

Integration of Geochemical and Mineralogical Data: An Example from the Central Victorian Goldfields, Australia

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Introduction

Both geochemical and mineralogical data are collected at various stages of the resource development cycle. However, they are generally interpreted separately and often the data are collected from different samples. In some instances, geochemical data may be used to constrain quantitative X-ray diffraction (XRD) interpretations or to calculate normative mineralogy. Petrology provides important textural information and key samples may constrain parageneses, but these observations are typically qualitative. The collection of quantitative and semi-quantitative mineralogical data can be integrated with total or near-total digestion geochemical data obtained from the same samples to enhance interpretation of both data sets and provide insight into geological processes associated with hydrothermal mineralisation (e.g. Halley *et al.* 2015).

This summary will demonstrate two of the principal ways in which geochemical and mineralogical data can be integrated. The simplest approach involves attribution of mineralogical information to samples as an aid to understanding geochemical processes. A more rigorous approach makes use of quantitative and semi-quantitative mineralogical data plotted with geochemical data. The mineralogical data may include estimates of the percentages or proportions of minerals determined by quantitative XRD. It may also include spectral parameters such as the wavelength of characteristic absorption peaks for various minerals or ratios derived using those absorption wavelengths. Quantification of mineralogical data allows for full integration of mineralogical and geochemical data.

Central Victorian Goldfields

The Victorian goldfields of the western Lachlan Fold Belt of Australia have produced an estimated 2490 t of gold since 1851, most of which was recovered prior to 1920 from shallow alluvial workings and most of which was mined in central Victoria (Phillips *et al.* 2003 (Fig. 1). The majority of these deposits are typical sediment-hosted orogenic deposits containing free gold associated with structurally-controlled quartz veins, although the upper levels of the Fosterville deposit are dominated by refractory gold in arsenopyrite and pyrite that is

continued on page 5

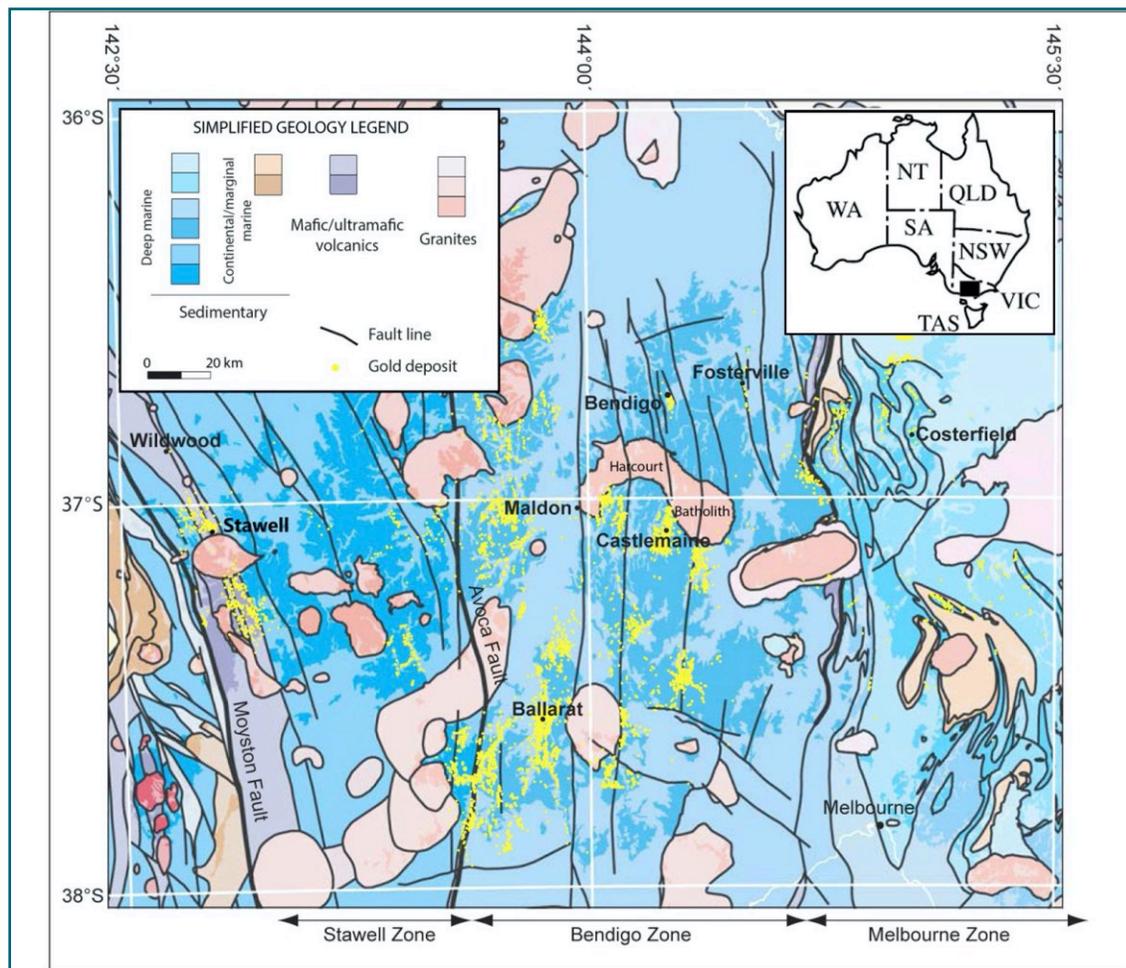


Figure 1. Paleozoic geology of the central Victorian goldfields with the locations of individual gold deposits in southeastern Australia. Darker colours for each geological unit represent exposed bedrock. Figure modified from Arne *et al.* 2016; copyright ©Geological Society of Australia, reprinted by permission of Taylor & Francis Ltd, <http://www.tandfonline.com> on behalf of the Geological Society of Australia.

A wide-angle photograph of a desert landscape at sunset. The sun is low on the horizon, casting a warm, golden glow over the rugged, layered rock formations. The sky is a clear, pale blue.

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March newsletter: January 15
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- **Manuscripts** should be double-spaced and submitted in digital format using Microsoft® WORD. Articles should be between 2000 and 3000 words. Do **not** embed figures or tables in the text file.
- **Figures and/or photos** (colour or black and white) should be submitted as separate 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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- An **abstract** of about 250 words must also be submitted that summarizes the content of their article. This abstract will be published in the journal ELEMENTS on the 'AAG News' page.

Submissions should be sent to the Editor of EXPLORE:

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TABLE OF CONTENTS

Integration of Geochemical and Mineralogical Data: An Example from the Central Victorian Goldfields, Australia	1
Notes from the Editor	3
President's Report	4
W.K Fletcher, AAG 2021 Gold Medal	12
Geochemistry: Exploration, Environment, Analysis	13
Obituary: Ed Dronseika (1953-2021)	14
Recently Published in Elements	15
Amendment to AAG By-laws: Article 2.11 Governing Senior Members and Fellows	15
Calendar of Events	16
The AAG-SGS Student Presentation Prize	18

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Overburden Drilling Management	19
Portable Spectral Services	6
SGS	17

Notes from the Editor

Welcome to the second **EXPLORE** issue of 2021. This issue features an article describing the integration of geochemical and mineralogical data using an example from the central Victorian Goldfields in Australia by Dennis Arne. **EXPLORE** thanks all those who contributed to the writing and/or editing of this issue, listed in alphabetical order: Steve Amor, Dennis Arne, Al Arsenault, John Carranza, Steve Cook, Richard Dyer, David Leng, David Murphy, and Jessey Rice.

