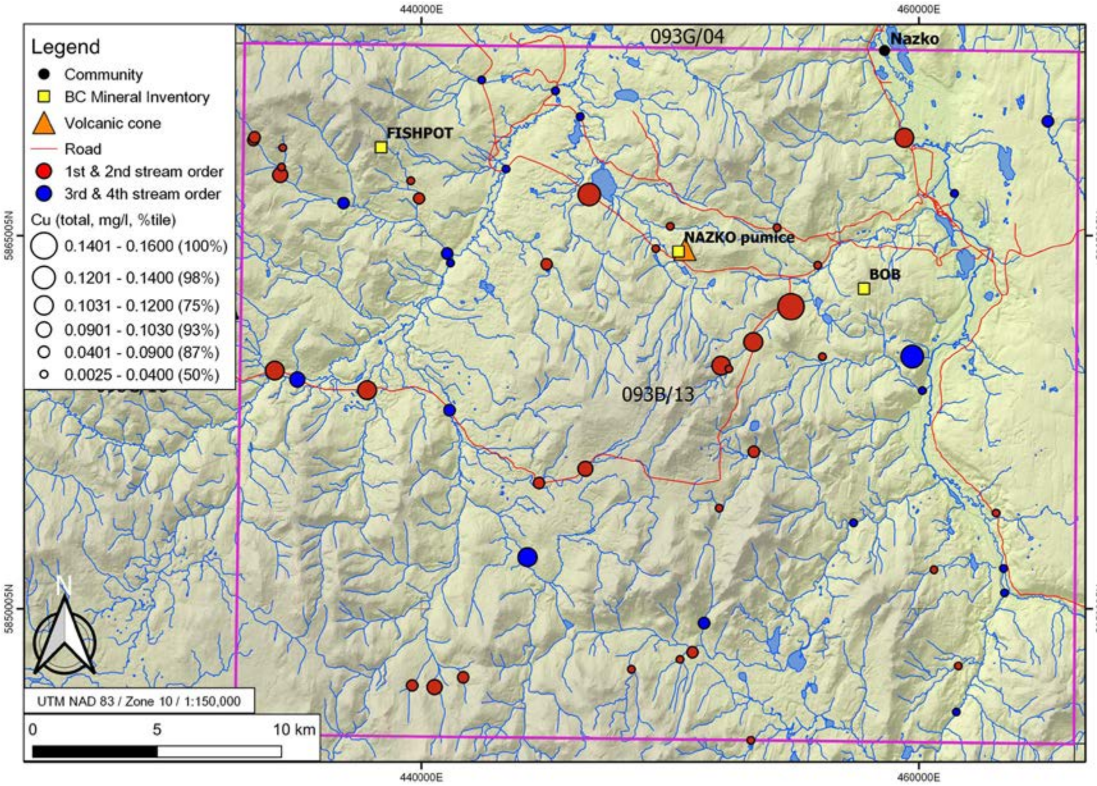
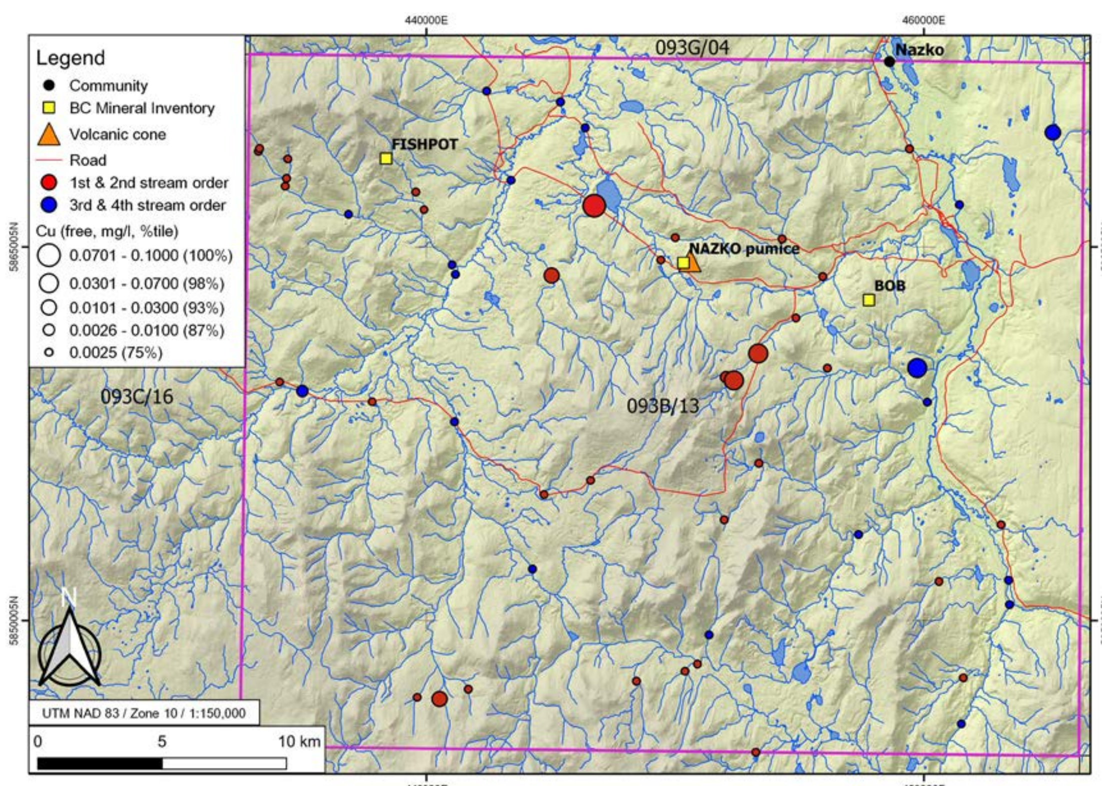


Figure 9. Report 2017-13 October photometer total Cu results for water samples from the Nazko study.

In the Nazko area, there are two drainages with elevated Cu concentrations in stream water (Figs. 9 and 10). Stream water near the Bob showing west of Fishpot lake and also in the southwest part of the survey area have elevated Cu values.

Figure 10. Report 2017-13 October photometer free (Palintest proprietary reagent terminology for dissolved Cu) Cu results for water samples from the Nazko study.



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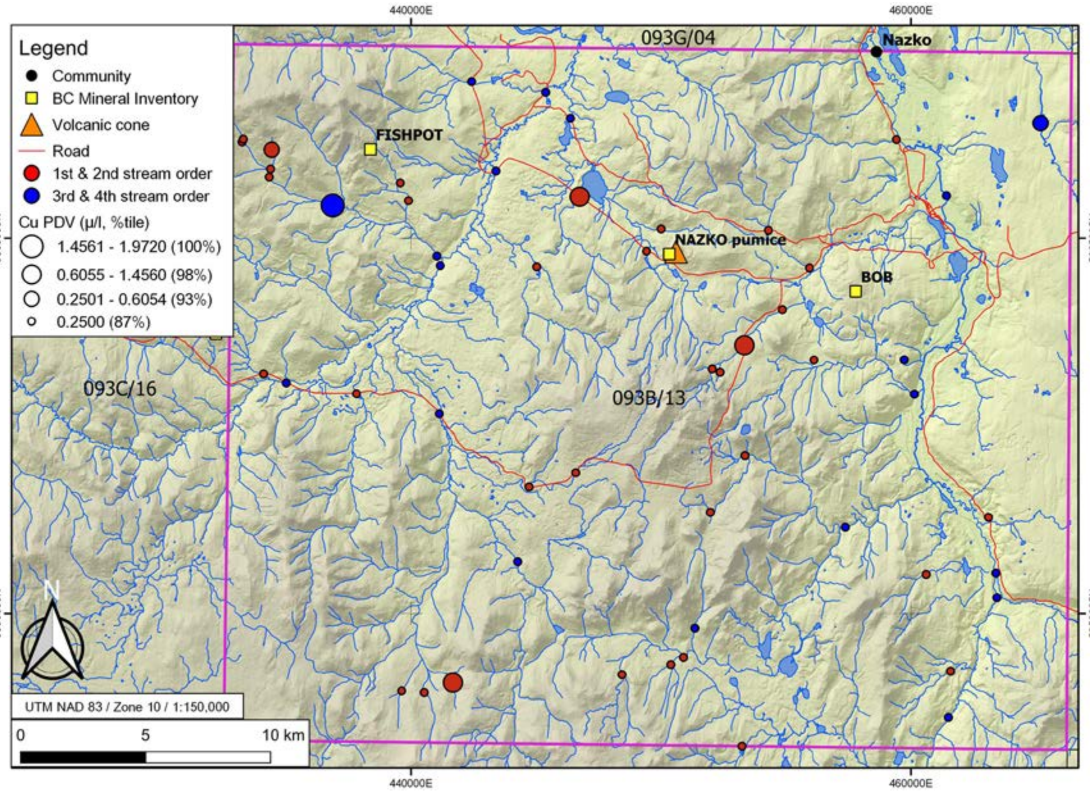

Figure 11. Report 2017-13 October voltammeter dissolved Cu results for water samples from the Nazko study. Note units are in microgram/litre.

