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Standardization of field-portable short-wave infrared processing for mineral exploration

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Introduction

Shortwave infrared (SWIR) spectroscopy began to enter the minerals industry as an exploration technique in the mid-1990s with the introduction of the Portable Infrared Mineral Analyzer (PIMA) by Integrated Spectronics (Thompson *et al.* 1999). Since that time, major advancements have occurred, including the continued development of spectral libraries for explorers to apply to various styles of ore deposits (Baldridge *et al.* 2009; Percival *et al.* 2016; Schodlok *et al.* 2016; Meerdink *et al.* 2019). Further research revealed that key spectral features related to mineral chemistry can be used by explorers to vector towards potential orebodies (Laakso *et al.* 2016; Neal *et al.* 2018; Cooke *et al.* 2020; Zhou *et al.* 2022). Within the last 10 years, spectral core scanning hardware has allowed large amounts of high-resolution spectral data to be acquired on drill cores (Tappert *et al.* 2011; Schodlok *et al.* 2016; Acosta *et al.* 2019; Tusa *et al.* 2019; Acosta *et al.* 2020).

The use of the SWIR technique using multi- and/or hyperspectral platforms has broad applications in mineral exploration, particularly for hydrothermal deposit types where alteration mineral zonation is well developed (Thompson *et al.* 1999; Hauff 2008). Commonly occurring alteration minerals that contain oxygen in water or hydroxyl bonds are SWIR-active and can be readily identified (Bishop *et al.* 2008), permitting the definition of alteration mineral patterns around potential orebodies (Duke 1994). In addition, subtle chemical variations of some minerals can be detected by changes in the wavelength position of key absorption features, which may be related to distance from a potential heat source and/or orebody (Neal *et al.* 2018; Cooke *et al.* 2020; Zhou *et al.* 2022). A third vector type involves calculating the crystallinity of minerals, such as white micas or kaolinite, which may indicate temperature of formation or degree of crystal development; likewise, crystallinity may also provide a proxy for distance to a potential hydrothermal source and/or orebody (Kübler 1968; Hauff *et al.* 1991; Scott and Yang 1997; Guggenheim *et al.* 2002; Wang *et al.* 2021). The three SWIR vector types described, alteration mineral patterns, mineral chemistry and crystallinity, are commonly difficult to identify visually (Crósta 1990). Deployment of SWIR platforms allow explorers to rapidly and inexpensively acquire data to detect these key vectors toward potential orebodies.

Currently, the mineral exploration industry is collecting large SWIR datasets, but in many cases without rigorous QA and QC (quality assurance and quality control) procedures in place. Suboptimal collection and processing practices may introduce problems with bulk processing (e.g., aiSIRIS™, The Spectral Geologist™ (TSG™)) and/or dataset fusion for subsequent interpretation and application of machine learning techniques. In addition, users who wish to interpret their SWIR datasets, but are not spectral experts, are commonly inundated with spectral outputs they do not know how to effectively apply, and for which the limitations may not be understood. This article provides guidance for effective data acquisition (with appropriate QA-QC measures in place), background for users to better interpret their SWIR spectral data, and examples of vectoring applications in the context of the calc-alkalic porphyry copper environment. A downloadable digital document associated with this article, "Field-portable SWIR acquisition, QA-QC, and processing guide" (herein referred to as the Guide), may be used to further explore this topic and construct a practical workflow. The intention is that new users start with an accessible framework, and that experienced practitioners consider some standardization procedures for their own workflows.

SWIR spectroscopy

The method detects a range of the electromagnetic spectrum from 1300 – 2500 nm, recently described as SWIR 1 (1300 – 1850 nm) and SWIR 2 (1850 – 2600 nm), differentiated by their vibrational modes (Laukamp *et al.* 2021). Hardware limitations restrict the upper detection limit to 2500 nm. Certain bonds, primarily those involving oxygen or

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- **Deadlines** for submission of articles or advertisements:
  March newsletter: January 15
  June newsletter: April 15
  September newsletter: July 15
  December newsletter: October 15
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- **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.
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- 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:
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- 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.

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Notes from the Editor

Welcome to the third **EXPLORE** issue of 2022. This issue features an article describing standardization of field-portable short-wave infrared processing for mineral exploration and was written by McLean Trott, Stephanie Sykora, Collette Pilsworth, Nicholas Jansen, Matt Leybourne, and Dan Layton-Matthews.

EXPLORE thanks all those who contributed to the writing and/or editing of this issue, listed in alphabetical order: Elizabeth Ambrose, Steve Amor, Dennis Arne, Al Arsenault, John Carranza, Theo Davies, Bob Garrett, Nicholas Jansen, Dan Layton-Matthews, David Leng, Matthew Leybourne, Jeanne Percival, Collette Pilsworth, Jessey Rice, Dave Smith, Monica Sorondo, Stephanie Sykora, Brian Townley, and McLean Trott.

Beth McClenaghan
Editor

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President's Report

In my last message (EXPLORE 195, June 2022), I mentioned that it is still unclear when the COVID-19 pandemic will end. However, the past few months have seen many parts of the world, including South Africa, continue their journey toward endemic COVID-19 although the WHO has not yet officially declared the end of the COVID-19 pandemic. Nevertheless, after 2 years of the pandemic, it seems that almost everything is back to normal nowadays. As a result, we can look forward with great hope to the 29^{th} International Applied Geochemistry Symposium (IAGS).

The 29^{th} IAGS was originally scheduled for November 8–13, 2020, but because of the COVID-19 pandemic, it was postponed twice, first to October 24 – 29, 2021, and then to October 16–21, 2022. Finally, it will now be held on October 23–28, 2022, in the “Garden City” of Viña del Mar, Chile. The symposium is just 10 weeks away as I write this report. I therefore thank, on behalf of the AAG, the Local Organizing Committee of 29^{th} IAGS, led by Brian Townley, for their patience and resilience to see to it that this event happens.

The 29^{th} IAGS will comprise the following nine technical sessions:

- Exploration geochemistry: present and future challenges.
- New field portable technologies: improving the analysis and turnaround times 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 modelling
- Environmental geochemistry: closing the gap for sustainable mining and development / Mine Tailing Revalorization (Unesco-IGCP682)
- Water and hydrogeochemistry: challenges in exploration, mining and sustainable development
- Isotopic geochemistry: new uses in applied geochemistry
- Linking geology and geochemistry to viticulture and wine
- Analytical geochemistry technologies and quality assurance / quality control

Each of these technical session could potentially contribute papers for special or thematic issue publication(s) in AAG’s journal – Geochemistry: Exploration, Environment, Analysis (GEEA). I encourage AAG members/fellows, particularly those who sit on GEEA’s editorial board, to organize/ propose thematic issue publication(s) of papers from those to be presented at the 29^{th} IAGS.

It is my pleasure to report that GEEA’s 2021 impact factor is 2.266, a big jump from its 2020 impact factor of 1.437. In fact, GEEA’s impact factor has been hovering above 1.1 but steadily increasing in the last five years. However, with its 2021 impact factor, I am confident that GEEA can now expect greater numbers of submissions in the years to come, provided that we help keep its impact factor rising. Thematic issue publication(s) of papers from those to be presented at the 29^{th} IAGS would be a great boost for GEEA.

I hope I will be able to travel to Chile to attend the 29^{th} IAGS and meet you all. Let’s see!

John Carranza
President

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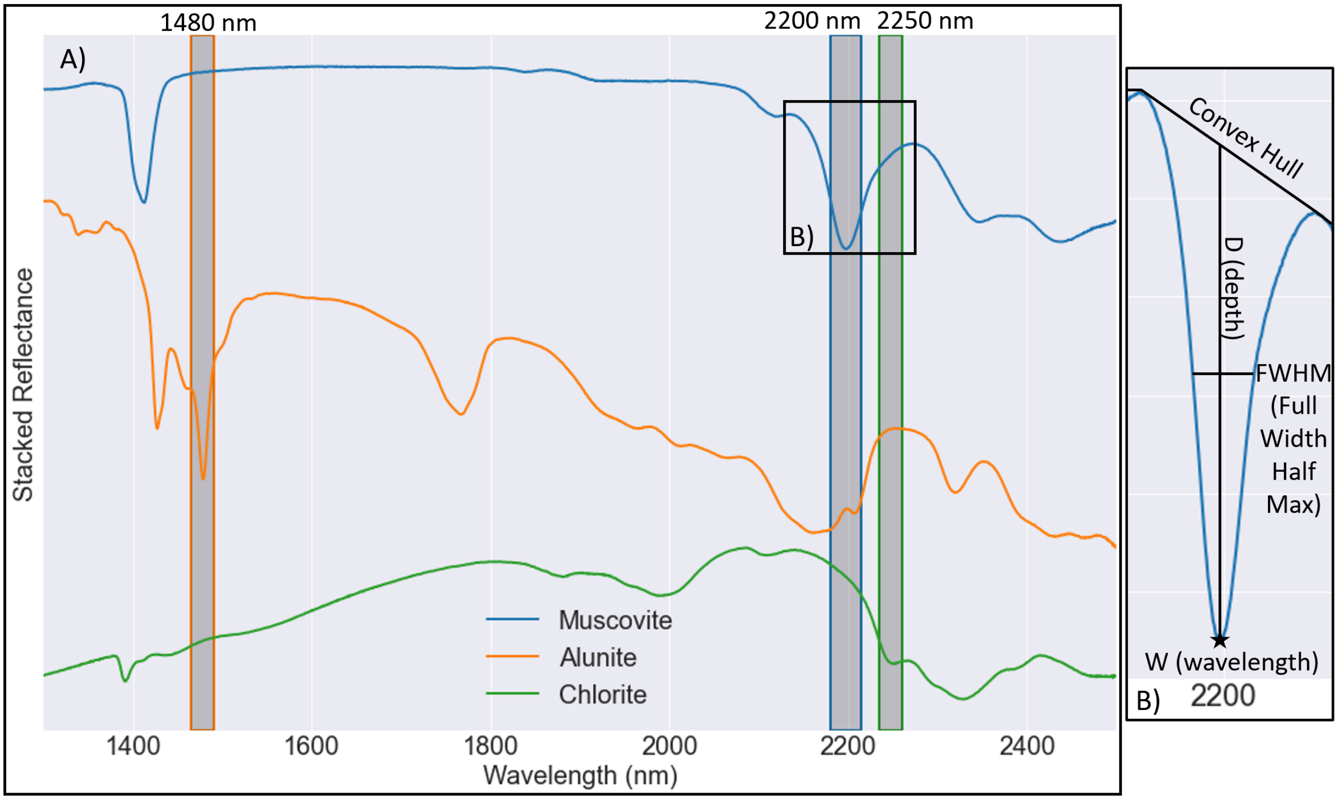

Figure 1. Examples of SWIR spectra extracted from the JPL Ecostress spectral library (Grove et al. 1992), showing key absorptions for the three minerals discussed as vectors. Inset (B) illustrates the nomenclature of absorption feature scalars applied to the 2200nm "AlOH" absorption for muscovite. Depth is measured from the base of the absorption (the minimum) vertically to where it intercepts the convex Hull line, formed by connecting apices along the spectral curve. FWHM is measured at the midpoint of D, between either side of the absorption feature.

ammonium, vibrate when impacted by energy at specific wavelengths within this range, converting some of the incident energy into kinetic energy and therefore reflecting a modified spectrum with lower intensity at the corresponding wavelength. In practical terms, this means shining a light on a sample, capturing the reflected spectra (Fig. 1), and processing the data such that the absorption features reveal the composition of the sample by comparing the geometry of absorption features (Fig. 1, inset B) to a specific SWIR-active mineral or combination of such minerals.