Beth McClenaghan
Editor



President's Report

AAG Council met virtually in March and endorsed the recommendation from the local organising committee (LOC) to postpone the next IAGS in Chile until 2022. The conference will likely follow a hybrid model, with both physical and virtual attendance to be available. The LOC has further suggested a trial virtual get-together later this year to focus on short courses. Our AGM, which was scheduled to occur at the IAGS this October, will now be re-scheduled as a virtual meeting. The timing will be announced in due course.

A motion has also been passed by council to change the bylaw relating to eligibility criteria for members proposing to become Senior Members or Fellows. The proposed changes are announced elsewhere in this issue of Explore and a vote of Fellows will be called by the Secretary to either endorse or reject the proposed changes.

Dave Cohen presented a discussion paper for the last council meeting entitled "A Comprehensive Continuing Professional Development Program in Exploration Geochemistry". This document provides a pathway for the AAG to follow to become a recognised provider of continuing professional development (CPD) in exploration geochemistry. This initiative brings together several threads that have been proposed in recent times, including:

- A thematic series of papers in GEEA outlining basic theory and approaches to exploration geochemistry;
- The development of a new series of digital practical problems in applied geochemistry;
- Revision and updating of the AAG publication "Writing Geochemical Reports";
- Continuing provision of short courses in exploration geochemistry.

The above would provide material to support the development of learning modules on an on-line delivery platform. The on-line delivery of continuing education has accelerated during Covid-19 and, at many universities, has largely replaced face-to-face teachings. The AAG is well positioned to provide the content to support this initiative. The first steps will involve a scoping study of CPD programs provided by comparable professional societies and to assess likely markets, followed by an estimate of costs involved to develop a CPD program of similar standard. The CPD modules would be offered at a discounted rate to AAG members. Council is expected to make a decision to proceed with the scoping study at the next council meeting in June.

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President



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Integration of Geochemical and Mineralogical Data... *continued from page 1*

disseminated within altered metasedimentary wallrock. Geochemically, the deposits show a strong Au-As association, with variable contents of Sb and base metals.

The Victorian goldfields have seen a resurgence in exploration and mining in the last 30 years, culminating in the discovery in 2016 of high-grade gold mineralisation hosted in quartz-carbonate veins at depth in the Swan Lode at the Fosterville deposit (Fuller 2019). Several gold deposits from the central Victorian goldfields have been the subject of wallrock alteration studies that have incorporated both quantitative XRD and hyperspectral (visible to near infrared and short wave infrared) analysis of the same samples analysed geochemically (Bierlein *et al.* 2000; Arne *et al.* 2008). The integrated interpretation of the combined geochemical and mineralogical data coupled with staining of diamond drill core to reveal disseminated ferroan carbonate minerals has allowed the recognition of widespread hydrothermal alteration around many of the major deposits that is not immediately obvious (i.e. cryptic alteration).

In brief, most central Victorian gold deposits are associated with the presence of ferroan carbonate porphyroblasts, or “spots”, that increase in amount and change to a more ferroan composition as mineralised structures are approached (Bierlein *et al.* 1998, 2000; Arne *et al.* 2008). Dugdale *et al.* (2009) suggest the earliest carbonate spots are of diagenetic origin and not associated with gold mineralisation. Host sandstones are also characterised by Na loss associated with the destruction of detrital albite and the formation of hydrothermal white mica with a muscovite composition (Arne *et al.* 2008, 2016), as well as kaolinite in the case of Ballarat. Elevated concentrations of chalcophile elements, particularly As and Sb, are associated with disseminated pyrite, with arsenopyrite developed proximal to mineralised structures (Bierlein *et al.* 1998, 2000; Arne *et al.* 2008). Stibnite occurs in quartz veins at Costerfield and Fosterville. Recognition of these alteration types provides an important tool for vectoring towards mineralised structures in the central Victorian goldfields.

Integration with Quantitative XRD Data

Bierlein *et al.* (2000) presented the results of quantitative XRD analysis of pulps for typical wallrock samples without veining at several central Victorian goldfields. These samples were also analysed geochemically using X-ray fluorescence (XRF) following a total fusion digestion. These data have been supplemented with quantitative XRD and geochemical data from the Bendigo goldfield in Swan (2002). The XRD results allow the geochemical data to be interpreted within a mineralogical framework and provide clear evidence of the mineralogical changes that occur during wall alteration in central Victorian gold deposits.

Figure 2 compares major elements with quantitative mineralogy from six different central Victorian goldfields, with

