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Measurement of seasonal variations in stream water chemistry using a portable photometer: case histories from central and southwestern British Columbia, Canada

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INTRODUCTION

Recognising the effect of seasonal variation on chemistry is important when sampling surface and shallow groundwater, as well as considering baseflow (the groundwater component of stream flow) interaction and chemical influence on stream flow from the surface environment (Hatcher *et al.* 2004). Analyte concentrations in surface water can be affected by various factors including dilution of dissolved solids during periods of precipitation, or increased concentration by input of solutes from erosion. Typically, there is more dilution in spring and early summer caused by snow melt runoff (Bhangu & Whitfield 1997). As well, a higher component of groundwater in flowing surface water (baseflow) is expected in summer and into fall as precipitation and associated runoff decreases. This occurs even though groundwater levels tend to decrease during this time (Allen *et al.* 2008). Water pH is dependent on geology, precipitation, environmental conditions and the interactions between them, but it is important to reliably monitor these variables to understand the environment of the area we are sampling the water. Hence, it is important to consider hydrogeochemical conditions, and not necessarily only at the optimal time for water sampling. This consideration will not only help in evaluation of seasonal variation but would also assist with interpretation of the analytical results.

A large seasonal water sampling campaign in which water samples are sent to an analytical laboratory can be expensive. A more cost-effective alternative technique for water sampling involves the use of a field portable photometer. A rapid hydrogeochemistry methodology using a photometer has been discussed extensively by Yehia & Heberlein (2015) and Yehia *et al.* (2017, 2019). This low cost and rapid method for water analysis could be an attractive option for a comprehensive seasonal variation study.

In this article, we describe two surveys that use a photometer to assess seasonal variation of ground water chemistry in regional and local settings (Fig. 1). The regional survey is a Geoscience BC-funded study carried out in 2016 southwest of the Nazko community in central British Columbia (BC), Canada. The second study involves weekly measurements of water chemistry in a city storm drain with suspected groundwater influx at Vivian Creek in southeast Vancouver, BC. This sampling was carried out between June 2018 and May 2019. For both projects, analysis was performed using the Palintest Photometer 8000 and an Oakton PCSTestr 35 pH meter.

Methods to evaluate the effects of weather

One of the objectives of the Nazko study was to investigate seasonal variations in surface water chemistry. The area is hydrologically complex. It has a variety of water body types, including lakes and bogs of different sizes (natural and beaver-dammed) occurring at a

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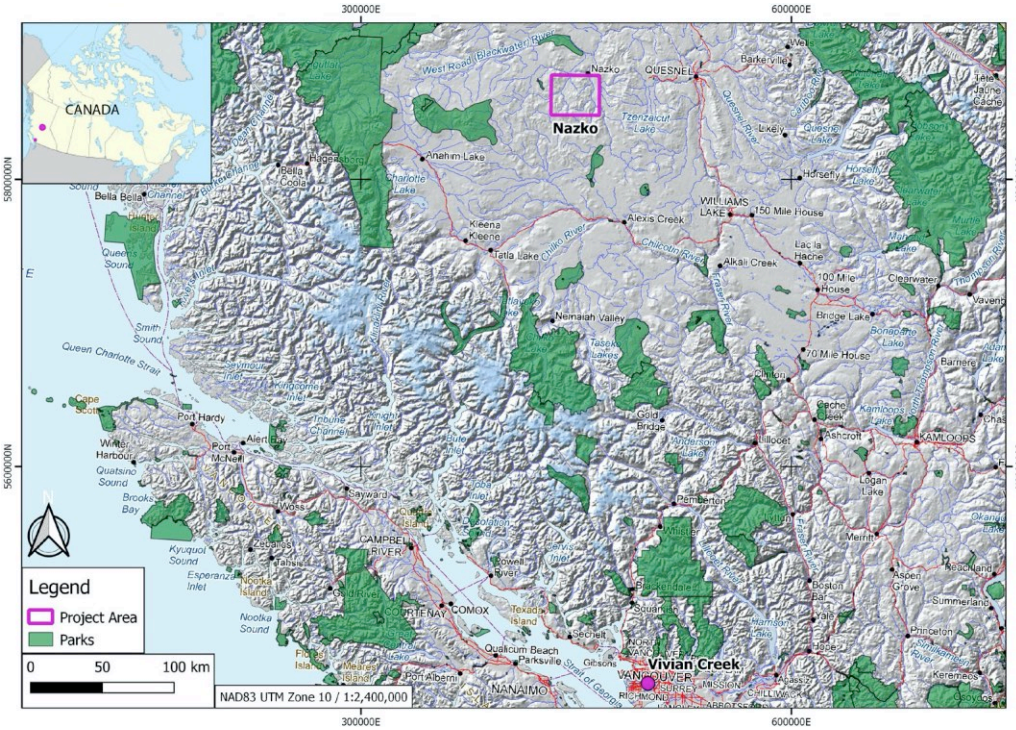

Figure 1. The locations of two study areas in British Columbia, Canada.

EXPLORE

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EXPLORE Publication Schedule

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

- **Deadlines** for submission of articles or advertisements:
  March newsletter: January 15
  June newsletter: April 15
  September newsletter: July 15
  December newsletter: October 15
- **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 high resolution (2000 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. 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 fourth **EXPLORE** issue of 2020. This issue features one article about seasonal variations in stream water chemistry and their measurement using a portable photometer - case histories from central and southwestern British Columbia, Canada. The article was written by Ron Yehia, Dave Heberlein and Ray Lett.

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, Bob Garrett, Stew Hamilton, Dave Heberlein, Ray Lett, David Leng, Jessey Rice, and Ron Yehia.

Beth McClenaghan
Editor

President's Report

I am sure most of us would agree that 2020 has been an *annus horribilus* and that we are all looking forward to seeing the end of it. In contrast to the disappointments of the past 8 months, the last few weeks have brought several promising announcements from pharmaceutical companies regarding preliminary results from stage 3 drug trials. These announcements suggest effective and safe responses to their vaccines. Even normally conservative epidemiologists in Australia now anticipate the roll out of a vaccine in early 2021 to high-risk individuals and the widespread vaccination of the Australian population by midyear.

The news is not just welcome to the World's population (particularly politicians, bar one), it is a credit to science in general and specifically to our colleagues in the life sciences. Not only have several vaccines been developed in an amazingly short time, the efficacy of some of the vaccines appears to have exceeded expectations. Still, it is early days yet and those of us who have worked in mineral exploration for the junior end of the market will understand the pressure to get early promising results out into the public domain, only to have subsequent testing (i.e., drilling) result in eventual disappointment. Let us hope this is not the case in this circumstance while acknowledging that the pharmaceutical companies involved are under enormous pressure.