Scales of application

At regional scales, multispectral satellite systems (e.g., Landsat, ASTER, etc.) apply the same principles as field-portable (point data) hyperspectral techniques, although at a much coarser spectral and spatial resolution. In areas of abundant outcrop these satellite-borne methods may be useful for identifying the geometry of large alteration zonation patterns (Bedell *et al.* 2009). Due to limited spectral resolution, multispectral techniques can detect mineral groups, but it is commonly difficult to detect individual minerals; likewise, extracting mineral chemistry or crystallinity information can be challenging. At an intermediate scale, airborne hyperspectral systems can be used for greater spatial and spectral resolution than satellite systems; these airborne platforms can typically identify individual mineral species and extract some mineral chemistry information (Cudahy *et al.* 2001).

At the target scale, field-portable hyperspectral SWIR instruments (e.g., PIMA, Malvern Panalytical TerraSpec™, Spectral Evolution OreXplorer ™) have a high spectral and spatial resolution and can be used in a time- and cost-effective manner. In many cases, handheld methods and airborne or satellite systems are used in conjunction with each other, whereby handheld measurements can help contextualize results by constraining the spectral response of representative samples from an area of study (Lampinen *et al.* 2017).

In recent years, hyperspectral techniques have been applied using core scanning platforms (e.g., HyLogger®, CoreScan®, Terracore®, SisuROCK®), which collect abundant point readings or capture a spectrum per 'pixel' to produce a spectral image (at the ~500 μm to ~1.2 mm scale)(Cracknell *et al.* 2019; Barker *et al.* 2021). These instruments provide exponentially more information and are most effectively applied at the mine-site to better characterize the rock for metallurgical studies (Lypaczewski *et al.* 2019; Byrne *et al.* 2020).

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Field-portable SWIR

The scale of application discussed herein focuses on spectra collected with field-portable instrumentation. Instruments like these typically expose a sample to a light source through a window with an approximately 2 cm diameter, and then route the reflected light back to sensors and a processing unit to capture a spectrum. Spectra are ultimately downloaded from the unit and can be processed by cloud-based, largely automated software (e.g., IMDEX's aiSIRIS™) or by using other semi-automated spectral interpretation products like CSIRO's (the Commonwealth Scientific and Industrial Research Organization) The Spectral Geologist™ (TSG™) software (Berman *et al.* 1999). Generally, the output can potentially identify up to 5 mineral species in a spectrum and extract geometric information for relevant absorption features, such as the width (or full width half maximum, FWHM), depth (D), and wavelength at minimum (W), as shown in Figure 1 inset B.

QA-QC considerations

Consistent data collection with QA-QC controls is critical, especially for large projects with multiple users, over a long period, and potentially with multiple instruments. Wavelength differences of up to 5 nm for W1480 (alunite-related) and 2 nm for W2200 (white mica-related) for the same samples analyzed using distinct instruments have been documented (Chang and Yang 2012; Uribe-Mogollon and Maher 2020). Proper standardization allows for robust interpretation and facilitates application of machine learning techniques, which tend to require 'apples-to-apples' feature inputs. The need for guidelines and standards in this space has been highlighted previously (Kerr *et al.* 2011).

Ideally, the analysis should be conducted in an environment with consistent lighting, however, good contact between the instrument and rock surface should minimize noise related to fluctuations in variable lighting conditions (Trott *et al.* in preparation). Good contact is achieved by ensuring that the interface between the sample window and sample medium is such that no large gaps exist where ambient light might enter the instrument-sample interface. This is straightforward for flat surfaces or loose material but uneven (e.g., roughly fractured) or rounded (e.g., drill core) surfaces may merit the use of a rubber grommet between the instrument and surface, such as that found around the sample window of a contact probe. Rock chips (1 to 5 mm, e.g., RC chips) provide the best medium for sample representativity; fine pulps generate noisy spectra and should not be used. Spectra can be captured for residual soils, sieved to a standard size (e.g., -80 mesh), and may be particularly useful combined with traditional soil geochemistry data. A critical requirement is that the sample is dry, as H_2O is spectrally active. Samples can be dried in a sunny area or an oven at temperatures less than ~40 °C, as higher temperatures could change the structure of some clays (e.g., convert smectite to illite) (Russell and Farmer 1964).

The first mandatory QA-QC measure for SWIR spectrometers includes measuring a Spectralon™ white reference disc comprised of a fluoropolymer with nearly 100% reflectance in the SWIR range (Bruegge *et al.* 1993); if the various sensors in the instrument are functioning properly and the instrument is calibrated it will produce a flat line spectrum. The Spectralon™ disc can also act as a ´blank´ to determine if there is any dust or debris in the analytical probe. Most instruments are shipped with at least one Spectralon™ white reference disc. Care must be taken to keep them clean and not touch the upper surface, as skin oils can contaminate the spectral response. Contaminated discs can be recovered by wet sanding the surface with fine carbide sandpaper and allowing it to dry overnight.

A second mandatory QA-QC measure is the analysis of a Mylar® 'standard', which has five pronounced absorptions (1128.7, 1660.1, 1952.9, 2131.6, and 2256.0 nm) allowing the user to determine the accuracy of their instrument and whether it is within calibration limitations (i.e. within ± 1 nm of the known absorption feature wavelength). The ideal method for analyzing the Mylar® standard is by placing it on top of the Spectralon™ disc. Mylar® is readily available at most art supply stores. We also recommend usage of an in-house standard consisting of a mineral with a relatively homogeneous composition and that occurs in the study area; ideal candidates might be white mica (illite, paragonite, muscovite, phengite), kandite (halloysite, kaolinite, nacrite, dickite), alunite, and/or a chlorite-rich sample. The Mylar® and in-house standards allow

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the user to track accuracy and variation in key absorptions features (e.g., 2200 nm "Al-OH" feature, alunite absorption, etc.) over time and between instruments, allowing results to be leveled, if necessary. Analytical duplicates (duplication of an analysis spot) are also recommended to ascertain the precision of results. These QA-QC measures should be used at the beginning and end of the analysis session and periodically (intervals of ~ 20 measurements) throughout the session. Key metadata that should be recorded at the time of collection include reading ID, user, date, instrument model and serial number, analysis time, and sample medium (e.g., rock, drill core, rock chips, QA-QC sample type, etc.). Instructions for evaluating QA-QC results are provided in the Guide, as well as a TSG template for extracting Mylar scalars (Appendix B: Mylar_QAQC_scalars.tsg).

Processing

There are various software solutions for processing spectra. Historically users required specialization in a very manual process of identifying mineral species from individual spectra, a time-consuming endeavor with the quality of results highly dependent on the expertise of the user. A commercial solution to this, aiSIRIS™, consists of a cloud-based, largely automated software wherein uploaded spectra are classified relative to a large library of expert-interpreted spectra. For users who wish to interpret spectra in a more involved way, The Spectral Geologist™ (TSG™) software enables bulk processing of large volumes of spectra through i) its implementation of 'The Spectral Assistant' to unmix spectra against a pure mineral reference library for mineral identification and ii) extract 'scalars' to quantify the geometry (shape) of key absorption features (Berman *et al.* 1999; Huntington *et al.* 1999). TSG is appropriate for bulk processing tasks but still requires a certain level of prior knowledge to operate effectively and reduce the resulting data into useful vectors, a subject which is discussed at length in the *Guide*. Storage of raw data is an important and often overlooked step. Individual spectral files (e.g., *.asd, *.sed, *.ascii) can be saved along with their corresponding metadata. However, the most ideal format is as tabular spectra that can be imported into a relational database linked with the spectral interpretation and any other geoscientific data (e.g., geochemistry). Preserving raw spectra permits consistent interpretation when new data is added to a project or future reprocessing using new advancements.

SWIR in mineral exploration: porphyry copper vectoring

Zonation patterns of alteration minerals with respect to hydrothermal deposit types are generally well established. These patterns may be observed upon visual inspection, but subtleties in alteration facies are commonly more difficult to differentiate, particularly in so-called "white rock" alteration zones such as the advanced argillic and phyllic (or "sericitic") zones of a porphyry copper system. In the case of the advanced argillic assemblage, the distribution of white, commonly fine-grained clay or sulfate minerals such as kaolinite, alunite, dickite, diaspore, pyrophyllite, zunyite, or topaz has distinct implications in terms of pH and temperature of formation and by proxy, relative distance to hydrothermal source and/or potential orebody. These minerals are commonly difficult to differentiate visually but are easily identified using SWIR methods. Figure 2 illustrates the broad geometric relationships between porphyry copper alteration assemblages and the physicochemical character of their SWIR-active mineral assemblages.

3D examination of SWIR mineral matches from systematically collected drill core data may prove vital in defining alteration assemblages and patterns, which provide indications towards mineralization, informing further drilling. These insights may prove crucial in an industry where exploration search spaces are becoming more complex, on peripheries of ore systems and under post-mineral cover.

The substitution chemistry of some mineral types may be examined through its spectral response (Bishop *et al.* 2008). Tschermak-type substitution, where Al is replaced by (Fe, Mg) + Si in white mica minerals (illite, phengite, paragonite, and muscovite) can be captured by examination of the wavelength at minimum (W2200) of the Al-OH absorption feature (Swayze *et al.* 1992; Duke 1994; Halley *et al.* 2015; Cloutier *et al.* 2021). This substitution is controlled by factors like pH and concentrations of Fe^{2+} and K^{+} in the hydrothermal fluid (Halley *et al.* 2015) as it reacts with country rock and precipitates white mica minerals during the formation of phyllic/sericitic alteration assemblages in a porphyry system. More specifically, the value of W2200 shifts from ~2190 to 2225 nm as white micas increasingly substitute (Fe, Mg) + Si for Al (Cloutier *et al.* 2021; Laukamp *et al.* 2021), transitioning from paragonitic to phengitic composition (Fig. 2).

Another potential SWIR vector involves estimation of the Mg# for chlorite-dominated spectra, observed in a wavelength shift of the "Fe/Mg-OH" absorption feature found around 2250 nm (W2250), and strongly coupled with a wavelength shift in the "Mg/Fe-OH" absorption feature (W2340) (Lypaczewski and Rivard 2018; Neal *et al.* 2018). Higher W2250 values indicate higher Fe relative to Mg, and vice versa (McLeod *et al.* 1987; Scott *et al.* 1998; Huntington *et al.* 1999; Jones *et al.* 2005; Bishop *et al.* 2008; Lampinen *et al.* 2017). The "Fe/Mg-OH" W2250 absorption feature is preferred over the "Mg/Fe-OH" W2350 because it occurs within a higher signal-to-noise region and has less overlap with other spectral-active minerals, unlike the W2350, which overlaps with carbonate minerals (Bishop *et al.* 2013). In settings containing alunite, the shift in the absorption feature around 1480 nm has been shown to be related to the K:Na ratio (Bishop and Murad 2005), where higher wavelengths indicate an increasing Na content corresponding to a higher temperature of formation, and by proxy, closer to the potential heat source and/or an underlying porphyry intrusion (Fig. 2; (Chang *et al.* 2011; Cooke *et al.* 2020)).