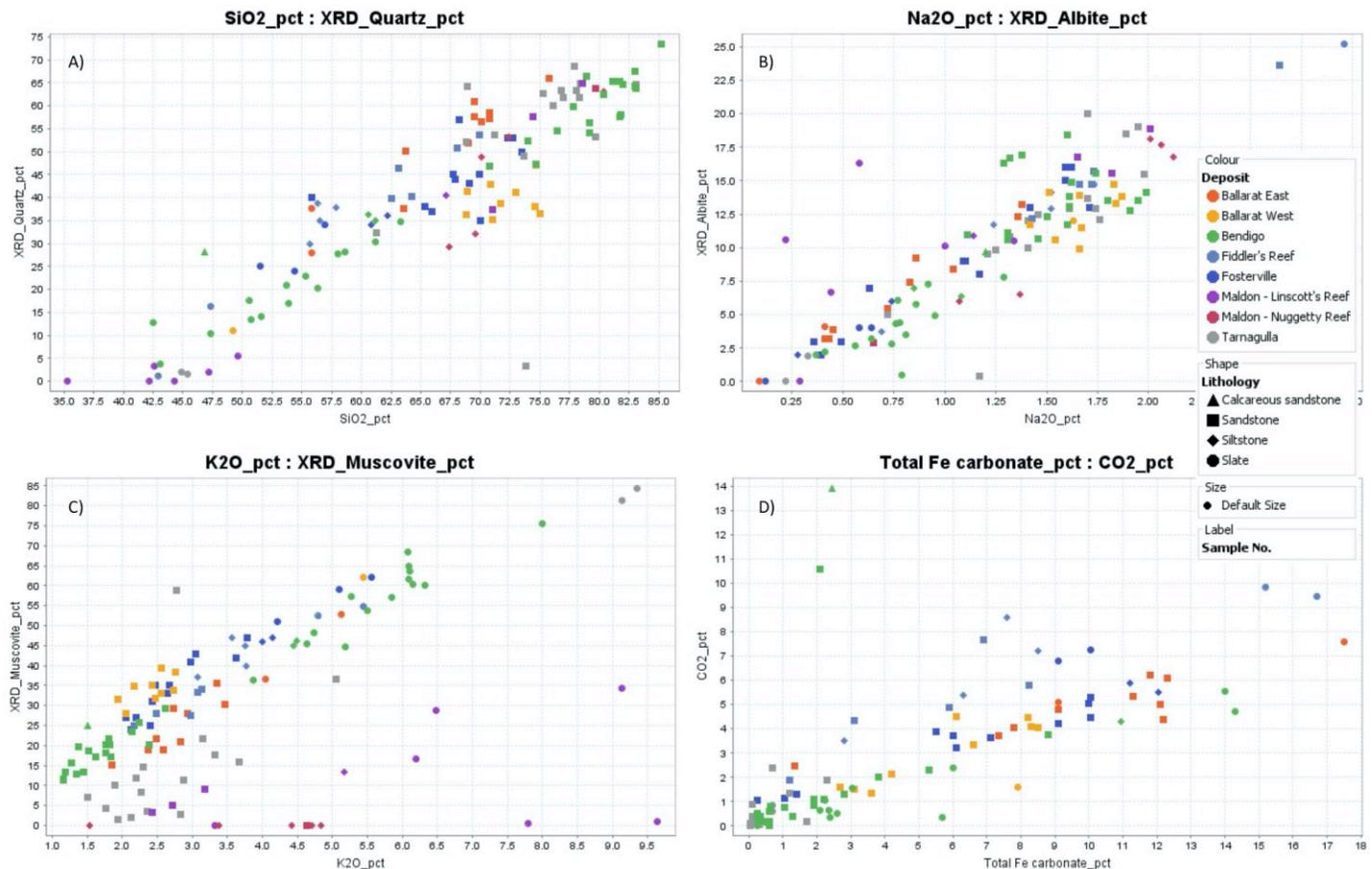


Figure 2. Scatter plots illustrating the relationships between major elements and quantitative XRD mineralogy. $N = 127$.

continued on page 6

Integration of Geochemical and Mineralogical Data... *continued from page 5*

some distinction for different zones within Maldon and Ballarat. In general, there is a positive correlation between SiO_2 , Na_2O , K_2O and CO_2 with quantitative XRD estimates of quartz, albite, muscovite and total ferroan carbonate (siderite + ankerite), respectively. Spearman Rank correlation coefficients vary from 0.88, 0.86, 0.55 and 0.87, respectively, for the geochemical and mineralogical data. Weak correlation between K_2O and muscovite is caused by the presence of samples from Maldon (Fig. 2c), in which the alteration assemblages have been affected by contact metamorphism, resulting in biotite as a significant K-bearing mineral. The Spearman Rank correlation for K_2O and muscovite increases to 0.85 if the data from Maldon are removed from the analysis. Two samples from Bendigo also plot off the trend defined by CO_2 and total ferroan carbonate due to the presence of calcareous sandstone samples (Fig. 2d). Figure 2 also illustrates the fundamental control on both geochemistry and mineralogy exerted by lithology, with slates generally having the highest contents of ferroan carbonate and muscovite, and the sandstones the highest contents of quartz and detrital albite.

Figure 3 illustrates trends in selected quantitative XRD mineralogy with respect to the lateral distance of the

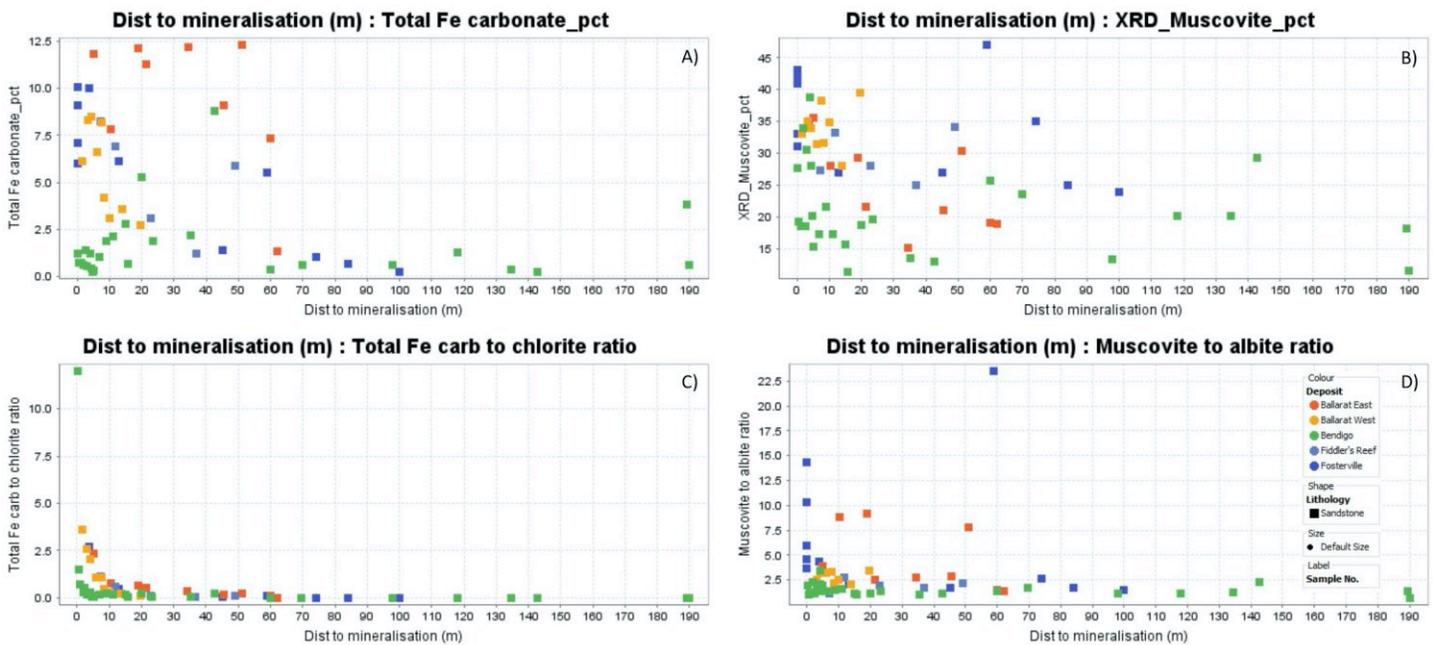


Figure 3. Scatter plots illustrating the relationship between distance of the samples from a mineralised structure and quantitative XRD mineralogy. $N = 62$.

continued on page 8



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Integration of Geochemical and Mineralogical Data... *continued from page 6*

samples from mineralised structures. Data from Maldon and Tarnagulla have been excluded, as both contain alteration assemblages that have been overprinted by contact metamorphism. The analysis has also been restricted to sandstone lithologies to minimise mineralogical variability related to lithology. There is considerable scatter in the mineralogical data (Fig. 3a and 3b) that reflects the variability in the degree to which wallrock samples are altered, in response to fluid-rock interactions controlled by local permeability. However, clear trends of increasing ferroan carbonate and muscovite are apparent with increasing proximity to mineralised structures when these minerals are ratioed against chlorite and albite, respectively (Fig. 3c and 3d). Whether ferroan carbonates replace chlorite, or whether chlorite represents an outer, more distal alteration assemblage is not clear. What is clear is that, aside from the Bendigo goldfield, chlorite is not a stable alteration phase proximal to the mineralised structures examined.