It is therefore ironic that science appears to be coming to the rescue at a time when scepticism in science and what scientists have to say is widespread. This may reflect a poor level of scientific literacy and/or critical thinking within a general population awash with misleading information on social media, but it also indicates a distrust of science by many. We should therefore all be concerned that evidence-based decision-making is under attack and that scientists are often co-opted into political debates that taint the perception of their objectivity in the eyes of the public.

But I digress. Assuming the roll-out of a coronavirus vaccine proceeds as anticipated, will this timing be soon enough for us to proceed with the IAGS in Viña del Mar, Chile in October 2021? We will have to monitor developments closely as the decision to move to a virtual symposium or postpone again would have to be made early in 2021 to allow for the new preparations required.

The AAG council is also moving forward with several initiatives, including:

- A reminder to our colleagues in academia about the benefits available to students through the AAG, particularly the potential for funding of research analyses
- Review and update of the AAG's guide to Writing Geochemical Reports (2nd edition published in 2000)
- Update of the scope for contributions to GEEA to make it more inviting for environmental and geometallurgical topics
- Finalisation of a memorandum of understanding with the International Association of Mathematical Geosciences (IAMG)
- Changes to the membership renewal process on the AAG web site to reflect that GEEA will only be available in digital form going forward
- Further development of on-line resources such as presentations, practical problems and reviews, and a listing of past articles in **EXPLORE**.

Many of these initiatives will be important to ensure the continuing relevance of our association, particularly during an upsurge in mineral exploration activity. I would encourage all members to contribute where they can. In closing, I would like to thank those members who attended the virtual Annual General Meeting in September. Their presence led to some robust discussion about the scope of GEEA and contributed to the revisions that have been recommended. However, I hope our next AGM will be non-virtual!

Dennis Arne
AAG President

Measurement of seasonal variations in stream water chemistry… *continued from page 1*

range of elevations, and complex water courses running into and out of the lakes as well as hard to identify groundwater discharge sites. Changes in water chemistry were monitored through the analysis of repeated water samples collected at the same locations during sampling campaigns in June, August, and October. Throughout the survey, above average precipitation (Fig. 2) raised concern about the possibility of large fluctuations in analyte concentrations (see below).

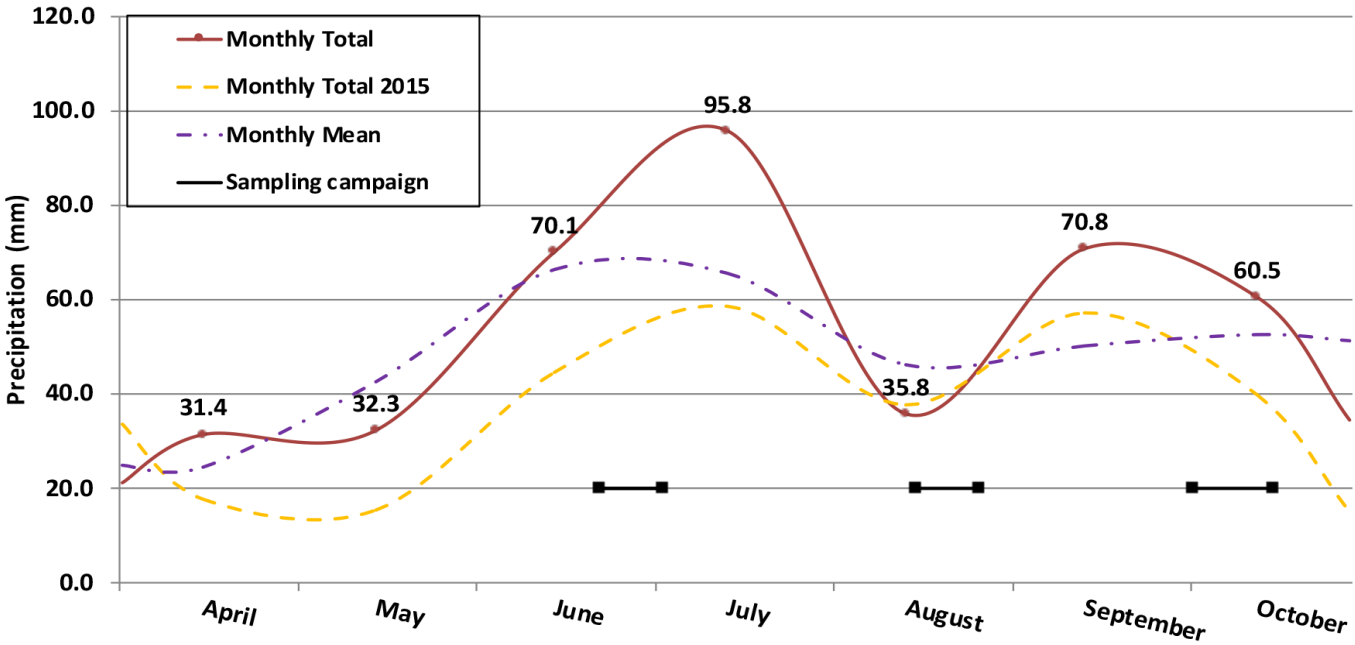

Figure 2. Nazko study precipitation chart. Values are from Environment Canada Quesnel station.

In the Vivian Creek study, one of the main objectives was to examine if the photometer was able to identify seasonal trends in the water chemistry at a single site. Unfiltered samples (according to reagent manufacturers' procedures) and field duplicates were collected and analyzed from the city storm drain output between 10 am and noon weekly (mostly on Mondays). Weather during the sampling period was marked by a drier than usual summer followed by a wetter than average fall (September-December) and winter (December-March), with late prolonged snowfall during February, and a drier than usual spring (March-June) (Fig. 3). A weather station using a digital La Crosse wireless rain gauge was used to measure precipitation close to the study site.