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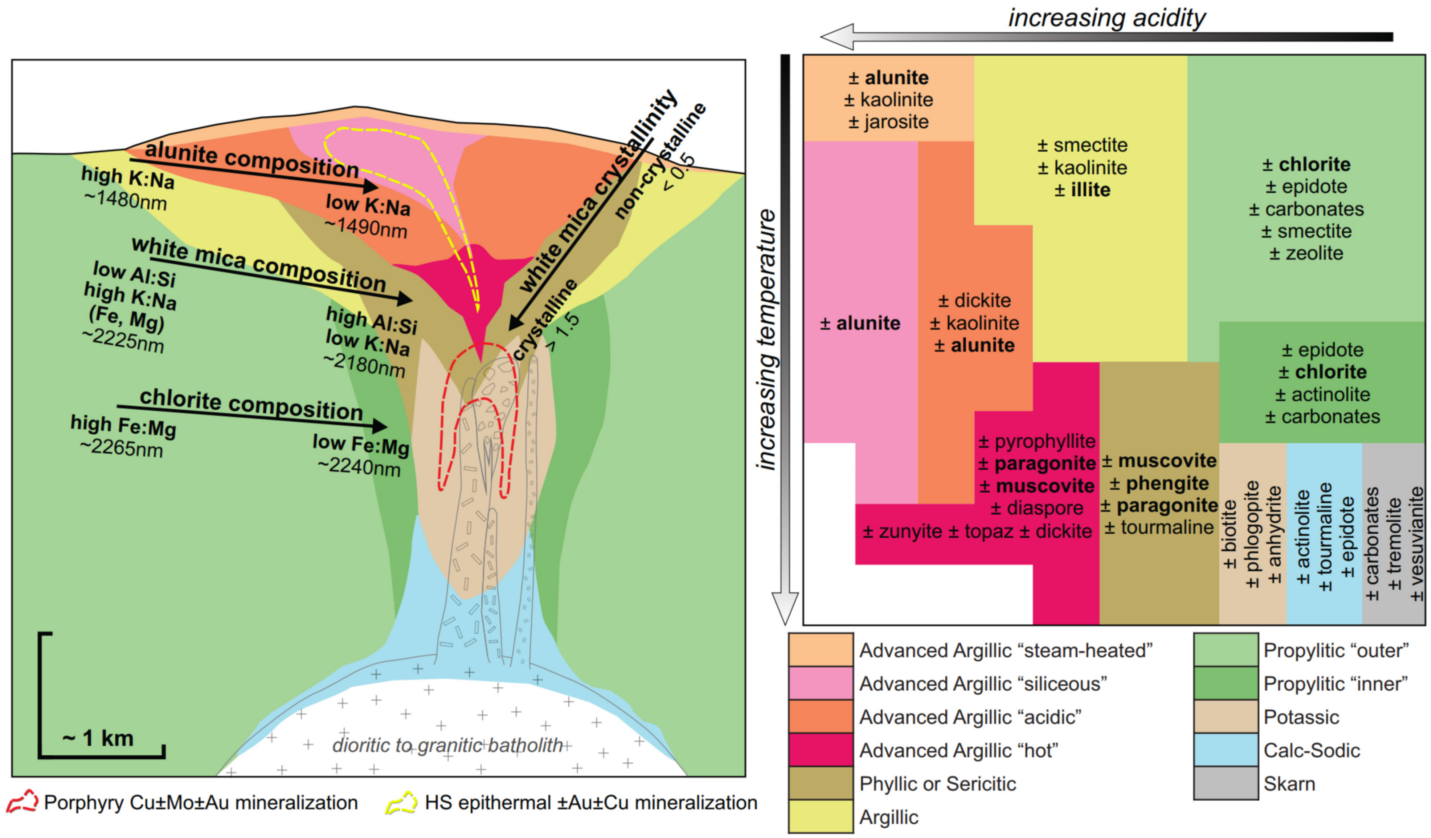

Figure 2. Idealized alteration pattern around a calc-alkalic Cu-Mo ± Au porphyry deposit (A-vein type). Discussed SWIR vectors shown on the left. Simplified acidity vs temperature diagram from (Corbett and Leach 1998) on the right with only key SWIR-identifiable minerals shown. Minerals in bold correspond to common SWIR vectors. Porphyry model modified from (Hedenquist et al. 2000; Seedorff et al. 2005; Sillitoe 2010; Halley et al. 2015; Hedenquist and Arribas 2022). Common porphyry SWIR-active alteration minerals, and properties of SWIR vectors, summarized from (Vedder and McDonald 1963; Kübler 1968; Hunt 1977; McLeod et al. 1987; Cathelineau 1988; De Caritat et al. 1993; Scott et al. 1998; Thompson et al. 1999; Bishop and Murad 2005; Bishop et al. 2008; Doublier et al. 2010a; Chang et al. 2011; Kamps et al. 2018; Neal et al. 2018; Cooke et al. 2020; Cloutier et al. 2021; Laukamp et al. 2021),
*Note that anhydrite is mentioned in the diagram. This cannot be detected directly by SWIR. Gypsum, however, is detectable and will be the output if anhydrite is present.

The crystallinity of white micas (illite, paragonite, muscovite, and phengite) can be estimated by division of the "Al-OH" feature depth (D2200) by the depth of the water absorption feature occurring at 1900 nm (D1900) (Doublier *et al.* 2010b; Medina *et al.* 2021). Under higher temperatures of formation, white micas tend to crystallize with a more ordered structure and as a result incorporate less water in interlayered smectites, proxied by the relative depths (spectral abundances) of the "Al-OH" feature and 1900 nm water feature (Kübler 1967; Doublier *et al.* 2010b).

Method limitations

Critical to implementing SWIR effectively is an

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understanding of some basic method limitations. What follows is a non-exhaustive discussion of some of the more common limitations, and, where possible, mitigation steps.

Minerals without SWIR-active bonds are not detectable

Quartz (SiO_2), silica, or alteration assemblages characterized by pervasive silicification, do not contain SWIR-active bonds. Some providers identify quartz using an indirect/proxy method of detecting the H_2O feature produced by fluid inclusions hosted in quartz. This method should be approached with caution as the supposed quartz response can be confused by other spectral responses (e.g., wet core). Likewise, feldspars, sulfide minerals, spodumene, amongst many other minerals, cannot be detected with SWIR (Thompson *et al.* 1999).

Differences in spectral activity and albedo between minerals

Minerals with low spectral activity and/or albedo (overall reflectance) can be masked by those with high spectral activity and/or albedo. For example, minerals such as chlorite, biotite, or tourmaline have their most pronounced and diagnostic absorption features in the >2250 nm region where signal-to-noise is at its lowest, in contrast to other minerals, such as white micas and kandites, whose key absorption features occur in <2200 nm region where signal-to-noise is at its highest.

Compounding this problem are differences in albedo; where increased overall reflectance of lighter-colored minerals may make it difficult to identify less reflective minerals in the same analyzed material. In porphyry copper systems, for example, biotite in the potassic zone may not be detected if even a small amount of retrograde smectite or overprinting white mica is present. This is less problematic with high resolution core scanning techniques; smaller pixel sizes mean that the likelihood of obtaining pure spectra for a dark-colored mineral grain is higher.

A Non-quantitative method

Related to the previous two limitations, the quantification of mineral abundance in a sample is not possible; the inability to identify many major rock forming minerals such as quartz and feldspar, and the spectral over- or under-representation of certain minerals due to contrasting spectral activities and albedo. It is, however, possible to obtain an indication of "spectral abundance" or "spectral strength" calculated from absorption feature depths (D). These values are more likely to be related to spectral activity and albedo than modal abundance in the rock, although they may provide vectors of interest from the relative perspective.

White mica W2200 and the influence of kaolinite

The white mica W2200 mineral chemistry vectoring example described above is contingent on the spectra having been carefully filtered to remove any influence of kaolinite, a rather common mineral in both hypogene and supergene settings. Although variations in the W2200 value for white micas are indicative of mineral chemistry (Tschermak-type substitution), the W2200 value for kaolinite consistently occurs at approximately 2207 nm and, when present in a white mica sample, shifts the spectral response accordingly. A simple W2200 versus FWHM2200 plot can help filter out any influence of kaolinite, as shown in Figure 3. Vectoring using this feature requires carefully removing any white mica spectra that may have been influenced by the presence of kaolinite.

Host rock dependency for scalar values

Differences between hydrothermal fluid composition and wallrock reactivity (buffering characteristics) of the same deposit type but in distinct geological settings means that it is difficult to place universal ranges on scalar values. Relative changes on a case-by-case basis are useful for this reason, to examine pH/temperature gradients as opposed to seeking out any predefined or idealized value ranges. Additionally, the variability in scalar values lends itself to be more significant with a larger data set, where trends can be supported statistically.

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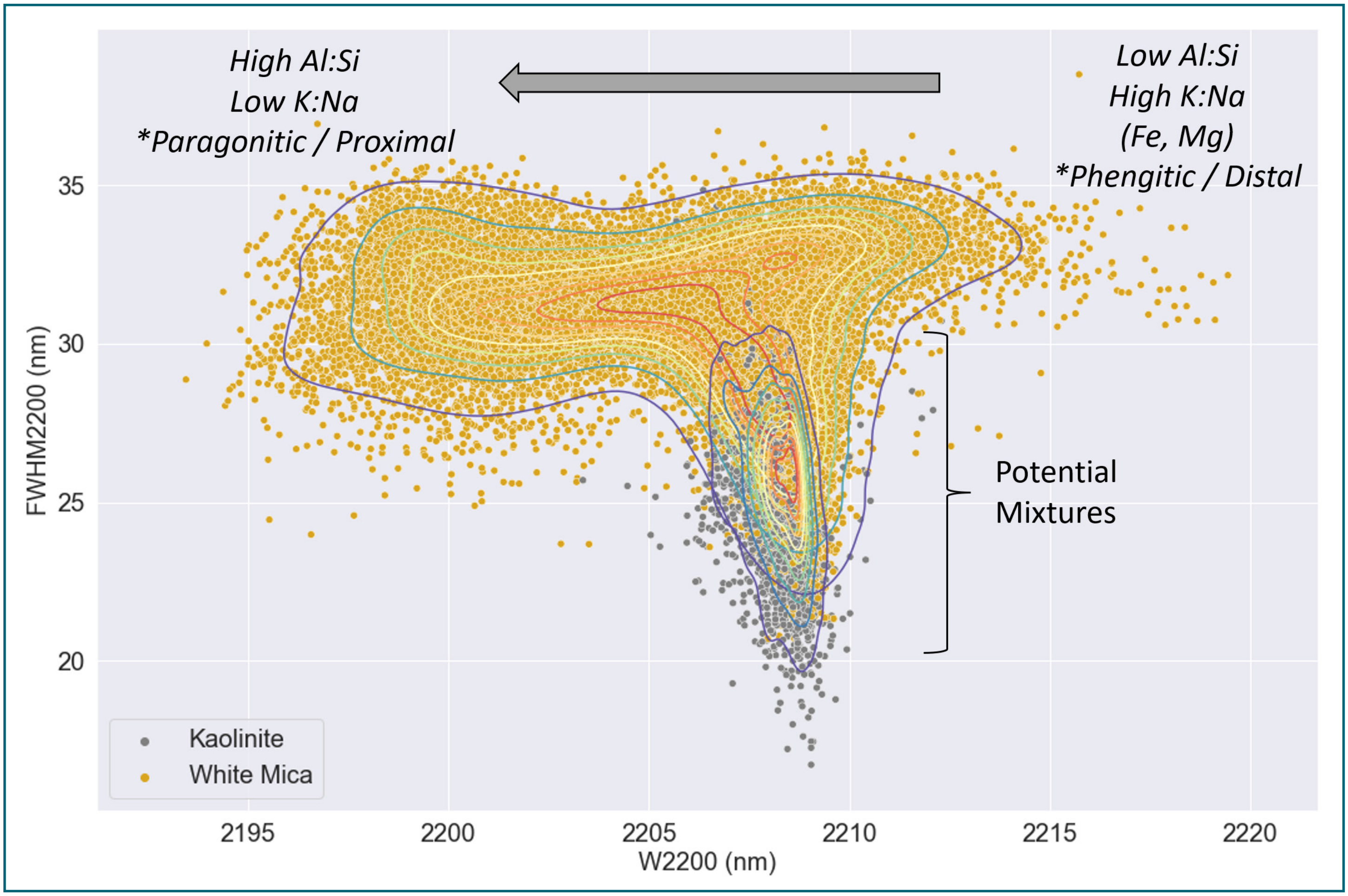

Figure 3. Spectra classified by TSG as white mica and kaolinite from a calc-alkalic porphyry (N=26506), with kernel density contours overlain for each species. Note the overlap between kaolinite and white mica spectra values in the subvertical density contours for kaolinite around 2208 nm; readings in this area must be used with caution when vectoring with W2200 due to likely influence of kaolinite on the white mica absorption position.