The voltammeter (Fig. 11) was able to identify dissolved Cu in the streams due to its higher sensitivity. There is also elevated SO_4 concentrations in streams near to Bob and Fishpot and at other locations in the Nazko survey area (Fig. 12), correlating with sites of higher Cu values. Sulphate is an important indicator of sulphide weathering and the results show that, even at such low SO_4 concentrations, the photometer can possibly detect presence of sulphide mineralization.

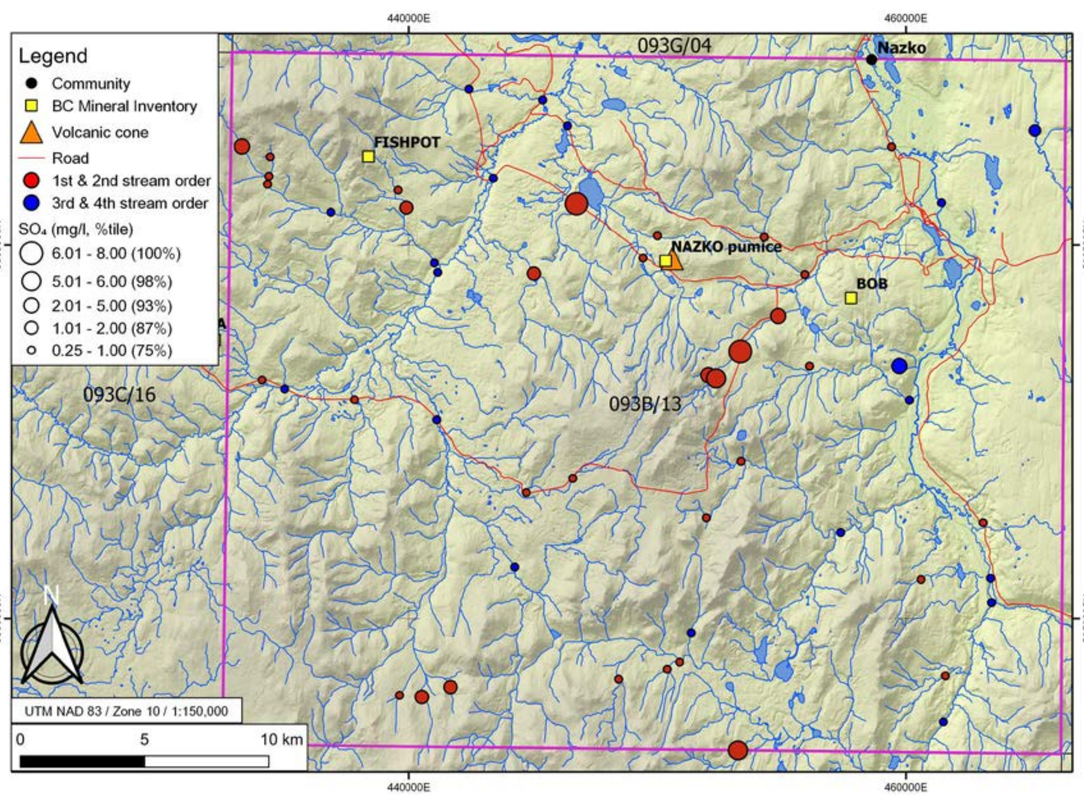

Figure 12. October photometer SO_4 results for water samples from the Nazko study.

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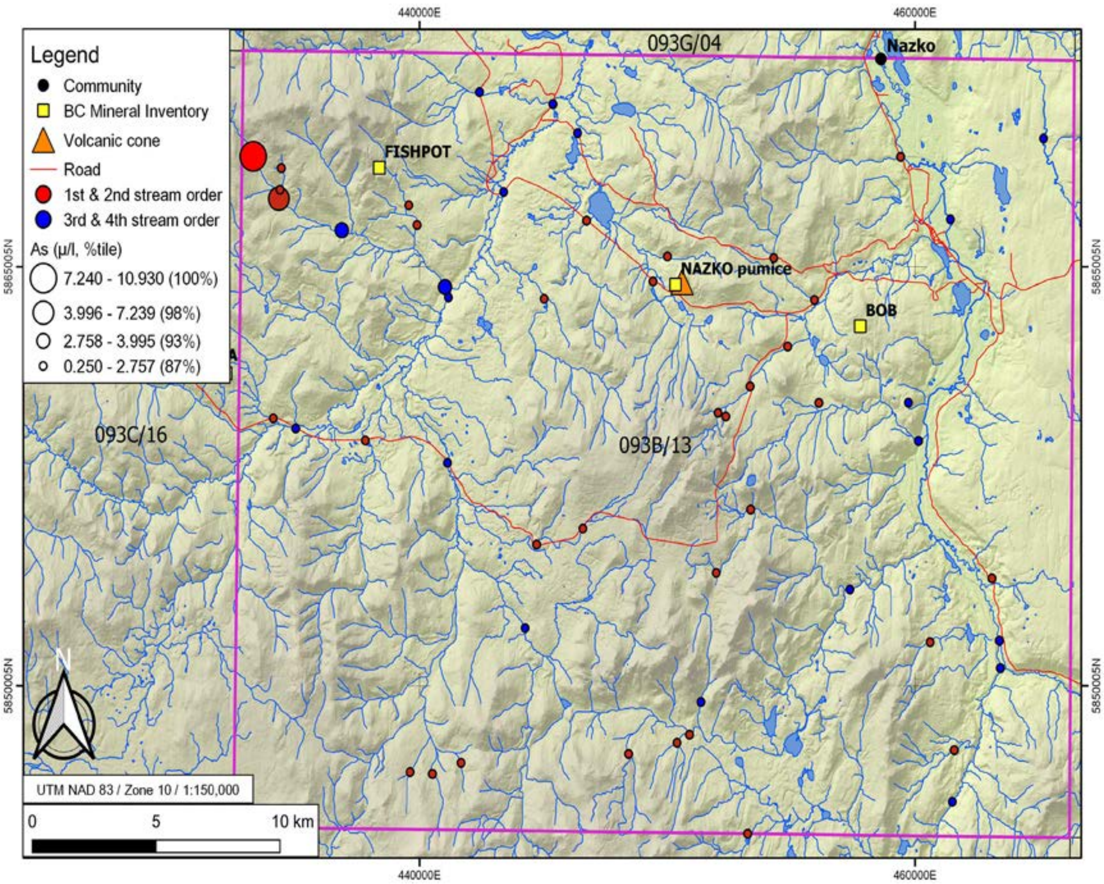

Figure 13. October voltammeter As results for water samples from the Nazko study. Note units are in microgram/litre (µg/L).

Elevated As concentrations occur in streams draining the area west of the Fishpot prospect (Fig. 13). Arsenic concentrations in water reveal a dispersion trend with decreasing values from about 10 µg/l to about 3 µg/l over a distance of about 10 km along the drainage downstream to southwest.

Discussion

The objectives of the Poison Mountain and Nazko surveys were to test the reliability of field portable devices and to provide meaningful field trace element and anion analyses of water samples. At Poison Mountain, most water samples were analysed within 24 hours of collection and at Nazko analysis was mostly completed the same day as sample collection.

The advantage of field-based analysis is its ability to determine trace element concentrations of water samples in ‘near real-time’. The analyses carried out within a few hours of sample collection could allow fast identification of priority areas for immediate follow-up. The low detection limits for some analytes, e.g. photometer total (all soluble element species measured in the water) Cu (0.01 mg/l) and voltammeter dissolved (ionic species) Cu (0.0005 mg/l), provide sufficient anomaly contrast to identify sulphide mineralization at both regional and local scales. The speed of analysis using these devices provides a considerable advantage over traditional laboratory-based methods, where results may not be available for up to several weeks depending transportation and laboratory turn-around delays. The ability to make decisions while in the field can have significant time and cost benefits by eliminating the need for a second follow-up sampling campaign. The methodology applied in these studies also allows for identification and correction of errors during the survey and where necessary re-sampling problematic sample locations.