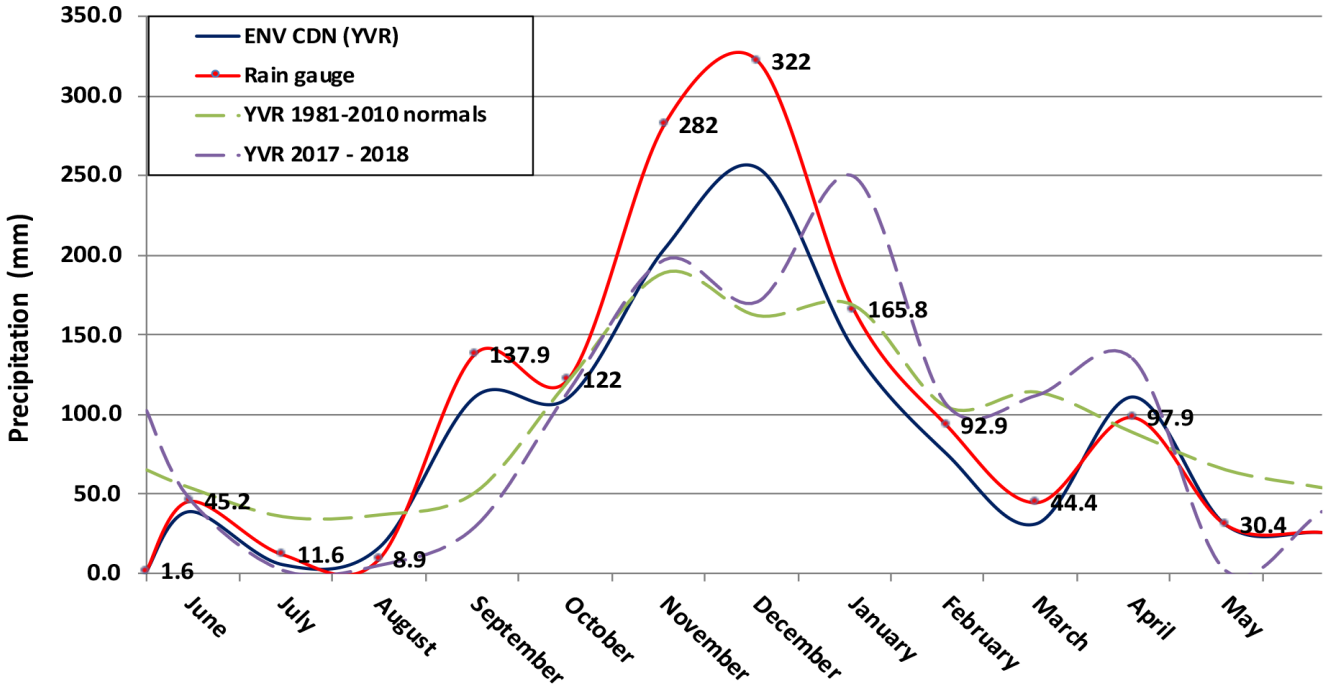

Figure 3. Vivian Creek, Vancouver precipitation chart. Environment Canada (ENV CDN) data are from the Vancouver airport (YVR) station ten kilometres west of the sample site.

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RESULTS

Nazko

For the Nazko study, the effect of rainfall and other seasonal changes on analyte levels can be demonstrated by (1) plotting the measured concentrations at each site over time; and (2) by plotting results for each season in order of increasing concentration. The first plot is useful because it compares concentrations directly by season at each site, while the second provides an overall seasonal comparison. Charts for total Cu and SO_4 do not include data for June because June turbidity readings revealed false trends in the photometer results caused by a high load of suspended particles that were too fine to be removed by the 0.45 micron filtration. This was corrected in the August and October data after consultation with Palintest (Yehia *et al.* 2017), but not in the June data because no archived water samples were available for reanalysis.

Water pH results (Fig. 4a) are reasonably consistent despite the variable precipitation during the sampling campaigns. Of all the analytes, Al (Fig. 4b) displays the strongest response to rainfall and there is a large difference in seasonal Al concentrations, with values increasing during higher precipitation events. In contrast, total hardness (as $CaCO_3$ - Fig. 4c) displays a gradual increase with the lowest concentrations measured in June and the highest values detected in October. Unsurprisingly, Mg and K show comparable trends to hardness reflecting concentrations of other cations measured by the hardness analysis

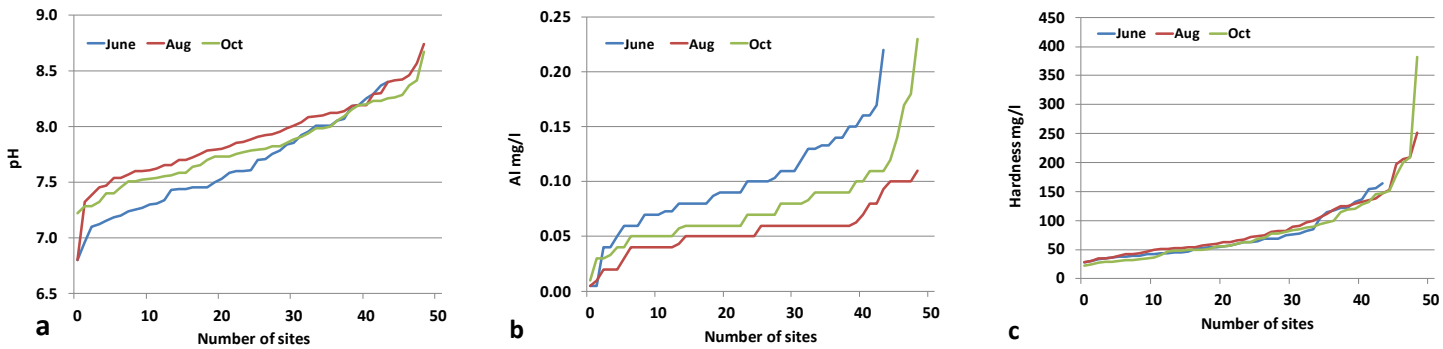

Figure 4. Nazko study seasonal variation Global Positioning System (GPS) stations and seasonal average for pH (a), and cumulative comparison for, Al (b), and total hardness ($CaCO_3$, c).

Copper displays a strong seasonal variability (Fig. 5a). As expected, concentrations were highest during the October survey when precipitation increased. This may be the result of higher concentrations caused by increased baseflow as a

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component of the surface water, in addition higher concentrations following rain known as first flush. Finally, SO_4 (Fig. 5b), an important mineralization indicator, displays low concentrations (1.0 to 14.0 mg/l) throughout the surveys.