Overprinted assemblages may not be visible

As with many other geoscientific methods, the most obvious signature is left by the final event in the evolution of a hydrothermal system. Overprinted assemblages tend to be retrograde altered or overwhelmed by minerals precipitated or recrystallized during later events, in some cases masking earlier events of greater economic significance (Cudahy *et al.* 2001; Jansen and Trott 2018; Trott *et al.* 2018).

Field-portable SWIR-VNIR acquisition, QA-QC, and processing guide

The *Guide* and appendices can be accessed at https://www.appliedgeochemists.org/explore-newsletter/explore-issues. It begins with introductory material to introduce new users to the electromagnetic spectrum, progresses to discuss the SWIR range, followed by its application to mineral exploration. Sections 3, 4 and 5 are intended to be used as a guided walk-through to enable the reader to systematically reconstruct a workflow for capturing spectra with adequate QA-QC measures in place, process the results in TSG, and carry out post-processing operations necessary to derive valid vectors. Metadata capture, color scheme, and TSG template files are included as appendices.

Conclusions

With continued application of this method in the exploration industry; and access to standardization of acquisition and processing methodologies like those outlined here and detailed in the introduced processing manual, it is our hope that SWIR methods become more attractive as a low-cost exploration tool and, as data continues to be acquired, amenable to large-scale integration and interpretation, advanced data analytics and machine learning processes. As suggested here, adopting minimum standards for QAQC and processing routines are key to unlocking these potentials and increasing value to exploration processes from the SWIR method. We hope that the accompanying *Guide* facilitates the adoption of the method, and leading to ever-improving SWIR data quality, interpretation, and subsequent improved exploration outcomes.

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Standardization of field-portable short-wave infrared processing… *continued from page 12*

Acknowledgements

We must thank the spectral geologists who paved the way for the invention, improvement, and uptake of this method in the geosciences: Anne Thompson and Phoebe Hauff for their tremendous contributions to the field; Scott Halley and Carsten Laukamp for directly and/or indirectly teaching and mentoring us (and many others) in this fascinating discipline; Sasha Pontual for bringing her knowledge to the world with her invention and popularization of aiSiris™ for bulk processing; and the talented group at CSIRO for their creation of TSG™, the tool that enabled us to explore what spectra mean and how best to apply the method in practice. Jon Huntington was extremely generous with his time and knowledge in editing this work. Finally, we thank Jeanne Percival and Bob Garrett for their comprehensive reviews, and Beth McClenaghan for encouraging us to complete this work and put it into the public domain for the benefit of others.

Supplementary material: "Field-Portable SWIR Acquisition, QA-QC, and Processing Guide, First Edition" ("the *Guide*") and related appendices are available at https://www.appliedgeochemists.org/explore-newsletter/explore-issues

References

Acosta, I.C.C., Khodadadzadeh, M., Tusa, L., Ghamisi, P. and Gloaguen, R. 2019. A machine learning framework for drill-core mineral mapping using hyperspectral and high-resolution mineralogical data fusion. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, **12**, 4829-4842. https://doi.org/10.1109/jstars.2019.2924292.

Acosta, I.C.C., Khodadadzadeh, M., Tolosana-Delgado, R. and Gloaguen, R. 2020. Drill-core hyperspectral and geochemical data integration in a superpixel-based machine learning framework. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, **13**, 4214-4228. https://doi.org/10.1109/jstars.2020.3011221.

Baldridge, A.M., Hook, S.J., Grove, C. and Rivera, G. 2009. The ASTER spectral library version 2.0. *Remote Sensing of Environment*, **113**, 711-715.

Barker, R.D., Barker, S.L.L., Cracknell, M.J., Stock, E.D. and Holmes, G. 2021. Quantitative mineral mapping of drill core surfaces II: Long-wave infrared mineral characterization using µXRF and machine learning. *Economic Geology*, **116**, 821-836, https://doi.org/10.5382/econgeo.4804.

Bedell, R., Crósta, A.P. and Grunsky, E. 2009. *Remote sensing and spectral geology*. Reviews in Economic Geology, Volume 16, Society of Economic Geologists (SEG).

Berman, M., Bischof, L. and Huntington, J. 1999. Algorithms and software for the automated identification of minerals using field spectra or hyperspectral imagery. *Proceedings of the 13th International Conference on Applied Geologic Remote Sensing*, 222-232.

Bishop, J.L. and Murad, E. 2005. The visible and infrared spectral properties of jarosite and alunite. *American Mineralogist*, **90**, 1100-1107.

Bishop, J., Lane, M., Dyar, M. and Brown, A. 2008. Reflectance and emission spectroscopy study of four groups of phyllosilicates: Smectites, kaolinite-serpentines, chlorites and micas. *Clay Minerals*, **43**, 35-54.

Bishop, J., Lane, M., Brown, A., Hiroi, T., Swayze, G. and Lin, J.-F. 2013. Spectral properties of Ca-, Mg-and Fe-bearing carbonates. *44th Annual Lunar and Planetary Science Conference*, 1719.

Bruegge, C.J., Stiegman, A.E., Rainen, R.A. and Springsteen, A.W. 1993. Use of Spectralon as a diffuse reflectance standard for in-flight calibration of earth-orbiting sensors. *Optical Engineering*, **32**, 805-814.

Byrne, K., Lesage, G., Gleeson, S.A., Piercey, S.J., Lypaczewski, P. and Kyser, K. 2020. Linking mineralogy to lithogeochemistry in the Highland Valley copper district: Implications for porphyry copper footprints. *Economic Geology*, **115**, 871-901, https://doi.org/10.5382/econgeo.4733.

Cathelineau, M. 1988. Cation site occupancy in chlorites and illites as a function of temperature. *Clay Minerals*, **23**, 471-485.

Chang, Z. and Yang, Z. 2012. Evaluation of inter-instrument variations among short wavelength infrared (SWIR) devices. *Economic Geology*, **107**, 1479-1488.

Chang, Z., Hedenquist, J.W. *et al.* 2011. Exploration Tools for Linked Porphyry and Epithermal Deposits: Example from the Mankayan Intrusion-Centered Cu-Au District, Luzon, Philippines*. *Economic Geology*, **106**, 1365-1398, https://doi.org/10.2113/econgeo.106.8.1365.

Cloutier, J., Piercey, S.J. and Huntington, J. 2021. Mineralogy, Mineral Chemistry and SWIR Spectral Reflectance of Chlorite and White Mica. *Minerals*, **11**, 471, https://doi.org/10.3390/min11050471.

Cooke, D.R., Agnew, P. *et al.* 2020. Recent advances in the application of mineral chemistry to exploration for porphyry copper–gold–molybdenum deposits: detecting the geochemical fingerprints and footprints of hypogene mineralization and alteration. *Geochemistry: Exploration, Environment, Analysis*, **20**, 176-188, https://doi.org/10.1144/geochem2019-039.

Corbett, G. and Leach, T. 1998. Southwest Pacific Rim Gold-Copper Systems: Structure, Alteration and Mineralization. *SEG Special Publication*, **6**.

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Cracknell, M., Parbhakar-Fox, A., Jackson, L., Fox, N. and Savinova, E. 2019. Automated identification of sulphides from drill core imagery. *Proceedings of the 2019 Mineral Systems of the Pacific Rim Congress (PACRIM 2019)*, 79-82.

Crósta, A. 1990. Unveiling Mineralogical Information in Ore Deposits: the Use of Reflectance Spectroscopy for Mineral Exploration in South-America. Brazil. https://www.malvernpanalytical.com/en/learn/knowledge-center/application-notes/ANASDI20111110UnveilingMineralogicalInformationOreDeposits

Cudahy, T.J., Wilson, J. *et al.* 2001. Mapping porphyry-skarn alteration at Yerington, Nevada, using airborne hyperspectral VNIR-SWIR-TIR imaging data. *IGARSS 2001. Scanning the Present and Resolving the Future. Proceedings. IEEE 2001 International Geoscience and Remote Sensing Symposium (Cat. No.01CH37217).* IEEE.

De Caritat, P., Hutcheon, I. and Walshe, J.L. 1993. Chlorite geothermometry: a review. *Clays and clay minerals*, **41**, 219-239.

Doublier, M., Roache, A. and Potel, S. 2010a. *Application of SWIR spectroscopy in very low-grade metamorphic environments: a comparison with XRD methods*. Geological Survey of Western Australia, Record 2010/7, 61 p.

Doublier, M.P., Roache, T. and Potel, S. 2010b. Short-wavelength infrared spectroscopy: A new petrological tool in low-grade to very low-grade pelites. *Geology*, **38**, 1031-1034, https://doi.org/10.1130/g31272.1.

Duke, E.F. 1994. Near infrared spectra of muscovite, Tschermak substitution, and metamorphic reaction progress: Implications for remote sensing. *Geology*, **22**, 621-624.

Grove, C., Hook, S.J. and Paylor III, E. 1992. *Laboratory reflectance spectra of 160 minerals, 0.4 to 2.5 micrometers.* Pasadena, CA: Jet Propulsion Laboratory.

Guggenheim, S., Bain, D.C. *et al.* 2002. Report of the Association Internationale pour l'Etude des Argiles (AIPEA) Nomenclature Committee for 2001: order, disorder and crystallinity in phyllosilicates and the use of the 'crystallinity index'. *Clay Minerals*, **37**, 389-393.

Halley, S., Dilles, J.H. and Tosdahl, R.M. 2015. Footprints: Hydrothermal Alteration and Geochemical Dispersion Around Porphyry Copper Deposits. *SEG Newsletter*, 1-7.

Hauff, P. 2008. An overview of VIS-NIR-SWIR field spectroscopy as applied to precious metals exploration. *Arvada, Colorado: Spectral International Inc*, **80001**, 303-403.

Hauff, P., Kruse, F., Madrid, R., Fraser, S., Huntington, J., Jones, M. and Watters, S. 1991. Illite crystallinity- Case histories using X-ray diffraction and reflectance spectroscopy to define ore host environments. *Thematic Conference on Geologic Remote Sensing, 8 th, Denver, CO*.

Hedenquist, J.W. and Arribas, A. 2022. Exploration implications of multiple formation environments of advanced argillic minerals. *Economic Geology*, **117**, 609-643.

Hedenquist, J.W., Arribas, A. and Gonzalez-Urien, E. 2000. Exploration for epithermal gold deposits, SEG REviews, 13, 245-277.

Hunt, G.R. 1977. Spectral signatures of particulate minerals in the visible and near infrared. *Geophysics*, **42**, 501-513.

Huntington, J., Cudahy, T. *et al.* 1999. Mineral mapping with field spectroscopy for exploration: Final report. *Commonwealth Scientific and Industrial Research Organization, Australia, Exploration and Mining Report*, **419**, 35.

Jansen, N. and Trott, M. 2018. NIR characteristics of porphyry copper deposits. Presented at the Resources for Future Generations (RFG), Vancouver, British Columbia, July 16-21, 2018.

Jones, S., Herrmann, W. and Gemmell, J.B. 2005. Short wavelength infrared spectral characteristics of the HW horizon: Implications for exploration in the Myra Falls volcanic-hosted massive sulfide camp, Vancouver Island, British Columbia, Canada. *Economic Geology*, **100**, 273-294.

Kamps, O.M., Van Ruitenbeek, F.J., Mason, P.R. and Van der Meer, F.D. 2018. Near-infrared spectroscopy of hydrothermal versus low-grade metamorphic chlorites. *Minerals*, **8**, 259.

Kerr, A., Rafuse, H., Sparkes, G., Hinchey, J. and Sandeman, H. 2011. Visible/infrared spectroscopy (VIRS) as a research tool in economic geology: background and pilot studies from Newfoundland and Labrador. *Geological Survey, Report*, **11**, 145-166.