In the Nazko survey area, elevated Cu, As and SO_4 concentrations in stream water samples near to the Bob and Fishpot occurrences not only provide evidence for the presence of sulphide minerals in bedrock, but also draw attention to other areas where sulphide mineralization may be present (Fig. 14). At least two additional locations in the southern portion of NTS 093B/13 were identified during the sampling campaign that are worthy of detailed investigation.

Hydrogeochemistry is also sensitive to other factors including bedrock geology, overburden type, precipitation and weathering rates. All these processes need to be considered when interpreting the results. For example, the results of till geochemical analysis from regional surveys reported by Jackaman & Sacco (2014) and Jackaman *et al.* (2015) show spatial relationship between photometer water total Cu in stream draining the Fishpot area and elevated Cu in till assuming a regional ice flow direction from southwest to northeast. Another source of the elevated Cu concentrations

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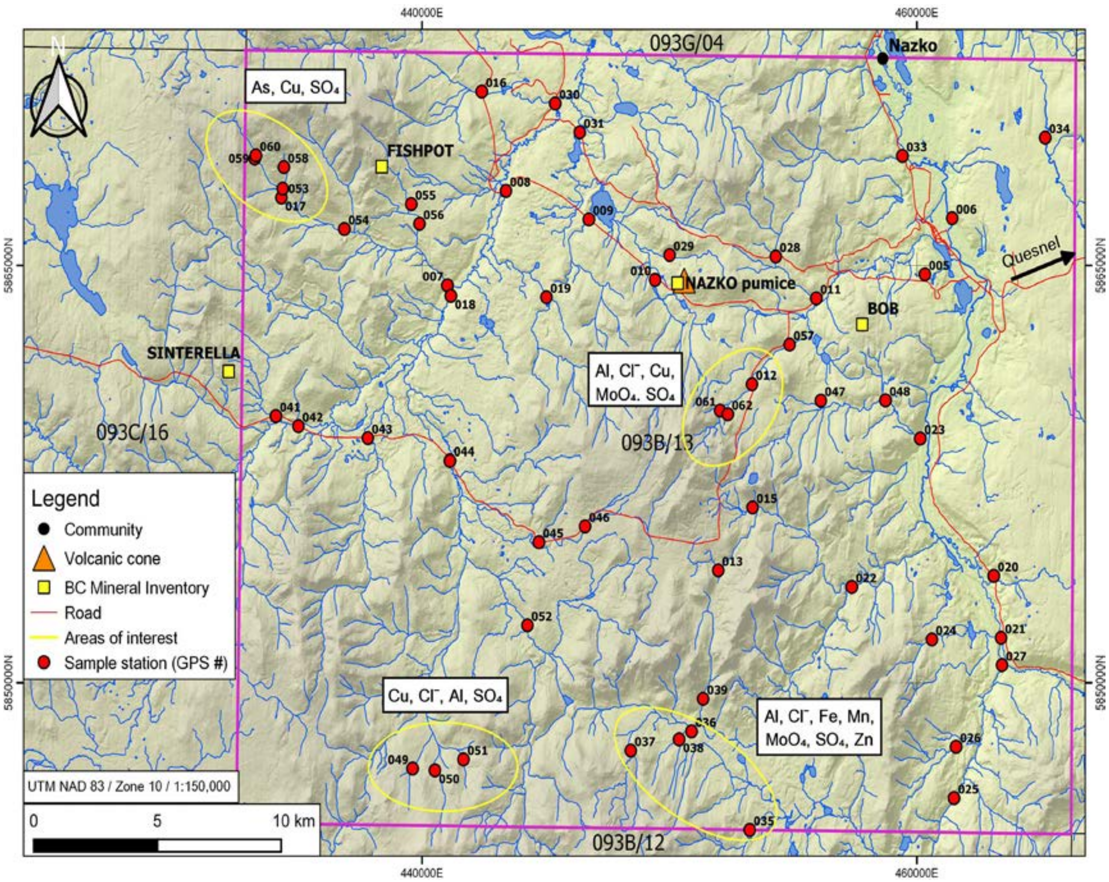

Figure 14. Identified multi-element associations in the Nazko study area.

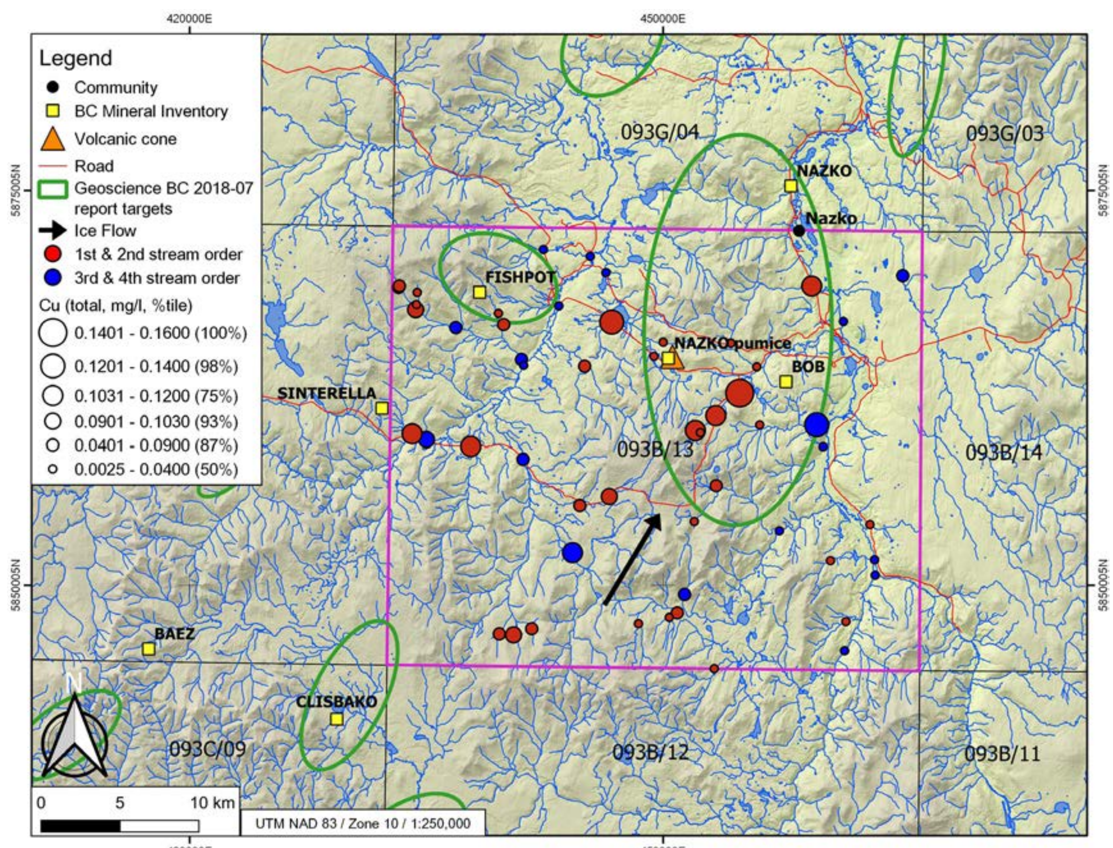

Figure 15. Compilation map for the Nazko area showing the October total Cu in water concentrations (Yehia et al, 2017) as red and blue dots. Outlined in green are the areas where there is a greater probability of discovering a mineral deposit based on modelling lake bottom sediment and till geochemical survey results by Sacco et al (2018).

in water could be Cu mineralized Eocene Ootsa Lake volcanic rocks in the survey area (Angen *et al.* 2015). Elevated voltammeter and photometer Cu values appear to correlate with the till Cu anomalies to the northeast of the Nazko cone, but not the Bob mineral occurrence. In fact, water samples with elevated Cu contents were collected from a stream

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Rapid Hydrogeochemistry: A summary of two field studies… *continued from page 15*

about two kilometers west of the Bob occurrence. North of the occurrence, there is a spatial relationship between a till Cu anomaly and elevated Cu in the stream water. Other examples are the regions shown as green outlines in Figure 15, which are predicted to have mineral deposit types from modelling of lake and till geochemical data (Sacco *et al.* 2018). The outlines do not necessarily show the spatial relationship between water geochemical anomalies and the till geochemistry but indicate a likely common metal source. For example, the area where the till values are most elevated north of Nazko could reflect ice transport of mineralized Anahim bedrock. In the northwest part of the study area there seems to be glacial dispersal of Cu and As to the northeast (down-ice) of the Fishpot occurrence, but the principle water Cu and As elevated values appear in streams draining from the west, i.e. up-ice from Fishpot.