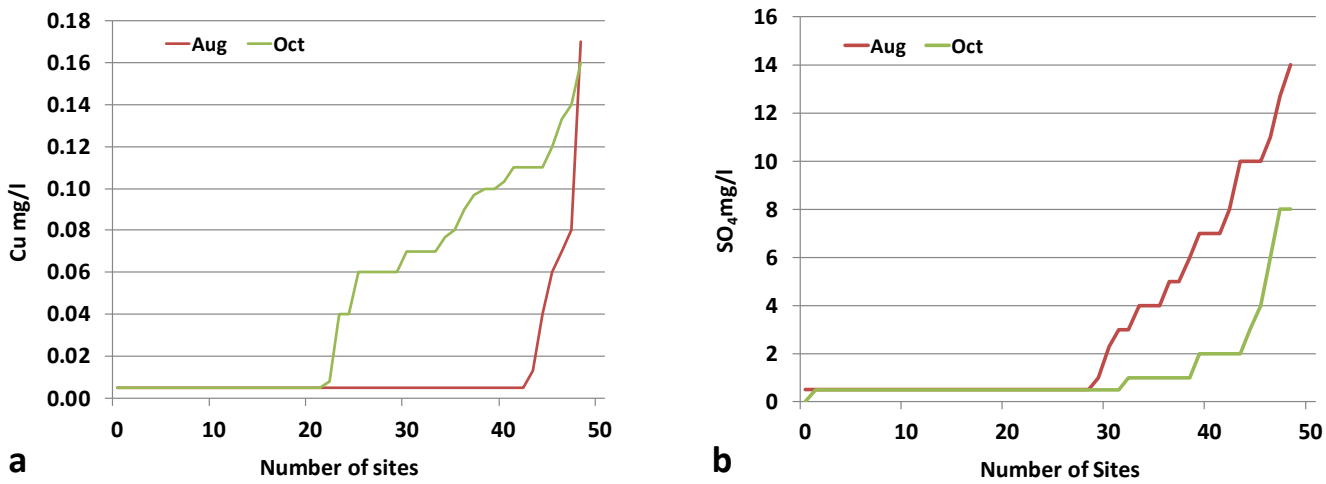

Figure 5. Nazko study seasonal variation GPS stations seasonal cumulative comparison for total Cu (a) and SO_4 (b).

Vivian Creek

In the Vivian Creek study, seasonal variations are demonstrated by (1) plotting results against weekly precipitation, (2) plotting results versus monthly precipitation and by (3) with box plot diagrams. The first charts examine in more detail the relationship between analyte concentration and precipitation. The second monthly chart provides simplified trends that show overall seasonal variation for the year of sampling. The boxplot (Krüzl, 1988) is a graphical way of visually summarizing the distribution of values in a sample or population and could aid in our comparison of water chemistry seasonal variations. Box plots provide information about the skewness of a distribution, the range of values as well as the median of the distribution.

As shown in Figure 6a-c, pH varies between neutral to slightly alkaline with a maximum value of 7.8. There is no obvious relationship between pH and precipitation (Fig. 6a). Vivian Creek pH appears to be more neutral during the summer and slightly more alkaline in the fall and winter, although the highest value recorded was in June (Fig. 6b). The box plots (Fig. 6c) show a gradual decrease in median values in late summer followed by a subtle increase from November to February followed by another gradual increase through the spring. The increase in pH in the winter occurs immediately after the period of maximum precipitation (in December), and may be attributed to increased dilution during the winter.

As seen in the Nazko study, the Al concentration in water at Vivian (Fig. 6d-f) is sensitive to precipitation and shows a strong trend of decreasing values between December and May (Fig. 6d). Although no results were measured in the summer of 2018, results for the remainder of the year show a systematic decrease in concentration starting immediately after maximum precipitation in December (Fig. 6e), which is clearly visible in the monthly chart and box plots (Fig. 6f).

Total hardness shows a positive correlation with precipitation between June and November (Fig. 6g-i) but from February to May, it remains consistently high while still demonstrating a sympathetic relationship to precipitation (Fig. 6g). Monthly graphs (Fig. 6h) and box plots (Fig 6i) confirm this pattern. The higher concentrations detected from February to May are likely due to the use of road salt following snowfall in the middle of February. The snow remained on the ground until the end of the month. Although the City of Vancouver uses

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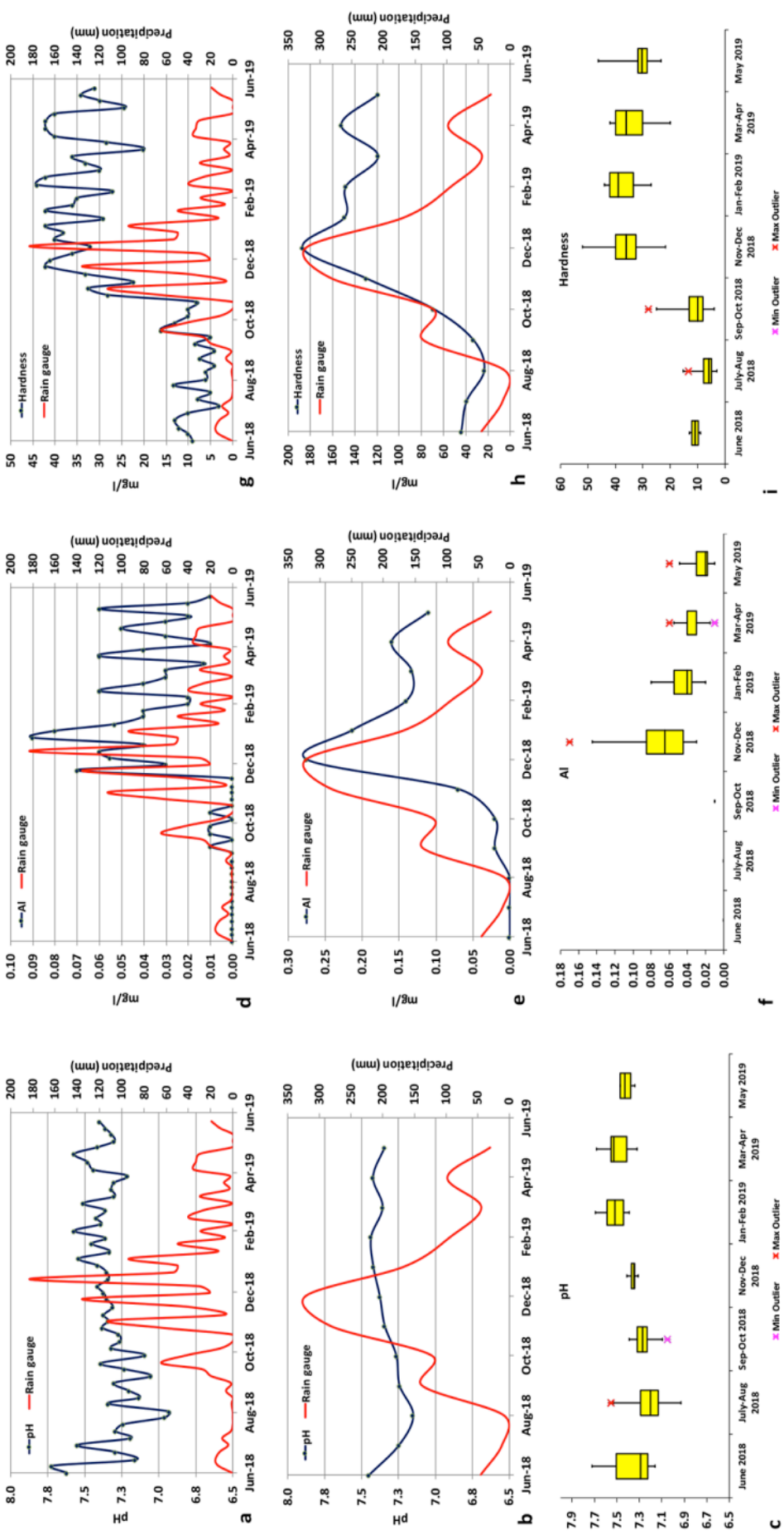