Kübler, B. 1967. La cristallinité de l'illite et les zones tout à fait supérieures du métamorphisme. *Etages tectoniques*, 105-121.

Kübler, B. 1968. Evaluation quantitative du métamorphisme par la cristallinité de l'illite. *Bulletin Centre de Researches de Pau-SNPA*, **2**, 385-397.

Laakso, K., Peter, J., Rivard, B. and Gloaguen, R. 2016. Combined hyperspectral and lithogeochemical estimation of alteration intensities in a volcanogenic massive sulfide deposit hydrothermal system: A case study from Northern Canada. *2016 8th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS).* IEEE, 1-5.

Lampinen, H.M., Laukamp, C., Occhipinti, S.A., Metelka, V. and Spinks, S.C. 2017. Delineating alteration footprints from field and ASTER SWIR spectra, geochemistry, and gamma-ray spectrometry above regolith-covered base metal deposits—An example from Abra, western Australia. *Economic Geology*, **112**, 1977-2003, https://doi.org/10.5382/econgeo.2017.4537.

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Standardization of field-portable short-wave infrared processing… *continued from page 14*

Laukamp, C., Rodger, A. *et al.* 2021. Mineral physicochemistry underlying feature-based extraction of mineral abundance and composition from shortwave, mid and thermal infrared reflectance spectra. *Minerals*, **11**, 347, https://doi.org/10.3390/min11040347.

Lypaczewski, P. and Rivard, B. 2018. Estimating the Mg# and AlVI content of biotite and chlorite from shortwave infrared reflectance spectroscopy: Predictive equations and recommendations for their use. *International journal of applied earth observation and geoinformation*, **68**, 116-126.

Lypaczewski, P., Rivard, B., Gaillard, N., Perrouty, S., Piette-Lauzière, N., Bérubé, C.L. and Linnen, R.L. 2019. Using hyperspectral imaging to vector towards mineralization at the Canadian Malartic gold deposit, Québec, Canada. *Ore Geology Reviews*, **111**, 102945.

McLeod, R., Gabell, A., Green, A. and Gardavsky, V. 1987. Chlorite infrared spectral data as proximity indicators of volcanogenic massive sulphide mineralisation. *Pacific Rim 87. International congress on the geology, structure, mineralisation and economics of Pacific Rim*, 321-324.

Medina, C.M., Ducart, D.F., Passos, J.S. and de Oliveira, L.R. 2021. Exploration vectoring from the white mica spectral footprint in the atypical auriferous Lavra Velha deposit, San Francisco Craton, Brazil. *Ore Geology Reviews*, **139**, 104438.

Meerdink, S.K., Hook, S.J., Roberts, D.A. and Abbott, E.A. 2019. The ECOSTRESS spectral library version 1.0. *Remote Sensing of Environment*, **230**, 111196.

Neal, L.C., Wilkinson, J.J., Mason, P.J. and Chang, Z. 2018. Spectral characteristics of propylitic alteration minerals as a vectoring tool for porphyry copper deposits. *Journal of Geochemical Exploration*, **184**, 179-198, https://doi.org/10.1016/j.gexplo.2017.10.019.

Percival, J., Olejarz, A. *et al.* 2016. The National Mineral Reference Collection (NMC) Digital Spectral (VIS-NIR-SWIR) Library. Part I: The Kodama clay mineral collection, Geological Survey of Canada, Open File 7923, 24 pp.

Russell, J.T. and Farmer, V. 1964. Infra-red spectroscopic study of the dehydration of montmorillonite and saponite. *Clay Minerals Bulletin*, **5**, 443-464.

Schodlok, M.C., Whitbourn, L. *et al.* 2016. HyLogger-3, a visible to shortwave and thermal infrared reflectance spectrometer system for drill core logging: functional description. *Australian Journal of Earth Sciences*, **63**, 929-940, https://doi.org/10.1080/08120099.2016.1231133.

Scott, K. and Yang, K. 1997. Spectral reflectance studies of white micas. *Australian Mineral Industries Research Association Ltd. Report*, **439**, 35.

Scott, K., Yang, K. and Huntington, J. 1998. The application of spectral reflectance studies of chlorites in mineral exploration. *North Ryde NSW: CSIRO Exploration & Mining Report*, **545**.

Seedorff, E., Dilles, J.H. *et al.* 2005. Porphyry deposits: Characteristics and origin of hypogene features.

Sillitoe, R.H. 2010. Porphyry copper systems. *Economic Geology*, **105**, 3-41.

Swayze, G., Clark, R.N., Kruse, F., Sutley, S. and Gallagher, A. 1992. Ground-truthing AVIRIS mineral mapping at Cuprite, Nevada. *JPL, Summaries of the Third Annual JPL Airborne Geoscience Workshop. Volume 1: AVIRIS Workshop*.

Tappert, M., Rivard, B., Giles, D., Tappert, R. and Mauger, A. 2011. Automated drill core logging using visible and near-infrared reflectance spectroscopy: A case study from the Olympic Dam IOCG deposit, South Australia. *Economic Geology*, **106**, 289-296, https://doi.org/10.2113/econgeo.106.2.289.

Thompson, A.J., Hauff, P.L. and Robitaille, A.J. 1999. Alteration mapping in exploration: application of short-wave infrared (SWIR) spectroscopy. *SEG Discovery*, 1-27.

Trott, M., Munchmeyer, C. and Valenzuela, C. 2018. The Valeriano porphyry copper deposit revisited: 3D geological/geochemical integration and characterization. *Resources for Future Generations 2018*, June 2018, Vancouver, Canada.

Trott, M., Pilsworth, C., Monte-Marcellino, B., Leybourne, M. and Layton-Matthews, D. in preparation. Time series evaluation of environmental variables and acquisition parameters on the quality of SWIR spectra. *TBD*.

Tusa, L., Andreani, L., Khodadadzadeh, M., Contreras, C., Ivascanu, P., Gloaguen, R. and Gutzmer, J. 2019. Mineral mapping and vein detection in hyperspectral drill-core scans: Application to porphyry-type mineralization. *Minerals*, **9**, 122.

Uribe-Mogollon, C. and Maher, K. 2020. White mica geochemistry: Discriminating between barren and mineralized porphyry systems. *Economic Geology*, **115**, 325-354.

Vedder, W. and McDonald, R. 1963. Vibrations of the OH ions in muscovite. *The Journal of Chemical Physics*, **38**, 1583-1590.

Wang, L., Percival, J.B., Hedenquist, J.W., Hattori, K. and Qin, K. 2021. Alteration mineralogy of the Zhengguang epithermal Au-Zn deposit, northeast China: Interpretation of shortwave infrared analyses during mineral exploration and assessment. *Economic Geology*, **116**, 389-406, https://doi.org/10.5382/econgeo.4792.

Zhou, Y., Wang, T. *et al.* 2022. Advances on exploration indicators of mineral VNIR-SWIR spectroscopy and chemistry: A review. *Minerals*, **12**, 958.

29th International Applied Geochemistry Symposium 2022

Facing the challenges of today using applied geochemistry

Sunday October 23rd – Friday October 28th, 2022

Viña del Mar, Chile

IAGS2022 is held in memory of Professor Dr. Peter Winterburn (1962 – 2019)

The **Local Organizing Committee (LOC)**, the **Association of Applied Geochemists (AAG)** and the **Sociedad Geológica de Chile (SGCh)** welcome you to the **29th International Applied Geochemistry Symposium, IAGS2022, Viña del Mar, Chile.**

Events, Dates, and Venue

IAGS2022 will be inaugurated on Sunday October 23rd, 2022, at Palacio Vergara. The Scientific Program will be carried out between Monday October 24th and Friday October 28th, 2022, at the Enjoy Convention Center. Wednesday October 26th is free of academic activities.

IAGS2022 will be held with the **1st International Geoscience, Viticulture and Wine Symposium, IGVWS2022**, and are to be inaugurated together. The Technical Session of the 1st. IGVWS2022 is to be carried out on Monday October 24th.

New deadlines (Last Call) for submission of abstracts and Early Bird Registration

The deadline for submission of abstracts has been extended until August 15th, 2022 (Last Call). Early Bird registration has been extended until August 31st, 2022.

Registration and Abstract Submission

Please access the following link to register to IAGS2022: https://profile.4id.science/iags002/register. Abstract submission must be done through your account on the platform. https://iags2022.cl/submission-of-abstracts/

Official Language

The official language of the IAGS2022 is English. Presentations will be in English, and abstracts must be submitted in this language.

Scientific Program

The Scientific Program of IAGS2022 is composed of invited keynote lectures, and oral and poster presentations to be submitted by the international geoscientific community to one of nine Technical Sessions. Please visit our website at https://iags2022.cl/scientific-program-2/ for a detailed description of each Technical Session.

Keynote Lectures

Dr. Qiuming Cheng, School of Earth Science and Engineering, Sun Yat-Sen University, Zhubai, China
Lecture: ***"Fundamental Laws of Geochemical Elements and Anomaly Recognition for Mineral Exploration."***

Dr. Bernhard Dold, Sustainable Mining Research & Consultancy, Chile and H2-SPHERE, Germany
Lecture: ***"Sourcing of critical elements and industrial minerals from mine waste/ore deposits – The role of Geochemistry."***

MSc. Britt Bluemel, GoldSpot Discoveries Corp., Canada
Lecture: "*Data Digs Deeper – using data science to transmute geochemical understanding into discovery."*

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29th International Applied Geochemistry Symposium 2022... *continued from page 16*

Workshops

It is not mandatory to participate in IAGS2022 to register for a Workshop. Workshops are subject to be held with a minimum number of registered participants.

If you would like to participate in any of the Workshops, please contact Monica Sorondo at contacto.iags2020@gmail.com before September 15th, 2022.

1. Fundamentals of geochemical exploration – A Workshop

Date: Friday October 21 and Saturday October 22, 2022
Duration: 2 days
Lecturers:
Dr. David Cohen, School of Biological, Earth and Environmental Sciences, University of New South Wales, Australia
Dr. Dennis Arne, Telemark Geosciences, Australia
Registration Fee: US$ 420.- CLP 400.000.- (per person). Registration fee includes coffee breaks, lunch, and a digital certificate

Description/Objectives:

Exploration geochemistry programs have led to the discovery of many major mineral deposits across the world. This workshop will provide a general overview of the principles that drive the design of exploration geochemical surveys, from the processes that control the dispersion of elements to the factors that should be considered when selecting sampling media, analytical methods and data processing. Focus will be given to case studies, to provide context to survey design in some of the archetypal terrains such as the glaciated terrains of the northern hemisphere to the deeply weathered terrains of Australia and Africa and areas under various types of cover in areas such as the Andes.

The Workshop is aimed at graduate geoscientists in the minerals exploration sector, senior students in geoscience programs, and others seeking a better understanding of current approaches to exploration geochemistry and the challenges posed by some geochemical landscapes and terrains. The workshop will provide an excellent introduction to the technical sessions of IAGS2022. Participants will have the opportunity to work on short practical exercises. The Workshop is being presented by a team of highly experienced exploration geochemists and AAG members, drawn from industry, government, and academia whose geochemical experiences span projects on every continent.

The AAG is offering the option for participants to complete assignment work after the workshop for which, if successfully completed, the AAG will issue a micro-credential. **Participants are requested to bring a laptop along.**

Program: To be announced on the IAGS2022 web page.