Cost analysis

A comparison of the relative cost per sample for both studies is presented in Table 5. The slightly higher cost for the second study was due to the addition of the voltammeter tests and need of a second assistant to operate the instrument. The results presented here show that the photometer and voltammeter can produce rapid and meaningful analyses for a suite of cations, anions and additional tests such turbidity, pH, colour, etc., at relatively low cost while in the field. The photometer and voltammeter methods are competitive with commercial laboratories that are more expensive and have much longer turnaround times. Although a rapid hydrogeochemistry suite is about 70% of a commercial laboratory suite, the field-based system does offer the ability to pick and choose the desired one; which could offer additional cost savings.

Table 5. Summary of cost per study sample for Poison Mountain (2014) and Nazko (2016) water sampling studies. Reported in Canadian dollars.

Type	Report 2015-17 cost/sample	Report 2017-13 cost/sample
Photometer reagents	$13.14	$10.36
voltammeter reagents	NA	$5.32
Operational analysis	$31.25	$57.09
Environmental disposal	$2.08	$2.21
Total	$46.47	$75.98

Conclusions

These studies to test a field-portable photometer and voltammeter devices for the rapid analysis of water samples show that:

- The photometer and voltammeter can produce rapid and meaningful results for a suite of anions and cations at relatively low cost when compared with conventional laboratory-based methods.
- Time and cost advantages of the methodology allow increasing sample density and field follow-up during the same sampling campaign.
- There is a good comparison between various tests field analyses by the photometer and by a commercial laboratory.
- Elevated SO_4 concentrations are present in streams draining areas where there known mineralization and suggest that the method can detect the presence of sulphide minerals.

Acknowledgements

The authors thank Geoscience BC for project funding and the Nazko Economic Development Corporation for their in-kind and logistical support. Stew Hamilton and Beth McClenaghan are thanked for their manuscript reviews. L. Schlechtleitner, C. Craig, and V. Guerra are thanked for their dedicated and valuable work on the devices and in the field.

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YEHIA, R., HEBERLEIN, D.R. & LETT, R.E. 2017. Rapid, Field-Based Hydrogeochemical-Survey Analysis and Assessment of Seasonal Variation Using a Field-Portable Photometer and Voltammeter, Marmot Lake NTS Area, South-Central British Columbia (NTS 093B/13). Geoscience BC, Report 2017-13.

Geochemistry

EXPLORATION, ENVIRONMENT, ANALYSIS

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Dr. Victor M. Levson (1956-2019)

Victor M. Levson passed away on 31 March 2019, at the age of 62. Vic was a Quaternary geologist and spent most of his professional career at the British Columbia Geological Survey in Victoria, British Columbia, in western Canada. He was an early adopter of drift prospecting for mineral exploration in the Canadian Cordillera and presented at the Drift Prospecting Workshop held at the AAG's 1999 IGES meeting in Vancouver. He made significant contributions to the discipline and provided important insights into the Quaternary history of British Columbia, and the effect of complex ice-flow histories (including ice-flow reversals) on the clastic dispersal of mineralized bedrock in subglacial tills. Vic also wrote important papers on the stratigraphy and geologic settings of gold placers in the Cariboo and Atlin regions of British Columbia.

Vic 's M.Sc. and Ph.D. research focused on the Quaternary sedimentology, stratigraphy, and history of the Jasper area under the supervision of Dr. Nat Rutter at the University of Alberta. Vic joined the British Columbia Geological Survey in 1989 and completed his Ph.D. in 1995. Upon leaving government in 2009, he formed his own consultancy, Quaternary Geosciences Inc. Throughout his career Vic was keenly interested in applied aspects of Quaternary geology, across a diverse range of research topics. He is best known for his contributions to Canadian Quaternary stratigraphy, sedimentology, and ice-flow histories, seismic hazard maps for parts of southwest British Columbia, and drift prospecting method development for the Canadian Cordillera. Vic authored or co-authored more than 150 scientific papers, reports and maps, and wrote countless conference abstracts and presentations. Known for his astute observations and attention to detail, his till geochemical datasets continue to guide mineral exploration in central British Columbia.

Vic was also an Adjunct Professor in the School of Earth and Ocean Sciences, University of Victoria, where he supervised 10 graduate students. He served as an external examiner for many theses at the University of Victoria and other Canadian schools. For 18 years, Vic taught a fourth-year applied Quaternary geology course at the University of Victoria. A highlight of the undergraduate program, this course inspired many students to pursue careers in Quaternary geology. His annual four-day field trip through Washington State, with stops at the Channeled Scablands and Mount Baker, became legendary. Vic also lectured in the Department of Geography (University of Victoria) and the Department of Chemistry and Geoscience (Camosun College).

Perhaps Vic's greatest contribution was how he treated people. Not only was Vic a respected geoscientist and gifted teacher, he was a selfless mentor and friend. Vic taught all of us that were fortunate to have worked with him how 'to do the right thing', a legacy that will endure. He led by example and passed on a set of core values that have continued to guide us well.

Cherished by his family, Vic squeezed the most out of every day. We will miss his infectious laugh, ingenious practical jokes, and unwavering friendship.

T. Ferbey
British Columbia Geological Survey

Current Status of Applied Geochemistry in Mexico

INTRODUCTION[1,2]

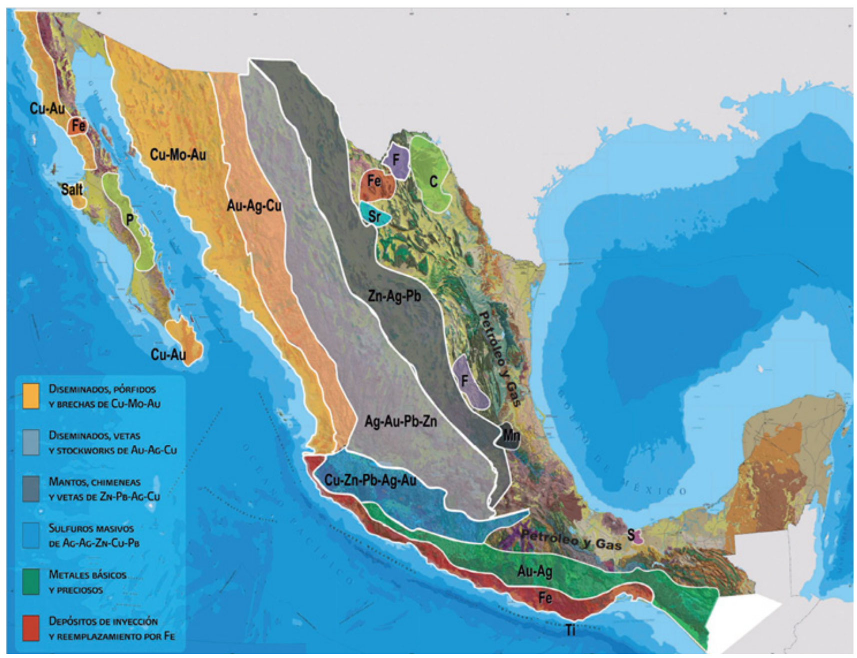
The history of Mexico is intimately related to mining activity. Mining has been present in the Mexican economy from pre-Hispanic times to the present. Ancient mine workings and vestiges of this activity abound in our territory and many of the ancient cities arose because of mining. In Mexico, a great variety of metallic and non-metallic minerals are produced, particularly silver, gold, copper, molybdenum, fluorite, barite and others.

Geological studies carried out by the Mexican Geological Survey (SGM) in the country indicate that in a large part of the national territory there is significant exploration potential for metallic and precious minerals, with the possibility of contained mineral deposits as or more important than those previously discovered.Only 30% of the territory has been explored in modern times with a further 70% to explore, indicating the attractiveness of our nation for this industrial activity.