Figure 6. Vivian Creek seasonal variation study weekly and monthly charts and boxplot for pH (a, b, c), Al (d, e, f) and total hardness ($CaCO_3$, g, h, i). Note that for pH, monthly values are average and for Al and hardness, monthly values are totals (weekly added). In the box plots the box, bisected by the median, extend from lower to upper hinge and contain 50 percent the values (interquartile range). The whiskers extend from the hinges to a value of hinge +/- 1.5 the interquartile range. Values beyond the whiskers are considered as outliers.

untreated NaCl as road salt in the winter (City of Vancouver, personal communication), impurities can be observed with pink and grey salt possibly containing higher Ca, Mg and Mn. Road salt input by Cl^-, Mg and Mn show comparable trends. Interestingly, although salinity increased considerably following the application of road salt (Cl^- weekly high of 45.80 ppm and salinity of 239.0 ppm), pH did not change significantly and this may be due to the increased buffering of the water chemistry by the higher dissolved Ca and Mg concentrations.

In contrast, Cu (Fig. 7a-c) and SO_4 (Fig. 7d-f) do not demonstrate a clear seasonal trend. There is no observable correlation between Cu, SO_4 and precipitation on either the weekly or monthly charts, while the box plot shows a wide range of values in January to May.

DISCUSSION

The two main objectives of this paper were to identify if seasonal variation in water chemistry could be measured by photometer and to assess those seasonal variations in regional and local settings. In both cases, we were able to observe seasonal variations in the water chemistry for some of the measured analytes and that the photometer could detect those trends.

For the Nazko study where there was above average precipitation from June to October, results reveal how the analyte concentrations responded to increased precipitation. Despite

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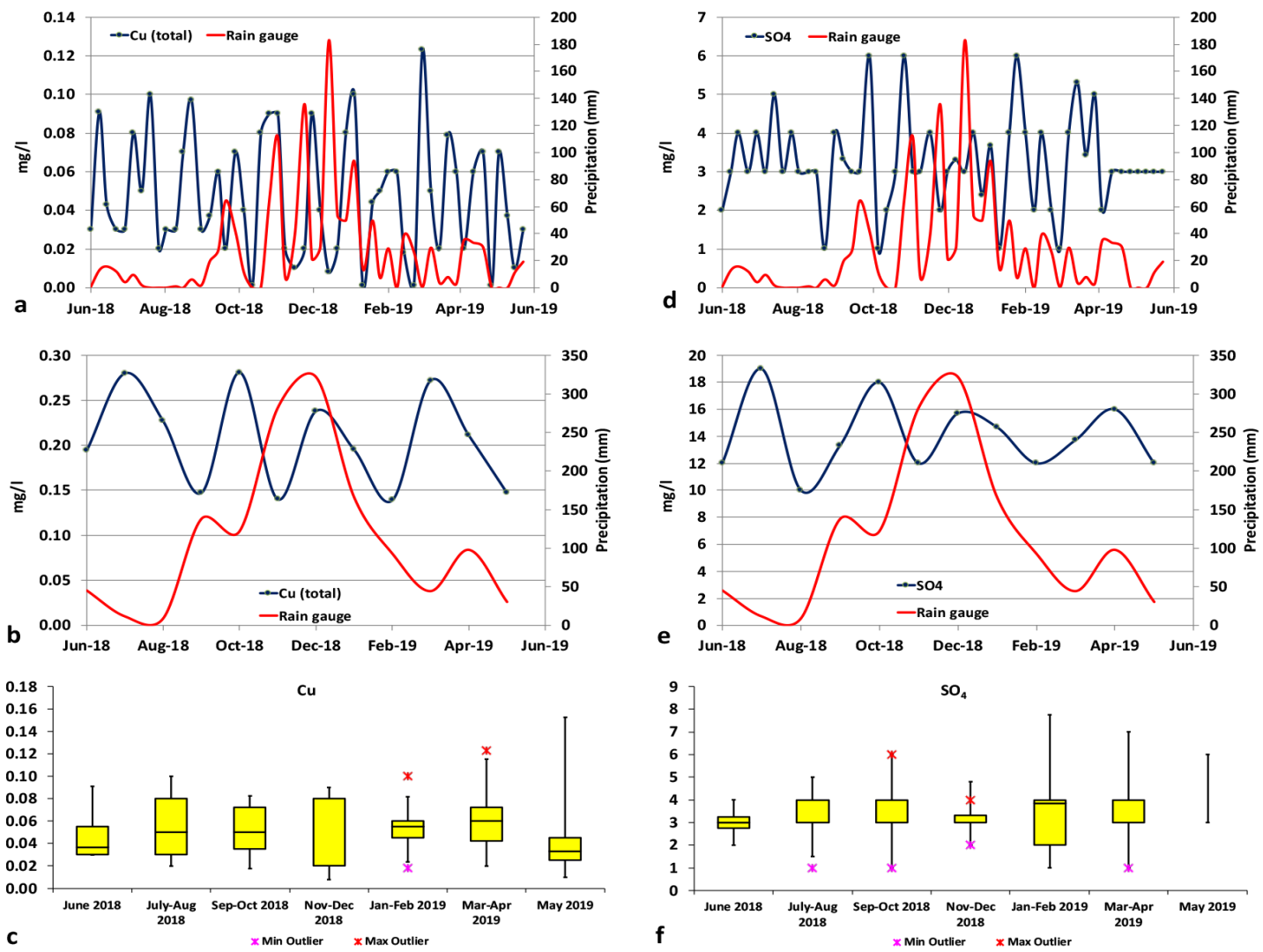

Figure 7. Vivian Creek seasonal variation study weekly and monthly charts and box plot for total Cu (a, b, c) and SO_4 (d, e, f).

the elevated turbidity and the problems caused by it in the June Cu and SO_4 readings, sufficient data were collected to provide an understanding of the behaviour of these analytes. Some of the analytes, including Mg, K and hardness, showed little variation between seasons whereas analytes such as Cu responded to changes in precipitation. Of note, the highest SO_4 measurement was in August, making it a better time for sampling streams as part of a resource exploration survey because the SO_4 peak is earlier than that of other pathfinder elements (e.g. Cu). Even though concentrations of Ca and K increased in October, their element patterns did not change significantly from August to October.

In the Vivian Creek study, some analytes such as Al and hardness displayed clear seasonal variations, whereas Cu and SO_4 did not. As with the Nazko results, Al showed a strong positive correlation with precipitation. Hardness showed a similar trend, albeit not as pronounced as Al, and we suspect that if it were not for the effect of road salt use, hardness may have continued decreasing during the second part of the year. For Cu and SO_4 no obvious seasonal trends were observed. The fluctuations in Cu and SO_4 concentrations may be attributed to: (1) precipitation and or weathering; (2) input of contaminants from city street runoff.