Integration with Hyperspectral Data

Arne *et al.* (2008) undertook further analyses of wallrock alteration in fresh core samples at six central Victorian goldfields. Samples were analysed mainly by a combination of 4-acid digestion with an ICP-ES/MS finish, with Au determined by fire assay/ICP-MS, carbonate C determined by LECO analyser and Ti, W, Ba and Zr determined by pressed pellet XRF. A separate 50 g split of <2 mm crush material was loaded into a plastic chip tray and analysed using a HyChips™ robotic table at the Commonwealth Scientific and Industry Research Organisation (CSIRO). The HyChips™ collects information on absorption by hydrous, oxide and carbonate minerals in the visible to near-infrared (VNIR) and short wave infra-red (SWIR) part of the electromagnetic energy spectrum. The data were analysed by AusSpec International using The Spectral Geologist™ software, also developed by CSIRO. The mineralogical data are summarised in terms of mineral assemblages ordered with respect to relative spectral intensity in each sample.

The relationship between the position of the AIOH absorption peak measured in the SWIR range (wavWMica) and As is illustrated in Figure 4, excluding Maldon and Castlemaine samples. The position of this peak is sensitive to white mica composition, specifically the substitution of Al by Fe²⁺ and/or Mg in the white mica structure (Tappert *et al.* 2013). The use of As is preferred as a measure of alteration over the distance to mineralisation as higher concentrations of As indicate interaction with a hydrothermal fluid. The dashed lines on the diagrams provide a general boundary between white

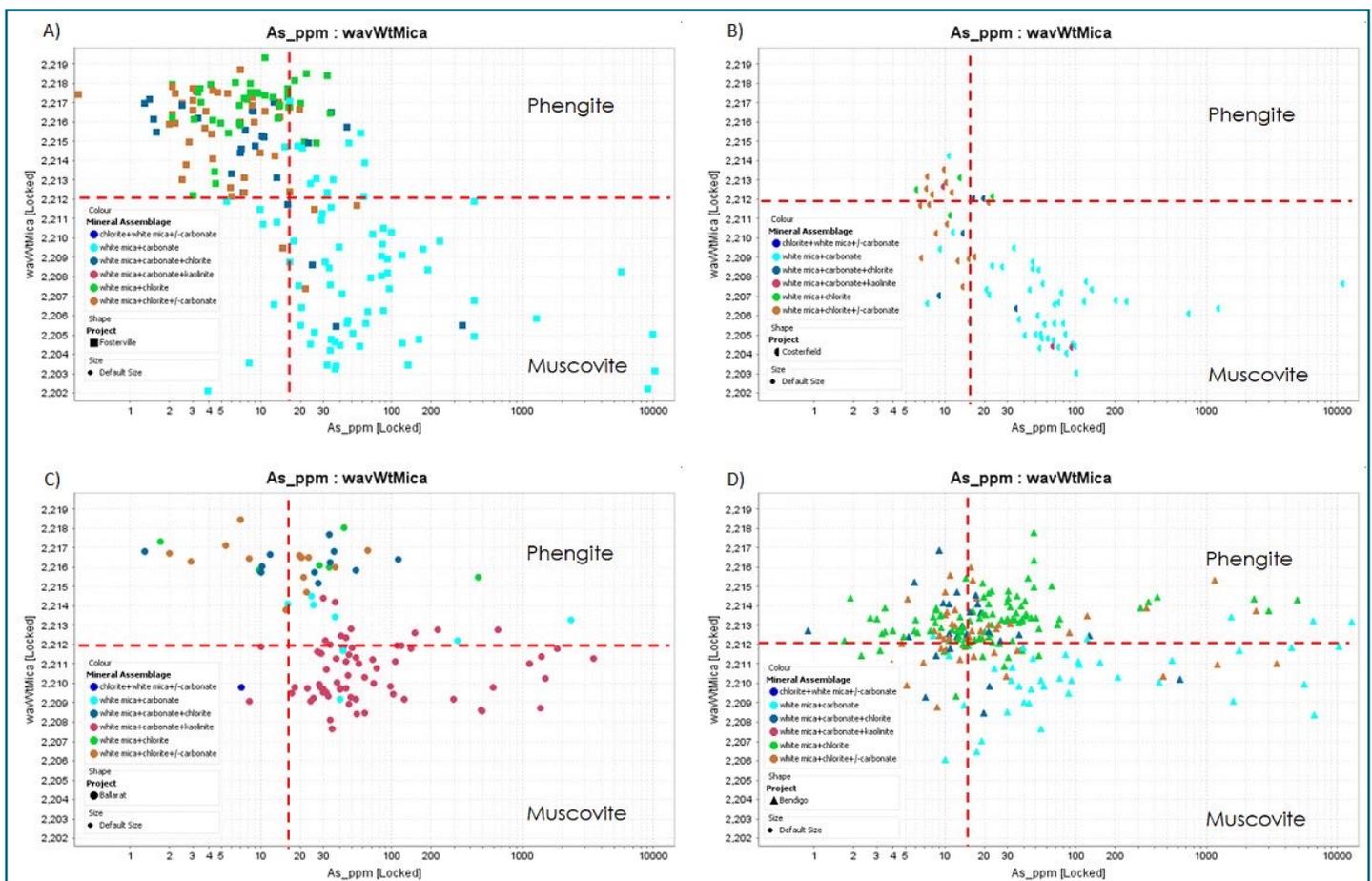


Figure 4. Scatter plots illustrating the relationship between the wavelength position of the AIOH absorption peak in white mica (in nanometres) and arsenic concentration for: a) Fosterville, b) Costerfield, c) Ballarat and d) Bendigo.

continued on page 9

Integration of Geochemical and Mineralogical Data... *continued from page 8*

micas of dominantly phengite composition, in which there is some substitution of Al by Fe²⁺ and/or Mg, and muscovite compositions, in which this substitution is minimal. The dashed line for As at approximately 15 ppm represents a lower threshold evident in some of the data, below which samples show no evidence of hydrothermal alteration.

White mica – ferroan carbonate assemblages are dominated by muscovite at Ballarat, Bendigo, Costerfield and Fosterville. The alteration assemblage at Ballarat also includes kaolinite (Fig. 4c), even though the samples were collected well below the base of oxidation in the goldfield. Samples that contain more phengitic white mica compositions are dominated by white mica and chlorite, with minor carbonate in some cases. The use of an upper As threshold of 100 ppm excludes most phengite-bearing samples at Ballarat, Costerfield and Fosterville, indicating that phengite generally does not persist in those samples with the strongest evidence for hydrothermal alteration. Although a trend to lower AlOH absorption wavelengths is apparent in the data from Bendigo (Fig. 4d), the relationship between white mica composition and As concentration is not as clear as at the other three deposits shown. Chlorite-bearing samples at Bendigo may have elevated As levels, as previously determined by Swan (2002).