It is important to note that Mexico has metallogenetic provinces where the geological framework has certain characteristics that allowed the formation of particular types of deposits (Fig. 1). Deposit types include:

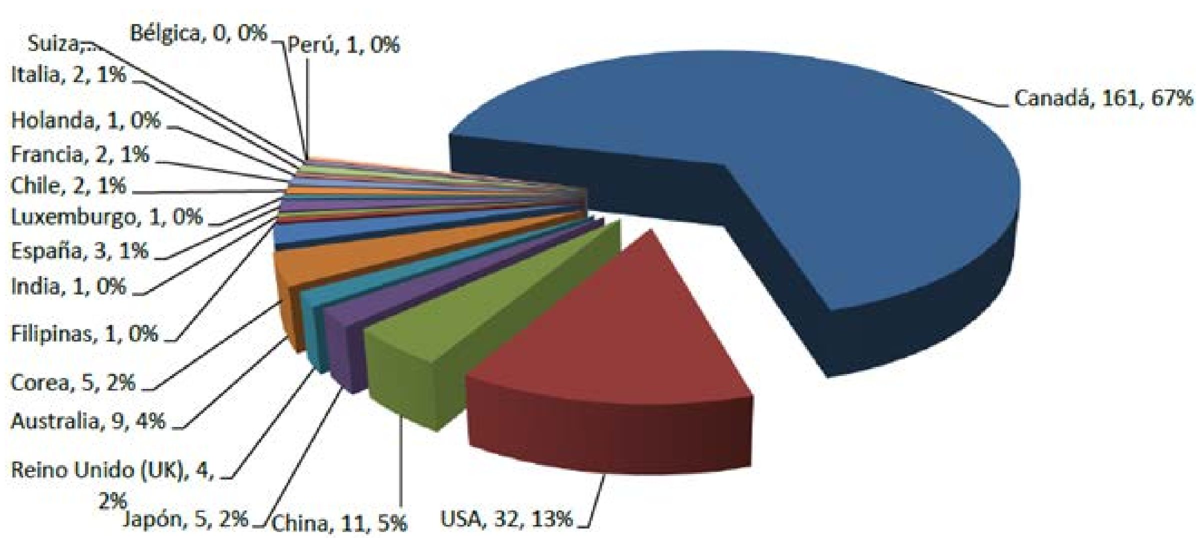
- Disseminated, porphyry and breccias of copper, molybdenum, and gold;
- Disseminated, veins and stockworks of gold, silver, copper;
- Mantles, chimneys, and veins of zinc-lead, silver, and copper;
- Massive sulfides of gold, silver, zinc, copper, and lead;
- Massive and precious metals; and
- Deposits of injection and replacement of iron (Pacific coast).

Figure 1. Principal Metallogenetic Provinces[1].



At the end of 2018 there were 242 companies identified with foreign capital operating in Mexico that manage a portfolio of 1,189 projects.Of these, 66.53% (161) have their central offices in Canada; 13.22% (32) in United States of America; 4.55% (11) in the People's Republic of China; and 3.72% (9) companies from Australia, as shown in the Figure 2.

Figure 2 Companies with foreign capital in Mexico. Name of the country, the number of projects, and the percentage of participants with projects in México. (Dirección General de Desarrollo Minero, Subsecretaría de Minería, Secretaría de Economía).



[1] https://www.gob.mx/cms/uploads/attachment/file/112612/portafolio_proyectos_mineros_1013.pdf
[2] Diagn_stico_2do_semestre_estad_sticas_2018_1_.pdf

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Current Status of Applied Geochemistry in Mexico… *continued from page 19*

Of those projects operating with foreign capital in Mexico, 50.13% (596) are in the exploration stage; 8.33% (99) in the production stage and the rest as shown in Figure 3.

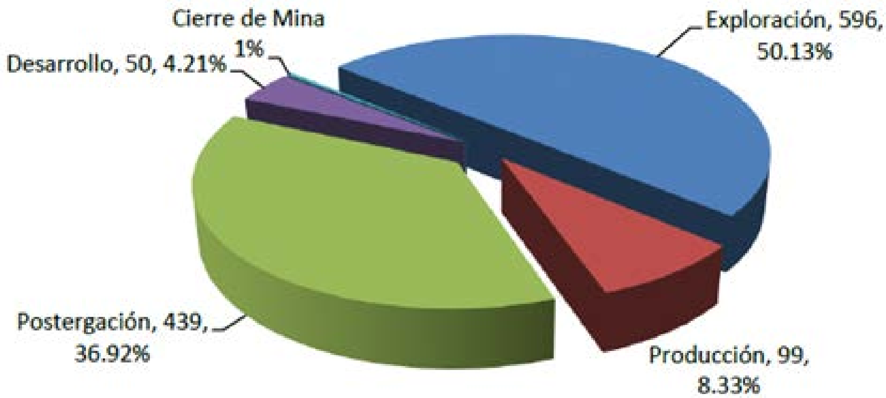


Figure 3. Projects with foreign investment in Mexico, showing the stage of the project, number of projects, and percentage of projects by stages. (Dirección General de Desarrollo Minero, Subsecretaría de Minería, Secretaría de Economía).

THE MEXICAN GEOLOGICAL SURVEY[3]

The Mexican Geological Survey is the agency that generates the geological-mining information for the country. It has vast experience in geological surveying, as well as in mining exploration and evaluation because it has more than 50 years' operating in Mexico in different specialties and at several scales.

An extensive part of the available geological information is historical, although currently there is still new information being generated concerning mining development and exploration. Nevertheless, since 1995, most of the work has been concentrated in creating the basic geologic infrastructure of the national territory, that is, geological-mining and geochemistry cartography, organized in two programs: 1:250,000 scale maps, and 1:50,000 scale maps. Mapping at 1:250,000 scale was completed in 2005, with mapping at higher resolution currently underway, with 29% of Mexico completed to date.

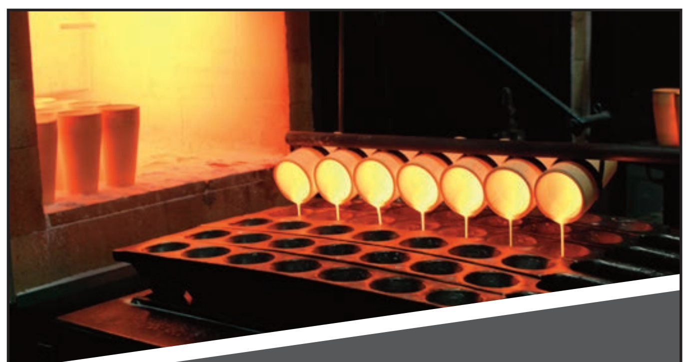
The geologic maps are relevant in several areas, as they can be used in exploration and the generation of mining projects, and also in regional geological research in collaboration with, for example, the USGS, the Geology Institutes of Universidad Nacional Autónoma de México and the universities of Sonora and San Luis Potosí. In addition, they constitute the database for editing the 1:4,000,000 scale map of Mexico, as well as the the 1:500,000 scale state maps.

Among other data, the cartographical program incorporates all metallic and non-metallic, active or inactive mines, and additionally provides information on mineralization or hydrothermally altered rocks, all of which is registered by a field geologist during their search so that the data can be related to potential mineral deposits. On this basis, the SGM identifies a number of valuable prospective areas that are classified in order of importance, then evaluated, and finally put forward for the consideration of interested entities or individuals.

Further information:
https://www.gob.mx/sgm/es/videos/the-mexican-geological-survey
www.gob.mx/sgm
https://www.sgm.gob.mx/Gobmx/en/About_SGM/Cartography.html
https://www.gob.mx/sgm/es/videos/cartography-and-special-studies
https://www.sgm.gob.mx/CartasDisponibles/

[3] https://www.sgm.gob.mx/Gobmx/en/About_SGM/Geology.html

continued on page 21



Current Status of Applied Geochemistry in Mexico…
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GEOPHYSICS[4]

The airborne magnetic data generated by the Mexican Geological Survey provides information that can be used, together with the geological and geochemical maps, in mineral exploration, radioactive minerals detection, cavities location to assess geological risks, contouring depth to basement, assessment of aquifers, intrusive rocks delineation, and detection of hidden subsurface mineralized bodies.

Infrastructure

- 24 geophysicists and specialized technicians.
- 1 turbo-charged Islander aircraft and 1 Piper Navajo Panther, each equipped with cesium vapor magnetometers;
- 2 Eurocopter helicopters, B-2 and B-3, with a magnetometer and gamma-ray spectrometer with 256 channels;
- A multispectral camera (hyperspectral) and aerial electromagnetic equipment;
- For ground surveys, equipment for induced polarization, electromagnetics, gravimeters, magnetometers, gamma-ray spectrometers, one seismometer, and one borehole recorder;
- 21 desktop and laptop computers; and
- 1 ink injection plotter.

Products

The magnetic cartography products are variable. The maps can be issued with contours and colored intervals; gray colored relief, or combined with the digital elevation model. The state maps are issued in 1:250,000, 1:500,000, 1:750,000 and 1:1,000,000 scales. The Mexican Republic magnetic map is available in 1:3,000,000 and 1:4,000,000 scales. Products include:

- Total magnetic field (TMI);
- Total magnetic field reduced to the magnetic pole (RTP);
- First vertical derivative (1VD) of the TMI;
- Digital elevation model (DEM) with a magnetometric layer;
- Digital files by flight lines in any specific area, with grids at 1:50,000 or 1:250,000 scale maps; and
- Report and text of the magnetic maps at 1:250,000 scale.