2. Quality Control and Quality Assurance Methods in Geochemical Exploration & Resource Assessment

Date: Friday October 21, 2022
Duration: 1 day
Lecturers:
Dr. Cliff Stanley, Department of Earth and Environmental Science, Faculty of Pure and Applied Science, Acadia University, Canada
Dr. Dennis Arne, Telemark Geosciences, Australia
Registration Fee: US$ 350.- CLP 330.000.- (per person). Registration fee includes coffee break, lunch, and a digital certificate

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Description/Objectives:

This short workshop presents both the theory behind geochemical data quality assessment methods for mineral exploration sampling and resource definition, and a clear and practical approach to the design, implementation, and assessment of such methods. Topics covered range from initial sampling, digestion, and analysis methods and how they impact QA/QC, through data quality assessment concepts, qualitative and quantitative data, types of errors, accuracy, and precision assessment methods, to best practices, component errors, and strategies to reduce errors. Included are several practical exercises allowing participants to develop confidence in plotting and assessing quality control data using real-world data. Emphasis will be placed on the use of quality control data to reduce ambiguities that impede the interpretation of mineral exploration results, and to minimize uncertainties in resource estimation. This workshop is designed for those new to managing QA/QC programs, as well as those involved in implementing programs but who have not been utilizing the QA/QC results to improve sampling/analysis outcomes. It is normally directed toward an economic geology-oriented audience with interests in mineral exploration and mining. After taking the workshop, the audience can be expected to have the background and insight necessary to design and undertake an appropriate QA/QC regimen that will be acceptable for public disclosure by a company listed on one of the major mining-oriented stock exchanges. **Attendees should bring a laptop computer loaded with an Excel® spreadsheet application (or equivalent) to allow them to undertake the practical exercises using spreadsheet templates provided to participants as part of the course.**

Program:

This Workshop is presented in a one-day format from 9:00 to 5:00, with a one-hour lunch break. Lectures are broken up by 20-minute coffee breaks in the morning and afternoon, and each are followed by computer exercises that allow participants to practice what they have learned.

3) Stable and radiogenic isotopes in mining exploration

Date: Friday October 21, 2022
Duration: 1 day
Lecturer: Dr. Ryan Mathur, Professor and Chair of Geology, Juniata College, United States
Registration Fee: US$ 500.- CLP 475.000.- (per person). Registration fee includes coffee break, lunch, and a digital certificate

Description:

This workshop will explore how stable metal, transition metal and radiogenic isotopes can be used in mineral exploration and solve problems associated with ore genesis. For instance, the workshop will cover how copper isotope values can be used in waters and minerals as a means to vector to mineralization. Brief discussions about tin, zinc, and silver isotopes in ores reveal important aspects of metallogenesis. It will also briefly discuss how radiogenic isotope systems can be used to define timing of mineralization and how integrated chronologies can be used in exploration and metallogenic studies.

Program: See in IAGS2022 web page

4) Data Science in Ore Deposit Geochemistry: Processes to Predictions

Dates: Friday October 21 and Saturday October 22, 2022
Duration: 2 days
Lecturers:
Dr. Cliff Stanley, Department of Earth and Environmental Science, Faculty of Pure and Applied Science, Acadia University, Canada
Dr. Simon Griffith, Third Planet Exploration Services, United Kingdom
MSc. McLean Trott, GoldSpot Discoveries, Corp., Canada
Registration Fee: US$ 505.- CLP 480.000.- (per person). Registration fee includes coffee break, lunch, and a digital certificate

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Description/Objectives:

This workshop steps through concepts of mass transfer in hydrothermal systems, application of those concepts on a large scale, and machine-learned prediction of the geological phenomena in question.

The workshop will be run over two days and includes a mixture of theory and practical modules to reinforce the theory and show its application. Attendees will learn fundamental principles of mass transfer, exploration geochemistry, and how to construct a simple machine learning workflow using open-source software.

Scope: Early career professionals in the exploration and mining industry, and graduate-level geoscience students will benefit. **Attendees are advised to bring their own laptops and install the required software ahead of time.**

Program: See in the IAGS2022 web page.

5) Fluid inclusions in fossil and active hydrothermal systems in Chile

Dates: Friday October 21 and Saturday October 22, 2022
Duration: 2 days
Lecturer: Dr. Daniel Moncada, Departamento de Geología, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Chile
Registration Fee: US$ 310.- CLP 300.000.- (per person). Registration fee includes coffee break, lunch, and a digital certificate

Description:

The Workshop is intended for participants to learn and apply the principles of fluid inclusions and recent advances in analytical techniques. These micro analytical techniques are useful to answer geological questions related to planetary processes and mineral deposit genesis. The practical use of fluid inclusions in exploration of different natural resources will be emphasized. The Workshop applies to principles of fluid and melt inclusions to geological processes and advances in analytical techniques. Participants are expected to have some knowledge of Geochemistry.

Program: See on the IAGS2022 web page.

Field Trips

It is not mandatory to participate in IAGS2022 to register for a Field Trip. Field Trips are subject to be held with a minimum number of registered participants.

If you would like to participate in a Field Trip, please contact Monica Sorondo at contacto.iags2020@gmail.com before September 15th, 2022.

1. Four-day Andean cross-section: Viña del Mar – Mendoza – Santiago

Led by Dr. Reynaldo Charrier, Universidad de Chile, Chile

Description:

The objective of this 4-day field trip is to introduce the participants in the general aspects of the tectonic and paleogeographic evolution of the Andean cordillera including the development of Paleozoic, Mesozoic, and Cenozoic basins in one of its most classic sections between the cities of Viña del Mar, in the Pacific coast, in the western margin of South America, in Chile, and Mendoza, in the Andean foreland in Argentina.

The trip is based on an E-W section along the Aconcagua river valley, in Chile, and the Mendoza river valley, in Argentina, at ~33ºS. This section of the Andes is located in the transition zone between (i) the flat-slab subduction segment (~27ºS to ~33ºS), where the passive Juan Fernández Ridge is subducting the continental margin with an eastward dip of ~15º, and (ii) the normal subduction segment, south of 33°S, where the Wadati-Benioff zone dips ~30ºE.

During the trip we will move, from west to east, through the following morphostructural units: Coastal

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Cordillera, Principal Cordillera, Frontal Cordillera, Uspallata Depression, and Precordillera. East of the Precordillera is the Andean foreland and further east the Pampa plain.

Along the coast, the Carboniferous Coastal Batholith is well exposed. East of the batholith, up to the city of Los Andes, are exposed (i) Jurassic and Early Cretaceous plutons and arc-associated volcanic deposits that interfinger to the east with backarc basin sedimentary deposits that extend as far as the Argentinean side of the mountain range, and (ii) Late Cretaceous continental sedimentary and volcanic deposits accumulated in a retroarc foreland basin. From there on and passed a major reverse fault that separates the mentioned Mesozoic from Cenozoic rocks. The latter consist of volcanic and volcaniclastic deposits accumulated in an intra-arc extensional basin (Abanico intra-arc basin) in late Eocene to early Miocene times. Shortly before the international border and passed another major reverse fault that borders to the east the intra-arc basin deposits, begins the Andean (Aconcagua) fold-thrust belt developed in the latest Jurassic to early Cretaceous backarc sedimentary deposits. Further east, past the frontal tip of the fold-thrust belt, begins the Frontal Cordillera. This morphostructural unit consists of Paleozoic sedimentary deposits intruded by a Carboniferous pluton, which is covered by Triassic felsic lavas. The Uspallata Depression is an ancient terrane suture that separates the present-day Frontal Cordillera (Chilenia terrane) from the Precordillera (Cuyania terrane) and is mostly filled with thick Mio-Pliocene gravel deposits resulting from the erosion of the cordillera. On the western border of the Uspallata Depression, the Frontal Cordillera is eastwardly thrusted on the gravels. The Precordillera consists of strongly deformed early Paleozoic sedimentary rocks capped by Triassic deposits. On the way to Mendoza, we will visit a site described by Darwin consisting of Triassic volcaniclastic deposits with fossil tree trunks in life position (Darwin's Forest). On the way down to the foreland we will observe a thick Silurian to early Devonian turbiditic succession. At the foot of Precordillera a major active reverse fault (La Cal fault) marks the tectonic front of the Andes.

This field trip will initiate and depart from the Enjoy Hotel venue on Saturday October 29th. All participants must oversee possible visa and other requirements to enter Argentina. Lodging (breakfast included) will be arranged in Los Andes, Uspallata and Mendoza, costs are included in registration. Meals (lunch and dinner) will be organized, payments are to be taken care of by each participant on site. The field trip will end in the city of Santiago and at Arturo Merino Benitez airport for those who plan to return to their place of origin at the end of the field trip.

Registration fee: Soon to be announced on the IAGS2022 web page.

Program: Will be announced on the IAGS2022 web page.

2. Four-day Mineral Deposits and Geology of Northern Chile

Led by Dr. Constantino Mpodozis, Consultant Geologist, Chile

Description:

This field trip will initiate from Antofagasta on Sunday October 30th, from a location to be announced. On day one participants will be introduced to the geology of the Jurassic and Cretaceous Coastal Cordillera of Antofagasta, to observe the major regional structural, geological and geomorphological features of the coastal domain, and their relation with the main types of ore deposits hosted within the Jurassic and early Cretaceous metallogenic belts. A visit to the copper stratabound deposit of Mantos Blancos is considered. Lodging is considered in Calama. On day two, participants in the field trip will observe the magmatic units of the Central Depression and the major structural, geologic and geomorphological features of the Paleocene and Eocene-Oligocene metallogenic belts. A Visit to the Centinela deposits are considered, including Tesoro (a copper exotic deposit) and Polo Sur (a porphyry copper). Lodging is considered in Calama. On day three, participants will travel to San Pedro de Atacama, to observe the morphostructural and geological characteristics of the Cordillera de Domeyko and the Salar de Atacama Basin. Lodging is considered in Calama. On day four a visit to the Sierra Gorda porphyry copper deposit is considered, this to present and discuss porphyry copper type deposits of the Paleocene metallogenic belt. The field trip ends at the Calama airport on the afternoon of day 4.

Participants will need to make reservations and pay for their own flights. Hotels (breakfast included) and lunches will be included in the registration fee. Dinner will be organized, but participants must pay for their own consumption.

Registration fee: To be announced on the IAGS2022 web page.

Program: Will be announced on the IAGS2022 web page

3. Geology and vineyards of Central Chile

Soon to be announced on IAGS2022 web page and 1st. IGVWS2022 2nd. Circular.

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New Announcement

1st.IGVWS2022
OCTOBER
Viña del Mar, Chile

1st. International Geosciences, Viticulture and Wine Symposium - IGVWS2022

Linking geology and geochemistry to viticulture and wine

Sponsored and organized by the AAG, I+D Wine Consortium of Chile and the ANIAE

We announce the 1st. IGVWS2022 to be held as a parallel event of IAGS2022 in the frame of Technical Session 8 "Linking geology and geochemistry to viticulture and wine - 1st. IGVWS2022"

Context

Climate, soil, and agricultural management are the main factors that impact yield and grape quality. Geologic studies are important in viticulture since the physical and chemical properties of soils are strongly influenced by lithological, geochemical, and structural characteristics of the soil parent materials. This Symposium and thematic session welcomes contributions that link diverse areas of geosciences (geology, geochemistry, geomorphology, geophysics, mineralogy, soil sciences, hydrogeology, hydrology, climatology, biogeochemistry, edaphology, etc.) that influence aspects such as viticulture potential and wine quality, the terroir concept, soil-plant interactions, root system development, water availability, the characterization of viticulture valleys, exploration of new areas apt for viticulture, environmental issues, challenges and impacts of climate change, standardization of methodologies, and technological solutions, among others.

This 1st International Geosciences, Viticulture and Wine Symposium opens an opportunity for scientists and professionals who work in the cultivation of vine for the production of wine to share knowledge and perspectives of agronomy, enology, viticulture, climate, and the relation of these conditions with site specific geological, geomorphological, mineral, and geochemical conditions that are defined by the local and regional geological background and landscape evolution processes.

Invitation for abstract submission to the 1st. IGVWS2022

We invite enologists, agronomists, soil scientists, and other related geoscientists to present results on studies involving site characterization and evaluation of viticulture aptitude that may impact aspects of Terroir definition and hence may represent site specific conditions that cannot be reproduced elsewhere.