A useful diagram for tracking feldspar-destructive alteration is the K/Al versus Na/Al molar ratio plot of Davies & Whitehead (2006) (Fig. 5). The progressive loss of Na with destruction of detrital albite in fresh sandstone samples follows the albite-muscovite tie line and is associated with an addition of K. The mineralogy inferred from geochemical trends and nodes on the diagram is supported by the hyperspectral alteration assemblages determined for the samples.

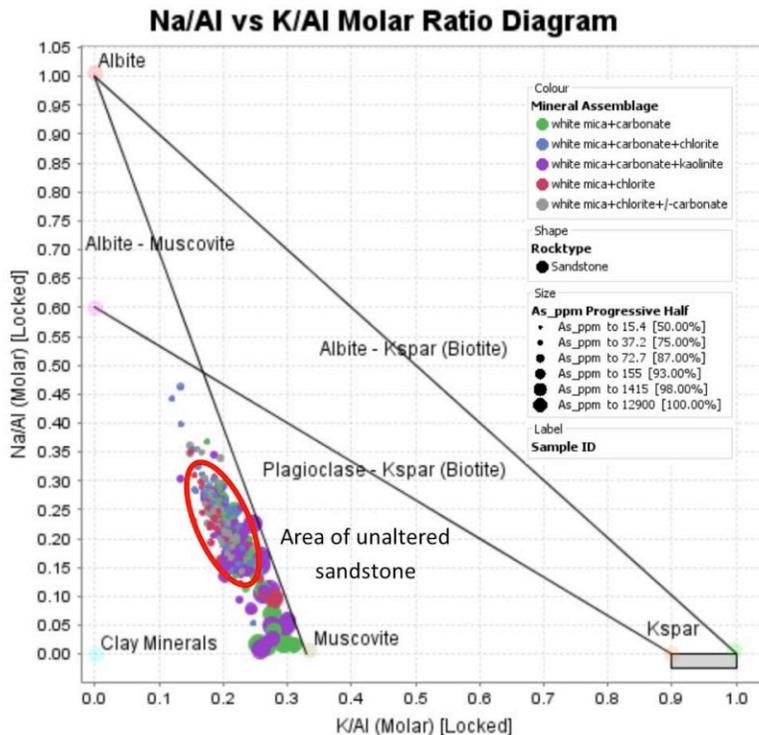


Figure 5. Molar plot for Na/Al versus K/Al modified from Davies & Whitehead (2006) combined with proportional dot plot of As concentration showing the trend in sandstone samples of decreasing Na with increasing As content for samples from Ballarat, Castlemaine, Fosterville and Costerfield. Data from Maldon and Bendigo have been excluded.

The presence of chlorite and/or kaolinite would drive the samples towards the origin, were they present in significant quantities, but this is not indicated by the geochemical data. Data from Maldon have been excluded due to contact metamorphic overprinting. Data from Bendigo have also been excluded because chlorite-bearing assemblages show enrichment in As, and this is not the case in the other central Victorian goldfields investigated. In general, sulphidation is spatially associated with albite destruction and the formation of muscovite.

Discussion

Although not illustrated in Figure 3a, the general increase in ferroan carbonate is also evident if data for siderite and ankerite are plotted independently. Electron microprobe analyses of carbonate spots in Fosterville samples indicate that these two carbonate types represent two distinct compositional populations (Arne *et al.* 1998) and that “siderite” in fact represents an intermediate composition between siderite and magnesite. Geochemical data from central Victorian goldfields are also consistent with an increase in the Fe content of ferroan carbonates with increasing As content (Arne *et al.* 2008). The spatial trends illustrated in Figure 3 and documented in Arne *et al.* (2008) suggest that the distribution of ferroan ankerite is controlled by hydrothermal fluids and unlikely to be a diagenetic feature, as suggested by Dugdale *et al.* (2009), although diagenetic calcite may be present in distal samples.

Feldspar-destructive alteration in sandstones provides a useful additional vector for indicating proximity to mineralised

Integration of Geochemical and Mineralogical Data... *continued from page 9*

structures in fresh rock using either total or near-total digestion geochemical analyses, hyperspectral data, or quantitative XRD analyses once the background lithological effects are accounted for. Shales contain little detrital albite and thus do not display the shift in white mica composition characteristic of sandstones. A preference for sampling sandstone has thus characterised the work of Bierlein *et al.* (2000) and Arne *et al.* (2008), but risks missing elevated ferroan carbonate in shales, as demonstrated by Swan (2002) at Bendigo.

The use of ICP-MS analyses of chalcophile elements such as Au, As and Sb should also not be discounted, as disseminated pyrite grains spatially associated with mineralised structures are often enriched in these elements and can be detected by litho-geochemical sampling. The hydrothermal nature of these pyrite grains or overgrowths is indicated by sulphur isotopic values near 0 per mil (Bierlein *et al.* 2004).

There remains a fundamental difference in alteration assemblages at Bendigo and, to lesser extent, Castlemaine, with those documented at Ballarat, Fosterville and Costerfield. These differences may relate to a different timing of mineralisation (Wilson *et al.* 2020). Gold mineralisation at Bendigo is estimated to have occurred at ca. 445 Ma based on Ar^{40}/Ar^{39} age determinations of hydrothermal white mica and Re-Os analyses of hydrothermal sulphide minerals (Arne *et al.* 2001; Phillips *et al.* 2003, 2012), and a similar timing can be inferred for the Castlemaine goldfield. The timing of gold mineralisation at Ballarat is also considered to have commenced at ca. 445 Ma, also based on Ar^{40}/Ar^{39} age determinations of hydrothermal white mica, but there is also evidence for a latter mineralising episode or remobilisation of gold around 370 Ma (Phillips *et al.* 2003, 2012). The Fosterville and Costerfield gold deposits are demonstrably younger than the Bendigo deposit (Phillips *et al.* 2003). Gold mineralisation occurs in rocks of Silurian age at Costerfield and Ar^{40}/Ar^{39} age determinations of hydrothermal white micas and U-Pb age determinations of inherited zircon grains in felsic dykes at Fosterville suggest a Devonian age for Au mineralisation (Bierlein *et al.* 2001). Thus, it appears that Au deposits in central Victoria have formed at different stages of the Lachlan Orogen with subtly different wallrock alteration styles and patterns, perhaps related to different ambient temperatures at the time of gold emplacement or to the geochemical and/or physical characteristics of the hydrothermal fluids.

Conclusions

The case study presented here illustrates a simple but effective approach to the integration of geochemical and mineralogical data using both descriptive mineralogy and quantitative results. This process necessarily begins with the collection of both data types from the same samples and requires geochemical and mineralogical data to be merged into a common data file for interpretation. Quantitative mineralogical data can be incorporated into statistical or geospatial evaluations of geochemical data to provide insight into the mineralogical controls on geochemical results. The integration of geochemical and mineralogical data therefore provides a more comprehensive understanding of wallrock alteration processes, as illustrated by the results of studies carried out within the central Victorian goldfields.