North America Magnetic Map project:

- A unique and transcendental experience was the assemblage of the North America Magnetic Map, published in agreement with the United States and Canadian geological surveys. This ambitious collaborative project was the result of the combined efforts of these three countries to bring together and integrate the airborne magnetic files issued by each country.
- This modern digital database of the North American magnetic map is a powerful tool to analyze geological processes, structural setting, and regional tectonic evolution, as well as providing strong support for continental and oceanic resources exploration. The magnetic map of North America provides a continental scale vision of magnetic lineaments thatcould not be assessed at the localscale.

The data processing details and the compilation are described in the brochure accompanying the map.
Download Map
Download document
Application examples of the magnetic map of North America:
Example in Spanish
Example in English

Further Information:
https://www.gob.mx/sgm/es/videos/geophysics-mexican-geological-survey

GEOCHEMISTRY[5]

The geochemical maps show the interpreted results from regional stream sediment samples and are produced following the procedures of well-known experienced authors and researchers. Similar standards are currently applied by most international companies and government entities. Sampling density is defined according to the surveying scale, averaging the following values:

- 1:50,000 scale, maximum samples = 210
- 1:250,000 scale, maximum samples = 660

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[4] https://www.sgm.gob.mx/Gobmx/en/About_SGM/Geophysics.html
[5] https://www.sgm.gob.mx/Gobmx/en/About_SGM/Geochemistry.html

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Sampling density is also a function of topographic accessibility and the drainage network, so the search establishes 1 sample for every 5 km^2 at 1:50,000 scale and 1 sample eveat 40 km^2 at the 1:250,000 scale. The main goal of the geochemical maps is to supply a tool able to support mineral deposit exploration through the analysis of the results in combination with the geological framework provided by the geological maps.

Methods
The sediment stream samples are collected under uniform climate conditions, preferably in the dry season to avoid the stream flow in the rainy period. Each sample is screened to -80 mesh, packed in Kraft paper bags, and then protected with an additional plastic bag to prevent contamination. Monitoring of mining and urban zones within the catchment basins is performed in order to detect elements that could influence the original secondary dispersion contents. Geochemical information is, by itself, valuable, but it can be more conclusive when used together with geological and geophysical information. The percentile statistical treatment of the data objectively exhibits the contrasts relative to background. The responses are defined with three size circles and colors: the red –the highest– shows the maximum anomalous concentration of the element; the ones in orange and yellow, value progressively lower. The elements gold, silver, lead, zinc, and copper may be absent when the concentration is not significant compared with the general background. Other elements are determined when they show affinity after statistical analysis and, additionally, according to the geologist's experience, which is able to suggest that certain elements should be included based in the mineralization model.

Analysis
All the stream sediment samples are shipped to the SGM labs (Experimentation Centers) and assayed for 31 elements. The analysis is performed in a plasma emitting spectrometer (ICP), except gold, which is determined by fire assay, and the volatile elements Sb, As, Te, Se, Sn and Bi that are first stabilized in a hydrides generator, and then quantitatively determined. The lab delivers the results in parts per million (ppm), excepting iron which is presented in percentage. The gold, tellurium, and selenium values are transformed into ppb, for reporting on the final map.

Map content
Ten to sixteen different maps are prepared, one for each element –usually those with more affinity to the mineralization model– according to the values and statistical analysis.

Publication
Sampling and location selection, as well as the statistical analysis, are supervised by the Geology and Geochemical manger. Once the material is collected and the analysis completed, it is delivered to the Geomatics area where the layers are digitized and a topographic base is added. After this, the map is published using Arc/Info and containsall the necessary attributes that are issued to the user.

Products
Geochemical maps are available at 1:250,000 and 1:50,000 scales in paper or in digital format, one for each element. By request, the maps may incorporate any additionalinformation, coverage or theme. Moreover, the lab results with sample coordinates and the Arc/Info digital layers are also accessible.It is highly recommended that the Arc/View digital are used as they contain all the themes and information layers.

Further Information:
https://www.gob.mx/sgm/es/videos/experimental-centers

ENVIRONMENTAL GEOLOGY[6]
The Mexican Geological Survey is committed to the preservation of the environment and to identify the geological conditions in areas under study so that users minimize environmental damage..

The activities of thematic mapping focus on:

- Protection and restoration of water bodies;
- Identification of sites for the confinement of solid waste and other substances; and
- The study of geological hazards including mass movements, land subsidence, volcanism, floods, landslides and mudflows, and coastal hazards.

[6] https://www.sgm.gob.mx/Gobmx/en/About_SGM/Environmental_Geol.html

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Geo-Environmental Field

- Anthropic impacts to the environment due to industrial activity and inappropriate use of land;
- Soils and aquifers pollution; and
- Desertification caused by clear-cut logging.

An agreement has been signed for the federal government and other government agencies to develop an atlas of risks and the location of natural and anthropogenic events. As a result of these agreements the Mexican Geological Survey is preparing atlases for Oaxaca, Chiapas, Tabasco, Puebla, Hidalgo, Querétaro, Tlaxcala and Tamaulipas, as well as the other Mexican States. The Mexican Geological Survey established the Environmental Geology Division to facilitate its participation in environmental preservation. This division has started coordinated work with organizations such as the Chamber of Mines of Mexico, Bureau of Mining Promotion, and the General Coordination of Mining and agencies of SEMARNAP (INE and PROFEPA) in the development of Official Mexican Standards (NOM), directed to environment protection.

Further Information:
https://www.gob.mx/sgm/es/videos/environmental-geology-and-hydrogeology
https://mapasims.sgm.gob.mx/AtlasRiesgosSGM/

HYDROGEOLOGY[7]

The natural shortage and inadequate administration of groundwater has resulted in over-exploitation of aquifers, which is due to excessive extraction, and increasing demand for agricultural, urban and industrial uses This has resulted in continuous declines of water in the aquifers and deterioration its quality.It is therefore necessary to know the characteristics of groundwater exploitation and hydrogeological conditions of the aquifers. The challenge for the Mexican Geological Survey is to compile knowledge about groundwater in different national hydrogeological basins, predict their evolution in the short to medium term, and also advise on water management without compromising the quality and quantity of this resource.

The types of studies developing by this division are:

1. Hydrogeological Prospecting for the presence of groundwater, including depth and direction of flow;
2. Hydrogeological Assessment to quantify available water in the aquifer;
3. Hydrogeological Modeling to predict operation of the aquifer system; and
4. Characterization hydrogeochemistry (quality) to determine the sources and potential contamination in groundwater.

The SGM studies geological parameters that determine the presence, distribution and flow of water, groundwater relationships with the geological environment, the conditions governing the movement of water, physicochemical characteristics of groundwater and its development, exploration and exploitation, and a large list of specific aspects, which may include the impact of water on infrastructure development. A fundamental part of this kind of study is the interpretation of satellite images and the application of geophysical methods for exploration, such as gravimetry, magnetometry, and airborne electromagnetics.

Further Information:
https://www.gob.mx/sgm/es/videos/environmental-geology-and-hydrogeology

ENERGY MINERALS[8]

The SGM implemented the GAC (Gas Associated to Coal) project, which has the purpose of evaluating the gas potential of Mexico, considering the geological characteristics that allow the delimitation of areas in various sedimentary basins possibly containing commercial gas deposits, and subsequently tendering prospective areas under General Directorate of Mining Regulation. This program consists mainly of four stages:

The first stage involves the collection, analysis, interpretation and integration of data in order to specify the geological factors determining potential areas containing gas associated with coal deposits.The second and most important stage involves fieldwork focused on regional and semi-detailed geology, the identification of the stratigraphic column and verification of structures, as well as sampling for carbon content, constructing geological cross-sections and measured stratigraphic sections. Sampling is carried out based on stratigraphic, sedimentological and structural criteria, with the aim of obtaining geochemical parameters that allow the identification of favorable rocks to generate gas associated with coal. The third stage is the characterization of coal based on laboratory analysis, including chemical analysis, vitrinite

[7] https://www.sgm.gob.mx/Gobmx/en/About_SGM/Hydrogeology.html
[8] https://www.gob.mx/sgm/acciones-y-programas/programa-de-minerales-energeticos

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reflectance, and Rock-eval in order to produce information that defines the deposit environment, maturity, evolution and its capacity to generate gas. The fourth stage consists of the interpretation of the results from laboratory analyzes, such as the maturity of organic matter, stage of generation of liquid or gaseous hydrocarbons for 1D numerical modeling, as well as the calculation of the on-site gas potential.
Further Information:

https://www.gob.mx/sgm/es/videos/sgm-energy-minerals

DIGITAL GEOSCIENCE[9]
The accumulated experience of seven decades of exploration is reflected in the development of a simple application that allows access to numerous databases of geological knowledge. A geological knowledge generation tool translates into a system of digital information which allows a source of quick, timely and reliable information to support planning and development of mapping projects, geological surveys, and all related Earth Science activities.