The photometer detection limit, sensitivity, and reliability are shown to be adequate to allow for measurement of seasonal variations in water chemistry. The low cost and rapid analysis mean that daily, or even multi-daily, variations can be investigated. The inexpensive reagents (about $0.50 per analyte) allow for customization of the analyte suite which can further reduce the cost.

An interesting implication of the Vivian Creek results is that this type of testing could be suitable for environmental monitoring. The increased water hardness after the addition of road salt could be detected well over two months after application of salt and may have had implications to base flow and ultimately groundwater contamination pH. This type of monitoring with the photometer can be extended to other types of resource industries, such as daily downstream analysis from drilling sites, tailings pond dams, landfills or forestry stream monitoring.

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CONCLUSIONS

In summary, this investigation of seasonal variability using a portable photometer shows that:

- The low cost, rapid analysis and low detection limits of the photometer make it a practical option for seasonal variability investigations, and for environmental monitoring.
- The seasonal timing for selection of various analytes, or when the samples were collected for testing, should be taken under careful consideration.
- On a regional mineral exploration water survey scale, the ideal season for sampling is late summer.
- For some analytes, two sampling campaigns in different seasons may be sufficient to demonstrate variation that will possibly be needed to be taken under consideration.

ACKNOWLEDGMENTS

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

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Benefits of student membership in the Association of Applied Geochemists

A number of you are actively involved in teaching or supervision of applied geochemistry at the tertiary level or know of students who are contemplating an applied geochemistry career. The Association of Applied Geochemists (AAG) realizes that the future of applied geochemistry is with students, and here we provide a brief overview of what the Association is doing to encourage student membership and support applied geochemistry students, with a view to you passing this information about what AAG can do for them on to the students that you know.

Student membership is inexpensive:
Students who are enrolled in an approved course in pure or applied science at a recognized institution can apply for Student Membership of AAG for just $US10/year. This membership provides digital access to the journal of the AAG - *GEOCHEMISTRY: Exploration, Environment, Analysis (GEEA)*– as well as digital versions of ELEMENTS, and the Association's quarterly newsletter EXPLORE. Go to www.appliedgeochemists.org Membership/Membership Registration for information on how to apply for Student Membership.

Defraying the cost of thesis-related analytical work: the Student Support Initiative
A major cost of applied geochemistry thesis work is acquiring high-quality geochemical analyses. Recognizing this, AAG introduced the Student Support Initiative (SSI), with which AAG student members can apply via AAG for in-kind analytical support from participating commercial laboratories. The SSI is open to all AAG student members who are carrying out full time thesis work involving applied geochemistry for a BSc (Hons), MSc, or PhD. Find out more about the scope of projects currently supported, the participating laboratories, and how to apply at www.appliedgeochemists.org Resources/Students.

Acknowledging peer-reviewed publication: the Student Paper Prize
Every two years, the AAG awards a prize to the best paper published in our journal GEEA by a student, on topics of exploration or environmental geochemistry related to mining activities. The prize consists of CAD $1000.00, a 2-year membership of AAG, and US $500 towards expenses for attending an AAG-sponsored meeting, where the prize is presented. Go to www.appliedgeochemists.org Resources/Students/Student Paper Prize.

Support to attend the biennial International Applied Geochemistry Symposium
The AAG holds its international symposium, the International Applied Geochemistry Symposium (IAGS), every two years. AAG provides financial assistance for costs of travel, accommodation and registration to student members presenting at the symposium. The next IAGS is in Chile in October 2021. Find out more at www.iags2021.cl.

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All AAG members, including students, can post and access online presentations on a newly developed part of the AAG website. Go to www.appliedgeochemists.org/ Presentations/Other Presentations for more information.

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Al Arsenault
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Call for Papers:
Hydrochemistry related to exploration and environmental issues

Scope

Our journal *Geochemistry: Exploration, Environment, Analysis* is seeking papers for inclusion in a thematic collection dealing with hydrochemistry. Specifically we seek papers that involve the use of hydrochemistry in mineral deposit exploration, understanding environmental issues related to mining and mineral processing, remediation of sites contaminated by mining and mineral processing, water quality connected to water resources and agriculture and the development of analytical techniques in hydrochemistry for mineral deposit and environmental applications.

We welcome papers involving major- and trace-element hydrochemistry, stable isotope hydrogeochemistry, radiogenic isotope geochemistry, and organic hydrogeochemistry applied to mineral deposits and the environment. We intend to publish a mix of review and original research papers. We welcome papers describing innovative approaches, classical approaches, and case histories that have broad international interest.

Photo courtesy of Rob Bowell.

Deadline for submission of manuscripts: **31 July 2021**

Submission

Submission of a manuscript for possible inclusion in this thematic collection is no guarantee of eventual acceptance and publication. All published contributions must meet the normal, rigorous review standards with regard to both content and presentation. Authors who are non-native English speakers should consider having a native English speaker edit their manuscript prior to submission.

When submitting manuscripts make sure to identify the submission as being for 'Hydrochemistry related to exploration and environmental issues' by selecting it from the 'Section/Category' drop-down list.

For queries please contact the Journal Manager: geea@geolsoc.org.uk

Author guidelines can be found: https://www.geolsoc.org.uk/geea-authorinfo

New publication from the Geological Survey of Canada

For more than 50 years, researchers at the Geological Survey of Canada (GSC) have developed, tested, and refined till geochemical and indicator mineral methods as they are applied to mineral exploration, provenance studies, and environmental research in glaciated terrain across Canada. The cumulative experience and knowledge were used to produce and publish the GSC's first comprehensive field and laboratory methods protocol manual for till geochemical and mineralogical surveys in 2011. The newly published (2020) version is an update and augmentation of this earlier version and presents the major concepts of till as a sample medium, glacial dispersal, field and laboratory procedures, and a geochemical and/or indicator mineral metadata reporting template to be included in reports that publish geochemical data. These protocols may be useful to other government organizations and the exploration industry.

Title:
Geological Survey of Canada Till Sampling and Analytical Protocols: from Field to Archive: 2020 update

Free download of the publication:
https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/downloade.web&search1=R=326162

Beth McClenaghan

OBITUARY

ARTHUR YOUNG SMITH JR. 1929-2020

Arthur Young Smith, Jr., age 90, passed away on Sunday, August 23, 2020, in Knowlton, Québec, Canada. He was born in Detroit, Michigan, USA and graduated from McGill University in 1957 with a Bachelor of Science (Honours) in Geology and received his Master of Science (Honours) in Geology from Queen's University in 1961. He completed course work for his PhD at Carleton University but started working before he could complete all the PhD requirements.