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Field analysis, metrology
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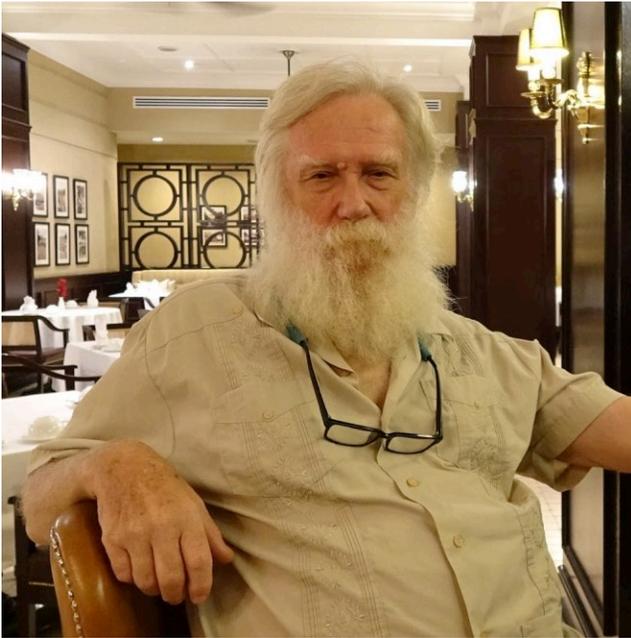
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W.K Fletcher, AAG 2021 Gold Medal

The Association of Applied Geochemists is pleased to announce that the 2021 Gold Medal for outstanding contributions to exploration geochemistry is awarded to Dr. W.K. Fletcher, Professor of Geological Sciences (retired) at The University of British Columbia in Vancouver, Canada.



Donna Baylis photo

William Kenneth ('K') Fletcher was born in England and received both his B.Sc. in Geology and his Ph.D. in Applied Geochemistry from the Imperial College of Science and Technology, University of London, where he was a student of the pioneering exploration geochemist John Webb. Shortly afterwards, in 1968, he moved to The University of British Columbia (UBC) in Vancouver, where he spent three years working as a postdoctoral fellow with Harry Warren on the application of geochemistry to agricultural and public health issues as well as to mineral exploration. K was to spend his entire professional career at UBC. He was appointed Assistant Professor in the Department of Geology in 1971 upon Warren's retirement, then was appointed Associate Professor in 1979 and Professor in 1987. He also served as Acting Head of the Department of Geological Sciences in 1992-93. From 1999 until his retirement in 2003, K occupied the Norman B. Keevil Chair in Mineral Exploration.

In all, K spent 35 productive years at UBC as a researcher and teacher, continuing and expanding on UBC's leadership in exploration geochemistry training and research which Harry Warren began many years before. During that time, he published over 100 scientific papers on exploration geochemistry and related topics, including 76 in refereed journals, and authored, co-authored or edited three books, most notably his 1981 textbook *Analytical Methods in Geochemical Prospecting*.

K's most significant research at UBC centred on the fluvial transport of heavy minerals, including gold and cassiterite, in temperate and tropical regions; on the development of effective methods of sampling and analysis of stream sediments for mineral exploration, and in statistical evaluation of the results of regional geochemical exploration surveys. His work in stream sediment transport in various climatic regions remains a foundation of regional geochemical programs in the mineral exploration industry. He also made important contributions to our understanding of the distribution and behaviour of base and precious metals in soil, till and organic sediments in glaciated terrain. K conducted field investigations, delivered invited lectures and gave short courses in many parts of the world, most notably in Canada, US, Brazil, Africa and Southeast Asia.

K was also fully engaged with the mineral industry outside the university environment and, during leaves of absence from UBC, was Chief Geochemist to MINDECO in Zambia (1975-78) and UN Geochemist and Team Leader at the South East Asian Tin Research and Development Centre in Malaysia (1982-84). He was active in the Association of Exploration Geochemists throughout his career, serving as President in 1991-92, and was AEG Distinguished Lecturer in 1988-89, with his lecture tour including several cities in Europe, Australia and Brazil. He was, at various times, an AEG Councillor and served as Chairman of both the Short Course Committee and the Regional Geochemical Committee. K also served as Co-Editor of the *Journal of Geochemical Exploration* in 1998-99, was a member of the



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continued on page 13

W.K. Fletcher... *continued from page 12*

Canadian Geoscience Council, and represented the discipline of Geochemistry on the Geoscience Committee of the Association of Professional Engineers and Geoscientists of British Columbia.

Perhaps K's greatest contribution to the discipline of applied geochemistry however has been as a teacher and mentor, in training many young scientists at the MSc and PhD level. He supervised 23 graduate students, many of whom went on to important leadership roles as exploration geochemists in industry, academia and government. He was very generous with both his time and ideas, and no less than 6 of his graduate students were awarded the Student Paper Prize of the Association of Exploration Geochemists for papers co-authored with K. With his energy, enthusiasm and many years of leadership in geochemical research and in teaching students, he played no small role in helping to make Vancouver the important global centre of exploration geochemistry which it has become.

K Fletcher retired from UBC in 2003, after which he and his wife Donna were able to devote themselves full-time to their avocation of wildlife photography. His exemplary record as a researcher, teacher and global ambassador for Exploration Geochemistry makes him a worthy recipient of the AAG's Gold Medal. The medal presentation will take place at the upcoming 29th IAGS in Vina del Mar, Chile.

**Stephen Cook**

AAG Awards and Medal Committee



Geochemistry: Exploration, Environment, Analysis

May Volume 21, Number 2

Geochemical characteristics of rare earth elements (REEs) in soils developed on different parent materials, in the Baoshan area, Yunnan Province, SW China

Li Zhang; Wei Han; Min Peng; Fei Liu; Yuntao Song; Xiujin Liu; Qiaolin Wang; Kuo Li; Dongjie Zhao; Wei Yang; Yuanli Qin; Hangxin Cheng

Vol.21, geochem2019-082. doi:<https://doi.org/10.1144/geochem2019-082>

Mineral control on the geochemistry of the Rock Canyon Creek REE-F-Ba deposit, British Columbia, Canada
George J. Simandl; Suzanne Paradis; Johnathan Savard; Deanna Miller; Rameses D'Souza; Daisuke Araoka; Carlee Akam; Mihoko Hoshino; Yoshiaki Kon

Vol.21, geochem2020-010. doi:<https://doi.org/10.1144/geochem2020-010>

Characterization of altered mafic and ultramafic rocks using portable XRF geochemistry and portable Vis-NIR spectrometry

Adams, C., Dentith, M., Fiorentini, M.