The following methods are used to manage and organize the geoscience data to the public:

Digitization
Edition
Database
Remote Sensing
GIS Applications
Computer networks

Access to SGM products
Cartographic products are available from the center of Earth Sciences documentation (CEDOCIT) located in Mexico City, as well as in seven different regional offices of the SGM and two offices strategically located in the interior of the Republic. The delivery time is usually immediately for simple products, but if the order is complex, or if the request involves a special combination of levels of information presentation, they are generated in a maximum of four days.
Digital information includes the geological-mining and geochemical (31 items) maps (Table 1).

Also included are satellite images at a resolution of 50 meters, total magnetics in the form of isocurves and polygons, infrastructure files and toponomy of INEGI (National Institute of Statistics and Geography;https://www.inegi.org.mx/).

Table 1. Summary of digital information available from SGM

INTERACTIVE DIGITAL PACKAGE	INTERACTIVE GEOLOGICAL-MINING MAP	DIGITAL GEOCHEMISTRY MAP
• Geology • Caneva • Geologic Structures • Mines • Technical Files • Zones of alteration • Geochemistry (31 elements) • Anomalous Values (Cu,Pb,Zn,Ag,Mn & Co) • Petrography • Hydrography • Satellite Imagery (TIFF) • Geophysics(CMTL y CMTP) • Beneficiation plants • Level curves • Infrastructure power lines cities towns etc.	• Geology • Caneva • Geologic Structures • Mines • Technical Files • Zonas of alteration • Petrography • Hydrography • Level curves • Infrastructure power lines cities towns etc.	• Geochemistry (31 elements) • Caneva • Hydrography • level curves • Infrastructure power lines cities towns etc.

[9] https://www.sgm.gob.mx/Gobmx/en/About_SGM/Digital_Geoscience.html

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Availability of Digital Information:

Geological Maps, scale 1:50,000
Geological Maps, scale 1:250,000
Geological Maps on hold
Geological Maps in production

Further information:
CEDOCIT - Care and Sales
https://www.gob.mx/sgm/es/videos/geoinfomex-english
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https://www.gob.mx/sgm/es/videos/map-mobile-in-the-capture-of-geological-data-mining
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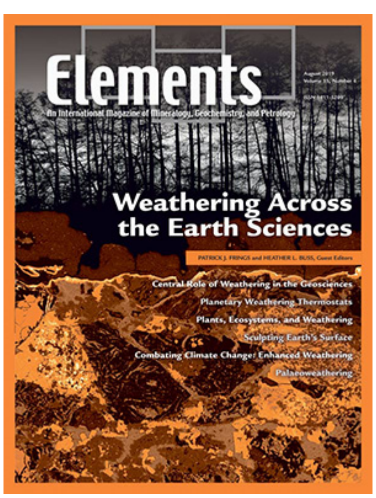
https://www.sgm.gob.mx/Web/SINEM/mineria/empresas_mineras.html
https://www.sgm.gob.mx/extranjeras/Consulta_Minera.jsp
https://portalags1.economia.gob.mx/arcgis/apps/webappviewer/index.html?id=1f22ba130b0e40d888bfc3b7fb5d3b1b

Recently Published in Elements

June 2019, Volume 15, no. 3, South Aegean Volcanic Arc
This issue of Elements focuses on the South Aegean volcanic arc, which lies at the intersection between Europe, Asia, and Africa, in the cradle of European civilization. This issue of Elements reviews particularly the arc's subduction architecture and back-arc geodynamics, genesis of magmas, eruption chronology recorded in marine tephra archives, and hazards posed by eruptions and tsunamis. AAG news in this issue include abstract of article "New Base Metal Mineral Potential in Southern Northwest Territories, Canada (which appeared in **EXPLORE** 181 Dec. 2018) and obituary for Gerry Govett (which also appeared in EXPLORE 183 April 2019).



August 2019, Volume 15, no. 4, Weathering Across the Earth Sciences
This issue of Elements explores the linkages between a variety of weathering processes, especially the play and integral role that they play across a range of geoscience fields. AAG news in this issue includes the AAG President's message and obituary for Tom Lane, both of which also **EXPLORE** 183 (April 2019).

Reminder: AAG members can access past issues of Elements at http://elementsmagazine.org/member-login/ using their e-mail address and member ID.

John Carranza

AAG Councillor Elections for the Term 2020-2021

Each year the Association of Applied Geochemists (AAG) needs motivated and energetic AAG Fellows to stand for election to the position of "Ordinary Councillor." Fortunately, each year some of our most outstanding Fellows are ready, willing, and able to meet this challenge. However, this year I'm sending this to **ALL MEMBERS**, to encourage those Members that have the experience and enthusiasm to be involved, to convert your membership status and look to make a bigger contribution to the AAG (see the website for details).

This note is the annual reminder to AAG Fellows (and Members that could become Fellows) that we need your participation on Council. It is our sincere hope that this email might entice more people to step forward for election to this important position. If you are not eligible to become a Fellow, but want to be more involved, please send me an email message as we are looking to get more of our junior members active in the AAG and other opportunities will be coming available.

Councillor Job Description

The AAG By-laws state that "the affairs of the Association shall be managed by its board of directors, to be known as its Council." The affairs managed by Council vary from reviewing and ranking proposals to host our biennial Symposium to approving application for new membership to developing marketing strategies for sustaining and growing our membership. These affairs are discussed and decisions made at Council teleconferences usually held 3-4 times per year. Each teleconference lasts about 1 hour. In addition, there is often a running email discussion about a selected issue or two between each teleconference. So for a commitment of about 5 hours of your time per year, you can help influence the future of your Association. If you want to spend more than the minimum time required, there is plenty of opportunity to do so through committee assignments and voluntary efforts that greatly benefit the Association.

Qualifications and length of term

The only qualification for serving as Councillor is to be a Fellow in good standing with the Association. Please note the difference between being a Member of AAG and being a Fellow. A Fellow is required to have more training and professional experience than a Member. Consult the AAG web site, Membership section, for further details. If you are not currently a Fellow and have an interest in serving on Council, please go through the relatively painless process of converting to Fellowship status in AAG.

Each Councillor serves a term of two years and can then stand for election to a second two-year term. The By-laws forbid serving more than two consecutive terms, although someone who has served two consecutive terms can stand for election again after sitting out for at least one year. Elections are usually held in Octber-November of the year for a term covering the following two years. Our next election will be in October-November 2018 for the term of 2019-2020.

How to get on the ballot

If you are interested in placing your name into consideration for election to AAG Council, simply express your interest to the AAG Secretary (Dave Smith, email: dsmith@usgs.gov) by October 15, 2019 and include a short paragraph (no more than 250 words) summarizing your career experience. This summary should include the following:

- Your name
- Year that you became a Fellow of AAG
- Earth science degrees obtained, year of graduation of each, and institution of each
- Employment—list major employers and state years worked for each, e.g. 1980-1990, and type of work
- Position(s) held as part of AAG or other past contributions to AAG
- 1-2 sentences about your professional experiences in applied geochemistry

All that is asked is that you bring energy and ideas to Council and are willing to share in making decisions that will carry the Association forward into a successful future. We look forward to hearing from you.

Steve Cook
President, Association of Applied Geochemists
Email: Stephen_Cook@telus.net

29th International Applied Geochemistry Symposium
EXPERIENCE CHILE
Facing the Challenges of Today Using Applied Geochemistry

On behalf of the Organizing Committee, we invite you to take part in the 29th International Applied Geochemistry Symposium which will be held in Viña del Mar, Chile, from November 8 to 13, 2020. The Symposium is sponsored by the Association of Applied Geochemists (AAG) in collaboration with the Sociedad Geológica de Chile (SGCh). It is organized by local representatives of both associations .All information concerning the venue, program, accommodation and events can be found on the Symposium website: http://www.iags2020.cl

Symposium Venue

The venue for IAGS 2020 is the historical Hotel O'Higgins in the City of Viña del Mar, which is also known as "The Garden City". Viña del Mar is 120 km northwest of the capital city of Chile, Santiago. It is a well-known tourist destination, famous for its beaches, the neighboring world heritage city of Valparaiso and abundant parks, as well as nearby famous vineyards in the Casablanca Valley to the east and the San Antonio Valley to the south. The Hotel O'Higgins is a landmark that was built in 1931 and is located in the central part of the city.