Abstract submissions of studies may be presented for oral or poster presentations.

To submit your abstract to the 1st. International Geosciences, Viticulture and Wine Symposium - IGVWS2022, please proceed as follows:

1. Create your account at https://profile.4id.science/iags002/register
2. Complete your personal information and select as Attendee Type "1st.IGVWS2022"
3. To create and submit your abstract go to the Abstract Module, select the Presentation Type (Oral or Poster) and select the "Area" Technical Session 8 "Linking Geology and Geochemistry to Viticulture and Wine" / 1st IGVS2022.
4. Guidelines: Short abstracts. Maximum 250 words. Do not include figures or graphics
5. Deadline for submission of abstracts: August 31st, 2022

Registration Fee to the 1st. IGVWS2022:

US$185.-/CLP$166.500.- Registration Fee includes participation in the Icebreaker on Sunday October 23rd and in

29th International Applied Geochemistry Symposium 2022… *continued from page 21*

the Technical Session on Monday October 24th, 2022. **Registration fee payment must also be made through your account on the IAGS platform.**

We hope to share and complement the fields of Geology, Geochemistry, Agronomy, Enology and Viticulture in a first combined effort aimed at linking the worlds of Geosciences and Viticulture, to provide the Wine Industry with further insight on those site-specific conditions that may influence and make vine cultivation valleys unique and non-reproducible.

Workshop

Influences of geology, mineralogy, and geochemistry on the cultivation of vine (R&D Wine Consortium of Chile / CORFO)
Dates: Friday October 21 and Saturday October 22, 2022
Duration: 2 days
Lecturers:
Dr. Pamela Castillo-Lagos, University of Concepcion, Chile
Dr. Brian Townley, University of Chile, Chile
Dr. Ignacio Serra, University of Concepcion, Chile
Paulina Flores, R&D Wine Consortium of Chile, Chile

Registration Fee: To be announced on IAGS2022/IGVWS2022 web page.

Description/Objectives:

This Workshop is an independent activity organized and sponsored by the R&D Wine Consortium of Chile and CORFO. The aims of this two-day workshop are to present the results and conclusions of over five years of research and development on the Influences of geology, mineralogy, and geochemistry on the cultivation of vine, integrated with influences of climate and global climate change, and implications on viticulture aptitude of land. Theoretical, empiric and practical results will be presented, together with the proposed standard protocols and methodologies developed for the characterization of geological and geomorphological properties of vineyards, from a wine valley scale down to vineyard and plot scales. A practical session will present contents and use of the newly developed digital platform VitisGeoClima ®, an online tool aimed at providing viticulture, geology and climate characterization and evaluation capabilities, including evaluation of future climate change under different scenarios. This tool provides the wine and agricultural sectors the ability to evaluate present and future potential use of agricultural lands, in view of global climate change, with the incorporation of site specific geological, geomorphological and viticulture characteristics. In addition, a practical on-site field activity is considered for the second day, to demonstrate vineyard characterization protocols and methodologies in the field. **Program:** To be announced on the IAGS2022 / IGVWS2022 web page.

Local Organizing Committee (LOC)
29th International Applied Geochemistry Symposium, IAGS2022
1st International Geoscience, Viticulture & Wine Symposium, IGVWS2022
Viña del Mar, Chile
contacto.iags2020@gmail.com

Lodging in Viña del Mar

The following hotels have special rates for IAGS participants. Please contact them directly to make your reservations and mention that you are an IAGS attendee.

Hotel Oceanic
Address: Av. Borgoño 12925, Reñaca, 2520000, Viña del Mar, Chile.
https://www.booking.com/hotel/cl/oceanic.es.html
Standard Single or Double (sea view): US$ 122/night, Continental breakfast included
Junior Suite Single or Double (balcony): US$ 142/night, Continental breakfast included
Contact: Vyasma Sandoval, vsandoval@hoteloceanic.cl

Hotel Diego de Almagro Viña del Mar
Address: 1 Norte 221, Viña del Mar, Chile
Standard Single Room: CLP 72.828.- / US$ 92/night, buffet breakfast included
Standard Double Room: CLP 84.609/ US$ 107/night, buffet breakfast included
Contact: Ximena Roldán, recepcion-vdelmar@dahoteles.com, gerencia-vdelmar@dahoteles.com
Located within walking distance from the venue of IAGS

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Hotel Sheraton Miramar
Address: Av. Marina 15, Viña del Mar, Chile
Single Standard Room: US$ 260/night
Contact: Felipe Saldías, Felipe.Saldias@sheraton.com

Hotel Pullman Viña del Mar San Martín
Address: Av. San Martín 667, 2520096, Viña del Mar, Chile
King or Twin Standard Room: CLP 153,510+IVA/night, breakfast included
King or Twin Standard Room, Bay View: CLP 166,600+IVA/night, breakfast included
Contact: Michelle Junod, mjunod@atton.com

Hotel Best Western Marina del Rey
Address: Ecuador 299, Viña del Mar
Single Standard Room: CLP 90,000+IVA/night – US$ 100/night, breakfast included
Double/Twin Standard Room: CLP 90,000+IVA/night – US$ 100/night, breakfast included
Contact: Marcela Figueroa, marcela.figueroa@marinahoteles.cl
Located within walking distance from the venue of IAGS

Borde Plaza Hotel
Address: 2 Norte 65, Viña del Mar, Chile
Standard Single Room: CLP 65,000 (including IVA). US$ 70.-
Standard Double Room: CLP 70,000 (including IVA). US$ 74.-
Standard Triple Room: CLP 78,000 (including IVA). US$ 82.-
Contact: Mónica Catrilao, hotelbordeplaza@gmail.com
Located within walking distance from the venue of IAGS

Hotel Gala
Address: Arlegui 273, Viña del Mar, Chile
Standard Single Room: US$ 90/night
Suite: US 190/night
Contact: María Teresa Solís, mtsolis@galahotel.cl
Located within walking distance from the venue of IAGS

Social Activities
Sunday October 23rd - Registration, Inauguration, and Icebreaker
Registration and the inauguration of IAGS2022 followed by the Icebreaker will take place at Palacio Vergara, Quinta Vergara, in Viña del Mar, Chile.

Wednesday, October 26th - Tour and Lunch at Estancia El Cuadro
https://elcuadro.cl/en/

Located in the Tapihue area, an exceptional sub-region of the Casablanca Valley, we offer an innovative and pioneering enotouristic opportunity delivering an unforgettable experience for wine lovers. The approach is informal and educational with an emphasis on the history of wine production, wine culture and local traditions. You will enjoy several entertaining activities led by tour guides while surrounded by a beautiful Chilean countryside setting.
Languages: English and Spanish. Duration: Approximately 5 hours
Cost per person: US$ 200.- - CLP 200.000.- Transportation is included and comfortable clothing and shoes are recommended.

Program:
- Tour Starts: 11:30 a.m.
- Chilean Horses Show
- Visit to the Grape Wine Garden
- Guided access to the Wine Museum
- Wine tasting with a cheese table
- Country Buffet – Lunch
- Wineshop Access

29th International Applied Geochemistry Symposium 2022... *continued from page 23*

Activities for Accompanying Persons

From its famous Flower Clock to Muelle Vergara or a stroll down Calle Valparaíso, Viña del Mar offers a variety of activities for tourists. If you are planning on visiting the city and its surroundings, while accompanying an IAGS attendee, please let us know so we can provide you with different options.

Gala Dinner, Thursday, October 27, 2022

To be announced.

How to get to Viña del Mar

International flights arrive and depart from Santiago's International Airport, Comodoro Arturo Merino Benítez (SCL) https://www.nuevopudahuel.cl/?language=en

Viña del Mar is a 45-60 minute drive from Santiago's airport along Route CH-68. Car rental companies operate at Santiago's airport https://www.santiago-airport.com/car-rental.php#/searchcars and it is also possible to arrange private transfers.

COVID 19

Please note the following information in reference to COVID 19 and requirements to enter Chile

Mobility Pass (Pase de Movilidad)

As of April 14, 2022, the Chilean government no longer requires travelers to obtain a Mobility Pass ("Pase de Movilidad") https://mevacuno.gob.cl/ to enter Chile. However, a valid Mobility Pass will still be required in many situations, including but not limited to the following:

- Domestic travel (by plane, bus, etc.) For example, if you are arriving in Santiago and have a connecting domestic flight, or a bus ride, to another city in Chile, a Mobility Pass will not be requested upon arrival in Santiago but will be required to board your connecting domestic flight/bus.
- Indoor dining at restaurants. Dining at open terraces is allowed without a mobility pass.
- Access to theaters and cinemas.
- Participation in organized tours.
- Attendance at large public events (sporting events, concerts, etc.)

The Local Organizing Committee encourages participants who may engage in any of the above activities to obtain a Mobility Pass prior to arrival in Chile. https://mevacuno.gob.cl/.

Please note that the mobility pass may take up to 10 days to be issued.

Organizing Committee

IAGS2022 is organized by the Local Organizing Committee (LOC) and the Technical Committee (TC).

The LOC is constituted by Dr. Brian Townley, President (Universidad de Chile), Dr. Joseline Tapia, Vice-President (Universidad Católica del Norte), and LOC members MSc. Germán Ojeda, Treasurer (Antofagasta Minerals), Dr. Pamela Castillo (Universidad de Concepción), Dr. Paula Ramírez (Flow Hydro Consulting), MSc. Fernando López (BHP Minerals), MSc. Sofía López (ICASS, France), MSc. Carolina Soto (WSP), Dr.(c) McLean Trott (GoldSpot Discoveries Corp., Canada), MSc. Catalina Siebert (Geológica SpA), Dr. María Isabel Varas-Reus (Universität Tübingen, Germany) and Dr. Carmina Jorquera, Chair of the Technical Committee (Teck Resources Ltd.).

We welcome you to IAGS2022 and look forward to meeting you in Viña del Mar, Chile, in October 2022.

Local Organizing Committee (LOC)
29th International Applied Geochemistry Symposium, IAGS2022
Viña del Mar, Chile
contacto.iags2020@gmail.com

AAG Council Elections 2022

This is the annual reminder to AAG Fellows (and Members that could become Fellows) that we need your participation on Council for the coming term. Each year the Association of Applied Geochemists (AAG) seeks motivated and energetic AAG Fellows to stand for election to the position of "Ordinary Councilor." Similarly, each year some of our most outstanding Fellows are ready, willing, and able to meet this challenge. I encourage those Members that have the experience and enthusiasm to be involved, to convert your membership status to Fellow, and work to make a bigger contribution to the AAG (see the website for details).

It is our sincere hope that this notice might entice more people to step forward for election to this important position. If you are not yet a Fellow but want to be more involved, please send me an email as we are looking to get more of our junior members active in the AAG and other opportunities will be coming available.

Councilor Job Description

The AAG Bylaws 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 for hosting our biennial Symposium, to approving applications for new members, to developing marketing strategies for sustaining and growing our membership. These affairs are discussed and decisions made at Council teleconferences which are usually held 3 to 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 of course 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 Councilor 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; don't hesitate to contact me directly if you have any questions.Each Councilor serves a term of two years and may 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 October-November of the year for a term covering the following two years. Our next election will be held in October-November 2022 for the term of 2023-2024.

How to get your name 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, dbsmith13@gmail.com) by **October 15, 2022** and include a short (no more than 250 words) summary of your career experience. This summary should include the following:

- ☐ Your name
- ☐ Year that you became a Fellow of AAG
- ☐ Earth science degree(s) obtained, graduation year(s) and institution(s)
- ☐ Employment—list major employers and state years worked for each, e.g. 1980-1990, and type of work
- ☐ Position 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.