Vol.21, geochem2020-065. doi:<https://doi.org/10.1144/geochem2020-065>

Application of multivariate geostatistical simulation and fractal analysis for detection of rare-earth element geochemical anomalies in the Esfordi phosphate mine, Central Iran

Mojtaba Shamseddin Meigooni; Mohammad Lotfi; Peyman Afzal; Nima Nezafati; Maryam Kargar Razi

Vol.21, geochem2020-035. doi:<https://doi.org/10.1144/geochem2020-035>

Application of exploration geochemistry data to identify anomalies in the plateau region: a case study from the Xionggun district in the Gangdese metallogenic belt, Tibet, China

Yuming Lou; Xinghai Lang; Xuhui Wang; Yulin Deng; Qing He; Chao Huang; Haihui Liang; Na Lv; Mi Dong; Kai Jiang; Zhong Zhang

Vol.21, geochem2020-083. doi:<https://doi.org/10.1144/geochem2020-083>

Chemical composition of iron sulphides contained in dust from pyrometallurgical Zn and Pb production

Katarzyna Nowińska; Zdzisław Adamczyk

Vol.21, geochem2020-073. doi:<https://doi.org/10.1144/geochem2020-073>



OBITUARY**Ed Dronseika (1953-2021)**

Exploration geochemistry has lost a real character with the death of Ed Dronseika on February 24, 2021 in Perth, Australia. Ed was a great enthusiast in all that he did. He was a passionate geochemist and a lateral thinker who often had a refreshingly different and interesting perspective on topics. He was inquisitive and never afraid to ask questions – many will recall being held to account by Ed if we were not able to fully explain our theories.

He was a pioneer in commercial laboratory partial digest methods and he became a world-leader in this field. His success was due to his quest to understand the mechanisms by which processes happen and his willingness to experiment, adapt and continually learn.

Ed was born in Melbourne and studied geology at Royal Melbourne Institute of Technology (RMIT) in the early 1970s. He worked as both a mine and exploration geologist in what is now Zimbabwe and Namibia in the late 1970s before returning to Australia to work for a decade on the west coast of Tasmania. He worked on tin at the Cleveland Mine, and then with Aberfoyle Ltd on the Que River polymetallic volcanogenic massive sulphide deposit. He spent most of the 1990s in Queensland working for Aberfoyle Exploration, first at Charters Towers and then based in Townsville. Ed was responsible for exploration in the Mt Isa region where he discovered several new prospects.

In 1998, he started specialising in the emerging field of partial digest geochemistry to create cost-effective methods for exploration under cover. After consulting to Terrasearch Ltd in Townsville on these methods, he was recruited by Genalysis Laboratory Services (now Intertek Genalysis) in Perth to work with Chief Chemist, Ann Evers, to set up what has become the successful and well-known suite of TerraLeach™ partial digests.

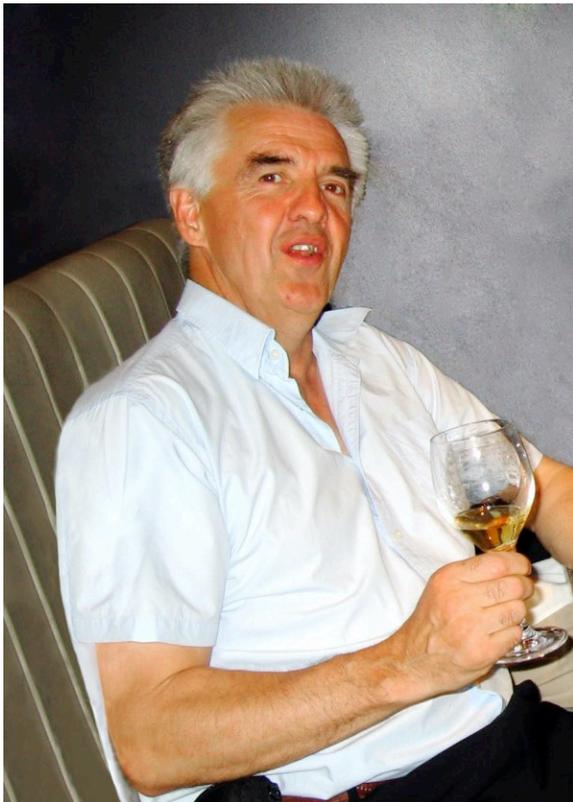
Ed continued to improve his methods and their applications in exploration by working closely with his many clients at Intertek Genalysis, with considerable success in several parts of Australia and Africa, in particular. He built a close-knit team in the Partials Lab at Intertek Genalysis and it is hoped that his work will continue in the capable hands of his 2IC, Irene Patchett, who has kept the “show on the road” during Ed’s recent period of illness.

Ed was a vibrant, multi-skilled person and knowledgeable on many topics, including wine. He was a regular at geology and geochemistry events and was generally a great bloke and lots of fun to socialise with.

The geology and geochemistry community extends their condolences to Ed’s family – his wife Elizabeth, son Anton and daughter Kate.

Please raise a glass (or two) to the one and only Ed Dronseika who will be missed by all.

Helen Waldron and Ann Evers



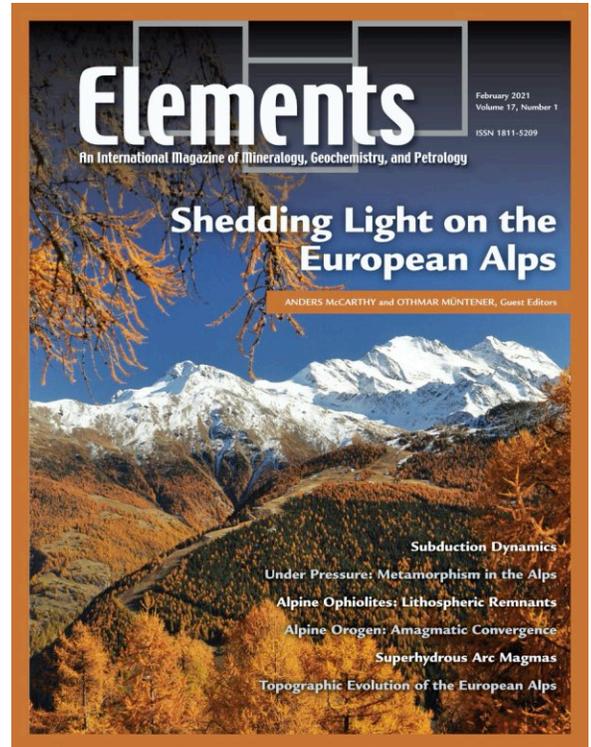
Recently Published in Elements

February 2021, Volume 17, no. 1, Shedding Light on the European Alps

The articles in this issue provide a petrological, geochemical, and tectonic overview of the Alpine Orogeny, from rifting and spreading to subduction and collision and, finally, to post-collisional uplift and erosion. There is one AAG news item in this issue: the citation for Gwendy E. Hall as Honorary Fellow of AAG.

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



Amendment to AAG By-laws: Article 2.11 Governing Senior Members and Fellows

The following proposed amendment to Article 2.11 of the AAG By-laws was approved at the March 24/25, 2021 Council meeting:

2.11 SENIOR MEMBERS and SENIOR FELLOWS. Members in good standing with the AAG may elect to become a Senior Member or Senior Fellow once they are over the age of 65. Senior Members and Senior Fellows may not receive the full range of AAG publications, but in return will pay reduced dues, as determined by Council from time to time. The range of publications available to Senior Members and Senior Fellows will be determined by Council and will be summarized in the newsletter and on the website.

AAG by-law 12.01 stipulates that once the proposed amendment has been announced, the Secretary will initiate a vote by Fellows. This by-law further stipulates that the number of valid votes we receive must exceed 10% of the number of Fellows and must be confirmed by at least two-thirds of the votes cast. Currently, we have 117 Fellows.