Scientific Program

The Scientific Program consists of oral and poster presentations over four days, November 9-10 and 12-13. Oral presentations will be divided into plenary (40 minutes) and general technical sessions (20 minutes). Poster presentations will be on-going throughout the Symposium, including networking sessions during the early evenings.

Proposed technical session themes

- Exploration geochemistry: present and future challenges.
- New field portable technologies: improving analysis and turnaround time in exploration.
- Big data: squeezing multi-element geochemical data by means of data science and self-learning techniques.
- Geochemistry applied to mineral characterization for geological, geometallurgical and resource modeling.
- Environmental geochemistry: closing the gap for sustainable mining and development.
- Water and hydrogeochemistry: challenges in exploration, mining and sustainable development.
- Isotopic geochemistry: new uses in applied geochemistry.
- Geochemistry of the critical zone: linking geology to viticulture and wine.
- Analytical geochemistry technologies and quality assurance / quality control.

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29th International Applied Geochemistry Symposium… *continued from page 27*

Workshops

Pre-symposium workshops planned for November 6 to 8:

- Fundamentals of geochemical exploration methods
- Quality Control / Quality Assurance.
- Field portable geochemistry (XRF, LIBS): applications and limitations.
- Data science in geochemistry: from exploration to geometallurgy.
- Geology, mineralogy and geochemistry in viticulture.
- Geology and metallogenesis of Chile.

Field Trips

The following Post-symposium field trips are planned for November 14 to 20:

- Mineral deposits of northern Chile (5 days).
- Geological and metallogenic evolution of central Chile: The Andean transect (5 days).
- Geology and Vineyards of central Chile: Geochemistry of the critical zone (3 days).
- Polluted areas of central Chile: Detecting the issues (2 days).

Important Dates

- Deadline for abstract submission March 31st, 2020
- Early bird registration June 30th, 2020
- Abstract review and decisions May 31st, 2020
- Pre-symposium field trip registration April 30th, 2020
- Post-symposium workshop registration April 30, 2020

Student Prizes

Prizes for student presentations will include the best oral paper (**the SGS-AAG prize**) and other oral (2nd and 3rd places) and poster presentations (1st, 2nd and 3rd). Sponsorship for various student prizes is available.

For more information see the symposium website: http://www.iags2020.cl

Welcome New AAG Members 2019

Members

Members *are non-voting members of the Association and are actively engaged in the field of applied geochemistry at the time of their application and for at least two years prior to the date of joining.*

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Fellows

Fellows *are voting members of the Association and are actively engaged in the field of applied geochemistry. They are nominated to be a Fellow by an established Fellow of the Association by completing the Nominating Sponsor's Form.*

Student Members

Student Members *are students that are enrolled in an approved course of instruction or training in a field of pure or applied science at a recognized institution. Student members pay minimal membership fees.*

CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry. These events also appear on the AAG web page at: www.appliedgeochemists.org.

Please let us know of your events by sending details to:
Steve Amor
Geological Survey of Newfoundland and Labrador
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Email: StephenAmor@gov.nl.ca Tel: +1-709-729-1161
Or Tom Meuzelaar, AAG Webmaster,
Email: Tom_Meuzelaar@golder.com

2019

22-25 SEPTEMBER	2019 GSA Annual Meeting. Phoenix AZ USA. Website: tinyurl.com/yblcfomo
22-27 SEPTEMBER	International Society for Environmental Biogeochemistry. 24th Symposium. Potsdam Germany. Website: tinyurl.com/y9yngecm
23-27 SEPTEMBER	14th International Congress on Applied Mineralogy. Belgorod Russia. Website: www.geo.komisc.ru/icam2019/en
25-28 SEPTEMBER	Mines and Wines Conference 2019. Wagga Wagga NSW Australia. Website: www.minesandwines.com.au
29 SEPTEMBER – 5 OCTOBER	International Conference on Gas Geochemistry 2019. Milazzo Italy. Website: icgg15.pa.ingv.it
7-20 OCTOBER	SEG 2019: South American Metallogeny: Sierra to Craton. Santiago Chile. Website: tinyurl.com/y7k4dm6j
10-13 OCTOBER	2nd Euro-Mediterranean Conference for Environmental Integration. Sousse Tunisia. Website: www.emcei.net
12-19 OCTOBER	Short course - Geochemistry of Hydrothermal Ore Deposits. Ottawa ON Canada. Website: science.uottawa.ca/earth/short_course
13-18 OCTOBER	9th Hutton Symposium on Granites and Related Rocks. Nanjing China. Website: www.hutton9.com
27-30 OCTOBER	6th International Conference on Selenium in the Environment and Human Health. Yangling/Xi'an China. Website: icsehh2019.csp.escience.cn
29-30 OCTOBER	12th Fennoscandian Exploration and Mining. Levi Finland. Website: fem.lappi.fi/en
6-8 NOVEMBER	XIV Latin American Symposium on Environmental Analytical Chemistry. Bento Gonçalves Brazil. Website: laseac2019.furg.br/inscricoes
25-28 NOVEMBER	2nd Conference of the Arabian Journal of Geoscience. Sousse Tunisia. Website: www.cajg.org
26-27 NOVEMBER	Global Summit on Earth Science and Climate Change. Lisbon Portugal. Website: earthscience.conferenceseries.com
2-6 DECEMBER	American Exploration and Mining Association Annual Meeting. Spokane WA USA. Website: www.miningamerica.org/2019-annual-meeting

2020

12-18 JANUARY	Winter Conference on Plasma Spectrochemistry. Tucson AZ USA. Website: icpinformation.org
20-23 JANUARY	Mineral Exploration Roundup. Vancouver BC Canada. Website: roundup.amebc.ca
7-9 FEBRUARY	Atlantic Geoscience Society Annual Colloquium. Truro NS Canada. ags.earthsciences.dal.ca/Colloquium/Colloquium.php
16-21 FEBRUARY	2020 Ocean Sciences Meeting. San Diego CA USA. Website: www2.agu.org/ocean-sciences-meeting
23-27 FEBRUARY	Minerals, Metals & Materials Society 2020 Annual Meeting & Exhibition. San Diego CA USA. Website: www.tms.org/tms2020
1-4 MARCH	Prospectors and Developers Association of Canada Annual Convention. Toronto ON Canada. Website: www.pdac.ca/convention
2-8 MARCH	36th International Geological Congress. Delhi India. Website: 36igc.org
16-17 MARCH	5th International Conference on Earth and Planetary Sciences. Las Vegas NV USA. Website: www.meetingsint.com/conferences/earthscience
3-8 MAY	EGU General Assembly. Vienna Austria. Website: www.egu2020.eu

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CALENDAR OF EVENTS... *continued from page 30*

7-9 MAY	6th International Conference on Geographical Information Systems Theory, Applications and Management. Prague Czech Republic. Website: www.gistam.org
20-24 MAY	Geological Society of Nevada 2020 Symposium Vision for Discovery: Geology and Ore Deposits of the Basin and Range. Sparks NV USA. Website: www.gsnv.org/2020-symposium
24-25 MAY	Geochemistry of Mineral Deposits (Gordon Research Conference). Castelldefels Spain. Website: tinyurl.com/ybkjgl37
8-10 JUNE	SIAM Conference on Mathematics of Planet Earth (MPE20). Garden Grove CA USA. Website: www.siam.org/Conferences/CM/Conference/mpe20
21-26 JUNE	Goldschmidt 2020. Honolulu HI USA. Website: goldschmidt.info/2020
13-16 JULY	7th Annual International Conference on Geology & Earth Science. Athens, Greece. Website: www.atiner.gr/geology
14-16 JULY	International Archean Symposium. Perth WA Australia. Website: 6ias.org
17-21 AUGUST	34th International Geographical Congress. Istanbul, Turkey. Website: www.igc2020.org/en
24-28 AUGUST	Eurosoil 2020. Geneva, Switzerland. eurosoil2020.com
6-9 SEPTEMBER	11th International Conference on Environmental Catalysis. Manchester UK. Website: www.confercare.manchester.ac.uk/events/icec2020
18-23 OCTOBER	IWA World Water Congress & Exhibition 2020. Copenhagen Denmark. tinyurl.com/y8tpg3jt
9-13 NOVEMBER	29th International Applied Geochemistry Symposium (IAGS). Viña del Mar Chile.

2021

16-20 AUGUST	12th International Kimberlite Conference. Yellowknife NT Canada. Website: 12ikc.ca

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