John Carranza
President

Welcome New AAG Members

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.*

Mr. Daniel Adekanmi
Laboratory Scientist
National Geosciences Research Laboratories
1 Aliyu Markana Road
Kaduna, Nigeria 800242
Membership no. 4491

Lars Dahlenborg
President
Hannan Metals Ltd.
Norderon 230
Froson
SWEDEN 83293
Membership no. 4493

Margaret Doolittle
Geologist III
EA Engineering, Science, Technology Inc.
555 University Ave., Suite 100
Sacremento, CA
UNITED STATES 95825
Membership no. 4495

Fellows

***Fellows** are voting members of the Association and are actively engaged in the field of applied geochemistry. They are Regular AAG Members that are nominated to be a Fellow by a Fellow of the Association by completing the Nominating Sponsor's Form. Consider becoming a Fellow of the AAG.*
Download the form here: https://www.appliedgeochemists.org/

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.

Mahendra Shukla
PhD Student
Division de Geociencias Aplicadas
Instituto Potosino de Investigacion Cientifica y Tecnologica (IPICYT)
Camino a la Presa San José #2055
Col. Lomas 4a Sec.
San Luis Potosi
Mexico 78216
Membership no. 4488

Ben Eaton
MSc student
University of British Columbia
3260 West 10th Ave.
Vancouver, BC V6K 2L2
Membership no. 4489

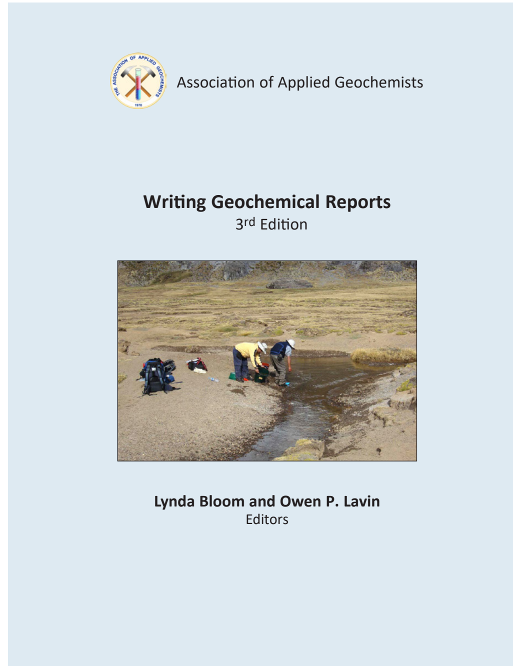
Billy Yeomans
University of Victoria
3811 Harding Rd.
West Kelowna, BC
Membership no. 4490

Margherita Denaro
PhD Student
Khalifa University
Al reef 2, street 41
Abu Dhabi
United Arab Emirates
Membership no. 4492

Yusuf Ibrahim
University of Jos, Nigeria
Plots 7 and 8 Pipc layout Guratopp
Guratopp
Jos Plateau State
NIGERIA 930103
Membership no. 4494

Writing Geochemical Reports, 3rd Edition

Edited by Lynda Bloom and Owen Lavin



Writing Geochemical Reports: Guidelines for surficial geochemical surveys was first conceived and written by Dr. Stan Hoffman and was published in 1986 by the Association of Exploration Geochemists as Special Volume No. 12. Stan was an energetic and passionate geochemist working for a large mining and exploration company based in British Columbia, Canada. In his job, he saw a lot of reports about surficial geochemical surveys and he recognized the need for rigour and standardization in this relatively young field of exploration geochemistry. During this time, geochemical reports were confined to hardcopy black-and-white documents.

Fifteen years later, advances in the science of exploration geochemistry necessitated a modernization of the original guidelines. Lynda Bloom, together with several co-contributors, produced the second edition in 2001. Twenty years hence, advances in technology have again made some of the earlier recommendations obsolete. Importantly, electronic publication of reports has become the norm, enhanced by the ability to bundle text, tables, figures, images, and oversized maps into one electronic file.

This third edition expands the original mandate of surficial geochemical reports to include multiple types of geochemical surveys with survey-specific recommendations.

The guide may be downloaded free of charge from the AAG website: https://www.appliedgeochemists.org/publications/writing-geochemical-reports-3rd-edition

International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network

The International Union of Geological Sciences Commission on Global Geochemical Baselines is pleased to announce the publication of the *International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*. Darnley et al. (1995) introduced the concept of producing a global-scale, multi-media geochemical atlas by sampling on the basis of the Global Geochemical Reference Network (GRN). The GRN is a grid-based sampling scheme comprised of 19,833 cells covering the whole globe. Of these, 7356 cells, approximately 160 x 160 km in size, cover the land surface of the Earth, and are known as the Global Terrestrial Network (GTN). This book provides in great detail the methods that should be employed for mapping the abundance and spatial distribution of chemical elements in rocks, soils, sediments, and water across the entire land surface of the Earth based on sampling according to the GTN. The 515-page book contains separate chapters providing extensive information on sampling protocols for rocks, residual soil, humus, stream water, stream sediments, and overbank and floodplain sediments. There are also chapters discussing sample site selection; sample preparation; quality control procedures, including development of project reference materials; data management; map preparation; project management; and information on how to level existing geochemical data sets. Any applied geochemist considering carrying out a geochemical mapping project at a global scale, or any other scale, should find a wealth of useful information within these pages. The sampling manual is available free of charge and can be downloaded from the Publications web page of the IUGS Commission on Global Geochemical Baselines (https://www.globalgeochemicalbaselines.eu/).

Demetriades, A., Johnson, C.C., Smith, D.B., Ladenberger, A., Adánez Sanjuan, P.A., Argyraki, A., Stouraiti, C., Caritat, P. de, Knights, K.V., Prieto Rincón, G. and Simubali, G.N. (Editors), 2022. ***International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network***. IUGS Commission on Global Geochemical Baselines, Athens, Hellenic Republic, Special Publication, 2, 515 pages, 375 figures, 35 Tables, 5 Annexes and 1 Appendix, ISBN: 978-618-85049-1-2.

Dr. Anna Ladenberger, Dr. Katherine Knights,
Co-chairs, IUGS Commission on Global Geochemical Baselines

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.

The status of the meetings was confirmed on August 15th 2022, but further changes are likely, and users of the listing are strongly advised to carry out their own research as to the validity of an announcement.

Please let us know of your events by sending details to:
Steve Amor, Email: steve.amor2007@gmail.com
or
Or Elizabeth Ambrose, Email: eambrose0048@rogers.com

2022

21-23 SEPTEMBER	Mongolia Mining 2022. Ulaanbaatar Mongolia. Website: mongolia-mining.com
9-12 OCTOBER	GSA 2022 Annual Meeting. Denver CO USA. Website: tinyurl.com/fuyh2t3z
17-19 OCTOBER	16th International Congress of the Geological Society of Greece. Patras Greece. Website: gsg2022.gr
23-28 OCTOBER	29th International Applied Geochemistry Symposium (IAGS). Viña del Mar Chile. Website: iags2021.cl
7-10 NOVEMBER	X Uruguayan Congress of Geology. Montevideo Uruguay. Website: 10congresogeologia.uy
14-16 NOVEMBER	Australasian Environmental Isotope Conference. Ballina NSW Australia Website: www.conferences.com.au/2022aeic
27-30 NOVEMBER	2nd MedGU - Mediterranean Geosciences Union. Marrakech Morocco. Website: www.medgu.org
4-9 DECEMBER	American Exploration & Mining Association (AEMA) Annual Meeting. Sparks NV USA. Website: tinyurl.com/ycktxmut
12-16 DECEMBER	AGU Fall Meeting. Chicago IL USA. Website: www.agu.org/Fall-Meeting

2023

23-26 JANUARY	Mineral Exploration Roundup. Vancouver BC Canada. Website: roundup.amebc.ca
29 JANUARY-3 FEBRUARY	Winter Conference on Plasma Spectrochemistry. Ljubljana Slovenia. Website: ewcps2021.si
13-18 MARCH	Australasian Exploration Geoscience Conference. Brisbane Qld Australia. Website: 2023.aegc.com.au

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CALENDAR OF EVENTS...

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19-23 MARCH	Minerals, Metals & Materials Society Annual Meeting & Exhibition. San Diego CA USA. Website: www.tms.org/AnnualMeeting/TMS2023
23-28 MARCH	EGU General Assembly 2023. Vienna Austria. Website: tinyurl.com/4b3cfvva
10-14 APRIL	Geociencias 2023 - X Earth Science Convention. Havana Cuba. Website: www.cubacienciasdelatierra.com
25-27 APRIL	International Conference on Geographical Information Systems Theory, Applications and Management. Prague Czech Republic. Website: gistam.scitevents.org
24-27 MAY	GAC-MAC Joint Annual Meeting. Sudbury ON Canada. Website: gac.ca/events/gac-mac-annual-meeting
18-23 JUNE	Catchment Science: Interactions of Hydrology, Biology and Geochemistry (Gordon Research Conference). Andover NH USA. Website: tinyurl.com/2p968pxe
19-22 JUNE	SIAM Conference on Mathematical & Computational Issues in the Geosciences. Bergen Norway. Website: tinyurl.com/4eesycan
9-14 JULY	Goldschmidt 2023. Lyon France. Website: tinyurl.com/32zcw7es
14-20 JULY	21st INQUA Conference. Rome Italy. Website: inquaroma2023.org
16-21 JULY	Chemical Oceanography (Gordon Research Conference). Manchester NH USA. Website: tinyurl.com/mu7ybfz6
25-27 JULY	6th International Archean Symposium. Perth WA Australia. Website: 6ias.org
28 JULY	Target 2023: Innovating now for our future. Perth WA Australia. Website: www.aig.org.au/events/target-2023
12-18 AUGUST	5th International Symposium on Environment and Health. Galway Ireland. Website: www.nuigalway.ie/iseh-iceph
18-22 AUGUST	Water-Rock Interaction WRI-17/ Applied Isotope Geochemistry AIG-14. Sendai Japan. Website: www.wri17.com
26-29 AUGUST	SEG 2023 Conference: Resourcing the Green Transition. London, England. Website: tinyurl.com/2p8b7mue
28 AUGUST-1 SEPTEMBER	17th Biennial Meeting of the Society for Geology Applied to Mineral Deposits. Zurich Switzerland. Website: sga2023.ch
28 AUGUST-1 SEPTEMBER	8th World Multidisciplinary Earth Science Symposium. Prague Czech Republic. Website: www.mess-earth.org
10-15 SEPTEMBER	International Meeting on Organic Geochemistry. Montpellier France. Website: eage.org/imog/imog-23
11-15 SEPTEMBER	IWA World Water Congress & Exhibition 2023. Beijing China. Website: www.worldwatercongress.com
31 OCTOBER-2 NOVEMBER	14th Fennoscandian Exploration and Mining conference. Levi Finland. Website: femconference.fi

2024

25-31 AUGUST	37th International Geological Congress. Busan, Republic of Korea. Website: www.igc2024korea.org

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

Statement from Elements Executive Committee

Dear Elements Participating Societies,

As you are likely aware there has been a delay in production of the 2022 issues of Elements Magazine. This is the result of continued pandemic delays and a workflow/staffing problem at Elements over the past few months. We have worked to overcome the resultant setbacks and are back on track and moving forward with production. We expect to have the first issue of 2022 (v.18, n1, Halogens) out to society members by the end of August and will follow relatively quickly with v.18,n2 (Organic Biomarkers). We are also working to update the Elements website.

We thank you for your patience and support as we strive to maintain the high quality that you and your members have come to expect from Elements.

The Elements Team

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
Elements Coordinator

Article of Interest

Davies, T.C. The position of geochemical variables as causal co-factors of diseases of unknown aetiology. *SN Appl. Sci.* **4**, 236 (2022). https://doi.org/10.1007/s42452-022-05113-w

Highlights:

- Understanding of geochemical perturbations in human metabolisms is emphasized
- Understanding could aid greatly in the decipherment of diseases of unknown aetiology (DUA)
- May help pave the way for better diagnosis and therapy of DUA

Submitted by:
Theo Davies