Art's career was as varied as the places it took him. Coming from an old Ottawa family that was artistic, Art started out as an assistant in the famous Ottawa studio of the photographer Malak Karsh and became an adept photographer in his own right. When the opportunity arose to put his photographic skills to work with the Geological Survey of Canada, Art seized the adventure of doing airborne photo and magnetic surveys in northern Alberta, the Northwest Territories and Yukon, often flying in the belly of old war-time Lancaster bombers and the Canso flying boat, operating the cameras and magnetometers. His photos of Fort McMurray in the early fifties, capturing Fort Mac before the oil boom, are in the archives of the city.

He quickly fell in love with the opportunities that geology, geological surveying, and geochemistry gave him for understanding the world at scales ranging from the continental to the elemental. Early in his career, he and the family spent summers in Bathurst, New Brunswick, Elliot Lake and Bancroft, Ontario, working on gold and uranium deposits, and doing groundwater surveys. His early survey work helped him develop some of the early radon detection equipment that came into commercial use. His work as a geologist and geochemist for the Geological Survey of Canada (GSC) and the International Atomic Energy Agency (IAEA) took him from Canada's Arctic, Subarctic, and Maritime provinces to Uganda, Greece, Peru, Morocco, Honduras, Chile, Pakistan, Fiji, Jamaica, Sri Lanka, and Niue – doing original fieldwork and training researchers on four continents in methods that he and his teams developed for uranium exploration and mapping.

A proud moment at the end of his work in Greece was the invitation to brief the Greek Prime Minister Constantine Karamanlis on the geology of North Greece. Upon completion of the Moroccan project he moved to IAEA headquarters in Vienna, Austria where he worked in the Division of Nuclear Fuel Cycle and Waste Technology until his retirement in 1989. In April 1986, during the Chernobyl accident, he was a member of the team that advised the IAEA on natural background radiation. After retirement, as a former member of the IAEA, he shared in the 2005 Nobel Peace Prize, which was awarded 'for their efforts to prevent nuclear energy from being used for military purposes and to ensure that nuclear energy for peaceful purposes is used in the safest possible way'. He was immensely proud of receiving the Nobel Peace Prize because he had been a lifelong proponent of the safe, non-military use of nuclear energy the result of seeing the Nagasaki and Hiroshima bombings and their effects as a young man.

Art was a lifelong member of the Prospectors and Developers (PDAC), the Society of Economic Geologists (SEG), and the Canadian Institute of Mining and Metallurgy (CIM). He was also a member of the Professional Engineers of Ontario, being granted a P.Eng. in July 1970 when geochemistry was admitted as an Engineering discipline.

He was the author or co-author of forty-six publications issued by the Geological Survey of Canada, the IAEA, and various journals on topics in mineral exploration, uranium and radon methods, technical reports in uranium exploration and development. He was also the editor of various IAEA publications on uranium geology, geochemistry, Gamma-ray spectrometry and uranium exploration policy. Through his work, Art and his family lived in Canada, Uganda, Greece, Peru, Morocco, and Austria. In 1989, he retired from the IAEA and moved full-time to his farm in Fulford, Québec, where he operated a woodlot and lived until a month before his death. He was a member of the Environmental Advisory Committee for the Town of Brome Lake and of Renaissance Lac Brome for many years.

He was a devotee of classical music, opera, jazz, and most other forms of music, a gifted storyteller, a voracious reader, and a proud Canadian, fascinated with Canada's history and contemporary politics. Always a bon vivant his taste in wine was exceptionally broad, but Scotch was his drink of choice. He was blessed with an international network of friends, developed through his professional life and personal contacts, with whom he stayed in contact throughout his long life and whose careers and adventures gave him great pleasure.

Modified from:
https://www.legacy.com/obituaries/theglobeandmail/obituary.aspx?n=arthur-young-smith&pid=196714593

The AAG-SGS Student Presentation Prize

The Association of Applied Geochemists, through the support of SGS Mineral Services, awards a prize for the

Best oral presentation by a student at the biannual International Applied Geochemistry Symposium (IAGS)

The intent of this prize is to encourage the presentation of high quality research by students at an International Applied Geochemistry Symposium (IAGS) and provide further incentive to publish the results of the research in the Association's journal, *Geochemistry: Exploration, Environment, Analysis* (GEEA). The winner is determined based on feedback from a group of judges that includes Fellows and Members of the Association. Criteria for judging the presentations include excellence and originality in research design, research execution, interpretation, and the oral presentation itself. Honours, Masters, and Doctoral students are all eligible. The format of the presentation may vary between IAGS.

The Rules

1. The paper must be presented by the student at an IAGS as an oral paper, in the format specified by the IAGS organizing committee.
2. The conference presentation and paper must be largely based on research performed as a student. The student's supervisor or Head of Department may be asked to verify this condition.
3. The decision of the AAG Symposium Co-ordinator (in consultation with a representative from SGS) is final and no correspondence will be entered into.
4. Entry in the competition is automatic for students (but students may elect to "opt out").
5. The detailed criteria and process for assessing the best paper will be determined by the AAG Symposium Co-ordinator in consultation with the AAG Council and the LOC.
6. A paper substantially derived from the material presented at the IAGS and submitted for publication in the Association's journal *Geochemistry: Exploration, Environment, Analysis* within the timeframe specified by the AAG (normally 12 months) will be eligible for the increased value of the prize.

The Prize

1. $700 CAD from SGS Minerals Services (normally presented to the winner at the end of the relevant IAGS) with a further $300 CAD from AAG if a paper related to the oral presentation is submitted to GEEA within the nominated time frame after the IAGS;
2. A 2-year membership of the Association, including subscription to GEEA and EXPLORE; and
3. A certificate of recognition.

David Cohen
Chair of Student Prize Committee
University of New South Wales
Email: d.cohen@unsw.edu.au

Welcome New AAG Members in 2020

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.

Alan Cardenas
PhD Student
University of New Brunswick
638 Forest Hill Road
Fredericton, NB
CANADA E3B 4K6
Membership # 4434

Chase Watkins
PhD Student
Boone Pickens School of Geology
Oklahoma State University
1909 Ironhorse Circle
Norman, OK
USA 73072
Membership # 4437

Sioban Keane
Queen's University
14 Vine Street, Unit 3
Kingston, ON
CANADA K7K 3X7
Membership # 4438

Michael Aberle
University of Canberra
20 Murranji Street
Hawker, ACT
AUSTRALIA 2614
Membership # 4439

Regular 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.*

Marco Alsina
Conference Professor
University of Talca
Camino a Los Niches Km 1
Curico, Maule
CHILE 3340000
Membership # 4431

Dr. Julien Walter
Professor, UQAC
555 boulevard de L'Université
Chicoutimi, QC
CANADA G7H 2B1
Membership # 4432

Mr. Davis Warren
Geochemist
Life Cycle Geo, LLC.
4585 S Zang St.
Morrison, CO
USA 80465
Membership # 4433