Please note that this change applies only to new applicants and the status of existing Senior Members and Senior Fellows will not be affected.

Dennis Arne





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 May 14th 2021, 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

Tom Meuzelaar, AAG Webmaster, tom@lifecyclegeo.com

2021

Virtual Meetings

- 21-24 JUNE SIAM Conference Mathematical and Computational Issues in the Geosciences. Website: www.siam.org/conferences/cm/conference/gs21
- 4-9 JULY Goldschmidt 2021. Website: tinyurl.com/y869e3wo
- 1-5 AUGUST Microscopy & Microanalysis 2021 Meeting. Website: www.microscopy.org/MandM/2021
- 3-4, 10-11 AUGUST International Uranium Digital Conference . Website: tinyurl.com/oxj7f1nw
- 5-7 AUGUST 11th International Conference on Environmental Pollution and Remediation. Website: icepr.org
- 16-20 AUGUST 34th International Geographical Congress. Website: www.igc2020.org/en **NOTE:** Also in-person
- 22-27 AUGUST 16th International Symposium on Biomineralization. Website: www.biomin2021.cn
- 23-27 AUGUST Eurosoil 2021. Website: eurosoil2020.com
- 29 AUGUST- 3rd European Mineralogical Conference. Website: emc2020.ptmin.eu
- 2 SEPTEMBER
- 9-11 SEPTEMBER 3rd International Conference on Tourmaline. Website: www.tur2021.com
- 12-17 SEPTEMBER 30th International Meeting on Organic Geochemistry. Website: eage.eventsair.com/imog-2021
- 13-15 SEPTEMBER Virtual GeoConvention 2021. Website: geoconvention.com
- 2-4 NOVEMBER 13th Fennoscandian Exploration and Mining. Website: femconference.fi

continued on page 17



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Co	0.005	1000
Pd	0.005	100
Pt	0.01	100
Sb	0.02	1000
Tl	0.005	1000
W	0.02	1000



CALENDAR OF EVENTS... *continued from page 16*

In-Person Meetings (status as of May 14th 2021)

- 12-15 JULY 8th Annual International Conference on Geology & Earth Science. Athens Greece. Website: www.atiner.gr/geology
- 15-17 JULY 2nd International Conference on Geology and Earth Sciences. Singapore. Website: www.icges.org
- 17-19 JULY 4th International Workshop on Environment and Geoscience. Hangzhou China. Website: www.iwegconf.org
- 8-10 AUGUST 28th International Conference on Geoinformatics. Nanchang China. Website: www.cpgis2021.com
- 16-20 AUGUST 34th International Geographical Congress. Istanbul Turkey. Website: www.igc2020.org/en **NOTE:** Also Virtual.
- 16-21 AUGUST 36th International Geological Congress . Delhi India. Website: www.36igc.org
- 6-10 SEPTEMBER 10th IAG International Conference on Geomorphology. Coimbra Portugal. Website: tinyurl.com/y4wxd49z
- 6-10 SEPTEMBER Multidisciplinary Earth Science Symposium. Prague Czech Republic. Website: www.mess-earth.org
- 9-10 SEPTEMBER Discoveries in the Tasmanides - Mines and Wines. Orange NSW Australia. Website: tinyurl.com/yyodhxcl
- 9-11 SEPTEMBER 3rd International Conference on Tourmaline. Elba Italy. Website: www.tur2021.com **NOTE:** In person registrants limited to 100. No limit to virtual registrants.
- 14-17 SEPTEMBER SEG 100 Conference. Whistler BC Canada . Website: www.seg100.org
- 15-20 SEPTEMBER Australasian Exploration Geoscience Conference. Brisbane QLD Australia. Website: 2021.aegc.com.au
- 9-17 OCTOBER 28th Colloquium of African Geology. Fez Morocco. Website: tinyurl.com/9bxy6a3t
- 10-13 OCTOBER GSA Annual Meeting. Portland OR USA. Website: community.geosociety.org/gsa2021
- 1-3 NOVEMBER GAC-MAC Joint Annual Meeting. London ON Canada. Website: gacmac2021.ca
- 25-28 NOVEMBER Conference of the Arabian Journal of Geosciences Istanbul Turkey. Website: www.cajg.org
- 1-5 DECEMBER 12th International Symposium on Selenium in Biology and Medicine. Honolulu HI USA. Website: se2021.jabsom.hawaii.edu
- 5-10 DECEMBER American Exploration and Mining Association Annual Meeting. Sparks NV USA. Website: www.miningamerica.org/2021-annual-meeting

2022

- 17-22 JANUARY Winter Conference on Plasma Spectrochemistry. Tucson AZ USA. Website: tinyurl.com/5csrtrfvc

Rescheduled

- 28-31 MARCH 15th Biennial Meeting of the Society for Geology Applied to Mineral Deposits. Rotorua New Zealand. Website: tinyurl.com/ykkf5wx8



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continued on page 19



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



CALENDAR OF EVENTS... *continued from page 17*

- 2-5 MAY Geological Society of Nevada 2022 Symposium. Sparks NV USA. Website: www.gsnsymposium.org
- 22-27 MAY Geochemistry of Mineral Deposits (Gordon Research Conference). Castelldefels Spain. Website: tinyurl.com/lyxyprqc
- 31 MAY-2 JUNE 10th World Conference on Sampling and Blending. Kristiansand Norway. Website: wcsb10.com
- 10-15 JULY Goldschmidt 2022. Chicago IL USA. Website: tinyurl.com/ybb4pct8
- 18-22 JULY 23rd General Meeting of the International Mineralogical Association. Lyon France. Website: www.ima2022.fr/
- 19-21 JULY 6th International Archean Symposium. Perth WA Australia. Website: 6ias.org
- 24-29 JULY 15th International Conference on Mercury as a Global Pollutant. Cape Town South Africa. Website: tinyurl.com/2ch7e6fa
- 31 JULY- 5 AUGUST World Congress of Soil Science 2022. Glasgow UK. Website: www.soils.org.uk/wcss2022
- 6-12 AUGUST Geoanalysis 2022. Freiberg Germany. Website: geoanalysis2021.de/en
- 15-21 AUGUST 5th International Symposium on Environment and Health. Galway Ireland. Website: tinyurl.com/canhu59c
- 22-26 AUGUST International Sedimentological Congress. Beijing China. Website: isc2022.scievent.com
- 23-26 AUGUST International Symposium on Environmental Geochemistry. Moscow Russia. Website: www.iagc-society.org/ISEG.html
- 11-15 SEPTEMBER IWA World Water Congress & Exhibition. Copenhagen Denmark. Website: worldwatercongress.org
- 13-15 SEPTEMBER 14th International Symposium on Nuclear and Environmental Radiochemical Analysis. York UK. Website: tinyurl.com/y989mvvz
- 16-22 OCTOBER 29th International Applied Geochemistry Symposium (IAGS). Viña del Mar Chile. Website: iags2021.cl

2023

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

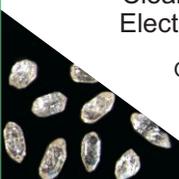


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