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 conversion to Fellow form. https://www.appliedgeochemists.org/documents/aag_fellowship_application.pdf*

Geochemistry
EXPLORATION, ENVIRONMENT, ANALYSIS

The journal is abstracted and/or indexed in *AGI's Bibliography and Index of Geology, Chemical Abstracts, Current Contents, Engineering Index, GEOBASE, GeoRef, Mineralogical Abstracts, PASCAL/CNRS, GeoArchive, Thomson ISI database (SCIE, CC/PC & ES)*

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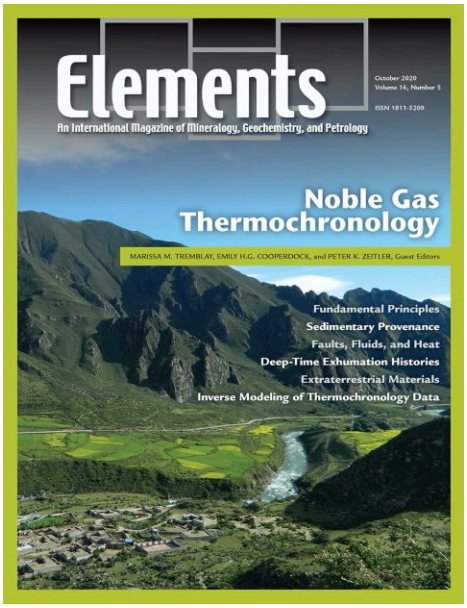
Recently Published in Elements

October 2020, Volume 16, no. 5, Noble Gas Thermochronology

This issue comprises six articles that highlight how noble-gas thermochronology can be used to address questions such as when and how valleys are cut by glaciers, from where sediment is sourced, what thermal conditions occur on fault planes during slip, and how the surfaces of planetary bodies evolve on billion-year timescales, as well as what new avenues of research noble-gas thermochronology could be used for in the future.

There are two AAG news items in this issue of Elements. First, obituary for John Alexander Hansuld (1931–2019). Second, the abstract of an article that appeared in issue 185 (December 2019) of the **EXPLORE** newsletter, namely "Petrological and Geochemical Study of the Precambrian Basement Complex Rocks in Katchuan Irruan Areas, Southeast of Ogoja, Southeastern Nigeria" by C.U. Ibe, S.C. Obiora, and T.C. Davies.



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

John Carranza

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, Email: steve.amor2007@gmail.com
or
Tom Meuzelaar, AAG Webmaster, tom@lifecyclegeo.com

Changes are likely, and users of the listing are strongly advised to carry out their own research as to the validity of an announcement.

2021

18-21 JANUARY	Mineral Exploration Roundup 2021. Vancouver BC Canada. Website: roundup.amebc.ca
9-12 FEBRUARY	Australian Earth Sciences Convention. Hobart TAS Australia. Website: www.aesconvention.com.au
7-10 MARCH	Prospectors and Developers Association of Canada Annual Convention. Toronto ON Canada. Website: www.pdac.ca/convention
14-18 MARCH	Minerals, Metals & Materials Society 2021 Annual Meeting & Exhibition. Orlando FL USA. Website: www.tms.org/tms2021
23-25 APRIL	3rd International Conference on Geographical Information Systems Theory, Applications and Management. Prague Czech Republic. Website: www.gistam.org
25-30 APRIL	EGU General Assembly 2021. Vienna Austria. Website: www.egu2021.eu
9-14 MAY	IWA World Water Congress & Exhibition 2020. Copenhagen Denmark. Website:tinyurl.com/y4s4u9fm
17-19 MAY	GAC-MAC Joint Annual Meeting London ON Canada. Website: gacmac2021.ca
17-20 MAY	Geological Society of Nevada 2021 Symposium. Sparks NV USA. Website: www.gsnsymposium.org
1-3 JUNE	9th World Conference on Sampling and Blending. Kristiansand Norway. Website: wcsb10.com
14-18 JUNE	9th International Workshop on Compositional Data Analysis. Toulouse France. Website: www.coda-association.org/en/codawork2021
21-24 JUNE	SIAM Conference Mathematical and Computational Issues in the Geosciences. Milan Italy. Website:www.siam.org/conferences/cm/conference/gs21
4-9 JULY	Goldschmidt 2021. Lyon France. Website: tinyurl.com/y869e3wo
8-9 JULY	Sampling 2020. Lima Peru. Website: tinyurl.com/y8ddlbxu
1-6 AUGUST	Geoanalysis 2021. Freiberg Germany. Website: geoanalysis2021.de
16-20 AUGUST	34th International Geographical Congress. Istanbul Turkey. Website: www.igc2020.org/en
16-21 AUGUST	36th International Geological Congress, Delhi India. Website: www.36igc.org
23-27 AUGUST	Eurosoil 2021. Geneva Switzerland. Website: eurosoil2020.com
29 AUGUST-2 SEPTEMBER	3rd European Mineralogical Conference. Cracow Poland. Website: emc2020.ptmin.eu/
12-17 SEPTEMBER	30th International Meeting on Organic Geochemistry. Montpellier France. Website: eage.eventsair.com/imog-2021
13-17 SEPTEMBER	41st International Symposium on Environmental Analytical Chemistry. Regensburg Germany. Website: iaeac.com
9-17 OCTOBER	28th Colloquium of African Geology (18th Conference of the Geological Society of Africa). Fez Morocco. Website: www.fsdmfes.ac.ma/CAG28
24-29 OCTOBER	29th International Applied Geochemistry Symposium (IAGS). Viña del Mar Chile. Website: iags2020.cl
2-4 NOVEMBER	13th Fennoscandian Exploration and Mining. Levi Finland. Website: femconference.fi
15-18 NOVEMBER	15th Biennial Meeting of the Society for Geology Applied to Mineral Deposits. Rotorua New Zealand. Website: confer.eventsair.com/sga2021

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CALENDAR OF EVENTS... *continued from page 19*

2022

24-29 JULY	15th International Conference on Mercury as a Global Pollutant. Cape Town South Africa. Website:www.ilmexhibitions.com/mercury2022
31 JULY- 5 AUGUST	World Congress of Soil Science 2022. Glasgow UK. Website: www.soils.org.uk/wcss2022
15-19 AUGUST	12th International Kimberlite Conference. Yellowknife NT Canada. Website: 12ikc.ca.
22-26 AUGUST	International Sedimentological Congress. Beijing China. Website: isc2022.scievent.com
13-15 SEPTEMBER	14th International Symposium on Nuclear and Environmental Radiochemical Analysis. York UK. Website: tinyurl.com/y989mvvz

2023

29 JANUARY-3 FEBRUARY	Winter Conference on Plasma Spectrochemistry. Ljubljana Slovenia. Website:https://ewcps2021.si